DYEING.

DYE, *v. a.* & *n. s.* } Sax. deagan, to color.
DYER, *n. s.* } Often written die. To
DYE'ING. } tinge; color; stain.

His looke was sterne, and seemed still to threat
Cruell revenge, which he in hart did hyde,
And on his shield Sansloy in blood lines was *dyde*.
Spenser. Faerie Queene.

It will help me nothing
To plead mine innocence; for that *die* is on me,
Which makes my whit'st part black.
Shakspeare. Henry VIII.

We have dainty works of feathers of wonderful lustre, excellent *dies*, and many.
Bacon's New Atlantis.

So much of death her thoughts
Had entertained, as *died* her cheeks with pale.
Milton.

He (an obstinate man) will rather suffer self-martyrdom than part with the least scruple of his freehold; for it is impossible to *dye* his dark ignorance into a lighter color. *Butler.*

A translator *dyes* an author, like an old stuff into a new colour, but can never give it the lustre of the first tincture; as silks that are twice *dyed* lose their glosses, and never receive a fair color. *Id.*

The fleece, that has been by the *dier* stained,
Never again its native whiteness gained. *Waller.*

All white, a virgin saint she sought the skies;
For marriage, though it sullies not, it *dies*. *Dryden.*

Darkness we see emerges into light,
And shining suns descend to sable night:
Even heaven itself receives another *die*,
When wearied animals in slumbers lie
Of midnight ease; another, when the grey
Of morn preludes the splendour of the day.
Id.

There were some of very low rank and professions, who acquired great estates: cobblers, *diers*, and shoemakers gave publick shows to the people.
Arbuthnot on Coins.

It is surprizing to see the images of the mind stamped upon the aspect; to see the cheeks take the *die* of the passions, and appear in all the colours of thought. *Collier of the Aspect.*

Flowers fresh in hue, and many in their class,
Implore the pausing step, and with their *dyes*
Dance in the soft breeze in a fairy mass. *Byron.*

PART I.

THE THEORY OF DYEING.

1. Dyeing is a chemical art which has for its object the extracting of the coloring particles from such substances as afford them, and transferring them to certain stuffs of wool, silk, cotton, or linen. No art has profited so much from the improvements of modern chemistry as the art of dyeing has; and it cannot be, nor ought it to be forgotten, that while we owe much to the discoveries of our own countrymen, and the application of those discoveries to the useful arts, the art of dyeing is highly indebted to the national operations of the French chemists.

2. The origin of this art seems to be of high antiquity; a circumstance which renders it impossible to say to whom or to what it is to be attributed: conjecture, therefore, is all we can pretend to. As most of the materials from which coloring matter is derived are, of themselves, either of dark and disagreeable colors, or else destitute of any particular color, it is probable that, even in the very earliest ages, the love of

ornament, which is natural to mankind, and which is founded on the love of distinction, one of the most active principles of the human mind, would induce them to stain their vestments with various coloring ingredients, especially with vegetable juices But the means of imparting permanent dyes to cloth, and affixing to its fibres such coloring materials, as could not easily be washed out by water, or be obliterated or greatly changed by the action of air, or of certain saline substances, to which they are liable to be exposed, and which are necessary to render them clean when soiled, was an art which required the knowledge of principles not within the reach of untutored men, and only to be obtained by gradual investigation, and by the lapse of a considerable portion of time.

3. According to Pliny, the Egyptians had discovered a mode of dyeing, somewhat resembling that which we use for coloring printed linens: the stuffs, probably after having been impregnated with different mordants, were immersed in vats, where they received various colors. And M. Delaval is of opinion, that they were possessed not only of the art of dyeing, but even of that of printing on cloths.

4. The Phœnicians seem to have a strong claim to the invention of this art, and they held a decided pre-eminence in the practise of it for many ages: their purple and scarlet cloths were sought after by every civilised nation; and the city of Tyre, enriched by its commerce, increased to an amazing extent. But her career was stopped by the vanity and folly of the eastern emperors; under whose dominion this opulent city had unfortunately fallen. Desirous of monopolising the wearing of the beautiful cloths of Tyre, these tyrants issued most severe edicts, prohibiting any one from appearing in the Tyrian blue, purple, or scarlet, except themselves, and their great officers of state. To this injudicious restriction is to be attributed the destruction of the Tyrian dyes. For under the impolitic restraint imposed on the consumption of the Phœnician cloths, the manufacturers and dyers were no longer able to carry on their trade; it grew languid and expired: and, with the trade, the art itself also perished. It is generally supposed from the name, that the Tyrian purple, so much celebrated among the ancients, was discovered at Tyre, and that it contributed not a little to the opulence of that celebrated city. The liquor which was employed in dyeing the purple was extracted from two kinds of shell-fish, one of which, the larger, was called the purple, and the other was a species of whelk. Each of these species was subdivided into different varieties, which were otherwise distinguished, according to the places where they were found, and as they yielded more or less of a beautiful color. It is in a vessel in the throat of the fish that the coloring liquor is found. Each fish only afforded a single drop. When a certain quantity of the liquor had been obtained, it was mixed with a proportion of common salt, macerated together for three days, and five times the quantity of water added. The mixture being kept in a moderate heat, the animal parts which happened to be mixed with it separated, and rose to the surface. At the end of ten days, when these operations were finished, a piece of white wool was immersed, by which means they ascertained whether the liquor had acquired the proper shade. Various processes were followed to prepare the stuff to receive the dye. By some it was immersed in lime-water, and by others it was prepared with a kind of fucus, which acted as a mordant to give it a more fixed color. Alkanet was used by some for the same purpose. The liquor of the whelk did not alone yield a durable color. The liquor from the other shell-fish served to increase its brightnesss; and thus two operations were in use to communicate this color. A first dye was given by the liquor of the purple, and a second by that of the whelk; from which it was called by Pliny purpura dibapha, or purple twice dipped. The small quantity of liquor which could be obtained from each shell-fish, and the tedious process of its preparation and application to the stuffs, raised the price of purple so high, that in the time of Augustus a pound of wool of the Tyrian purple dye, could not be purchased for one thousand denarii, equal to about £36 sterling.

5. Among the Greeks the knowledge of dyeing must have been very imperfect, and little assisted by science; for the art of dyeing linen appears not to have been known in Greece before Alexander's invasion of India, where, according to Pliny, they dyed the sails of his vessels of different colors. The Greeks seem to have borrowed this art from the Indians.

6. India seems to have been the nursery of the arts and sciences, which were afterwards spread and perfected among other nations. Accidents, which had a tendency to improve the art, could not fail to be multiplied rapidly, in a country,—rich in natural productions; requiring little labor for the support of its inhabitants; and the population of which was favored by the bounty of nature, and simplicity of manners, till it was opposed by the tyranny of succeeding conquerors. But religious prejudices, and the unalterable division into castes, soon shackled industry; the arts became stationary; and it would seem, that the knowledge of dyeing cotton in that country (for silk was then unknown, or at least very scarce) was as far advanced in the time of Alexander, as it is at the present period.

7. The beautiful colors, which are observable in some Indian linens, would lead one to suppose that the art of dyeing had there attained a high degree of perfection; but we find by the description which Beaulieu, at the request of Dufay, gave of some operations performed under his own eye, that the Indian processes are so complicated, tedious, and imperfect, that they would be impracticable in any other country, on account of the great difference in the price which is paid for labor.

8. It is unquestionably true, that European industry has far surpassed them in correctness of design, variety of shade, and facility of execution; and, if we are inferior to them with respect to the liveliness of some colors, it is only to be attributed to the superior quality of some of their dyes, or perhaps to the length and multiplicity of their operations and processes. In our own country, however, the art of dyeing made no considerable progress till about the beginning of the

seventeenth century. Before that period our cloths were sent to Holland, to be dressed and dyed. This, however, was probably practised only in the case of particular colors. The dyeing of woollen and silken goods has indeed long since attained a considerable degree of excellence; but the manufactures of cotton, owing to the small attraction of that substance for coloring matters, have been very deficient in this point. Till within these few years, the colors employed in the dyeing of fustians and cotton velvets were few; and, even at this day, many of them are fugitive. But it must be allowed that great improvements have been made within these few years, from the application of chemical principles, and by a diligent investigation of the nature of coloring substances. There is however still much room for the improvement of the art, but this can only be effected by the practical dyer acquiring chemical knowledge, an acquisition now happily placed within the reach of every dyer who is capable of reading and understanding the English language. It will not be necessary for our present purpose to enter into a minute examination of the various theories that have been advanced of the nature of colors; at the same time it may be proper, before we deduce a general theory of dyeing, to make a few observations on the common properties of coloring substances.

9. In explaining the cause of color, and the nature of coloring particles, two great inconveniences have arisen. First, from an attempt to illustrate the action, which the particles of coloring substances have on the rays of light, in consequence of their density and thickness, without having any means of ascertaining this, and without any regard to the attractions which result from their chemical composition; in comparing the coloring particles to mucilages and resins, from some very faint resemblances; and in attempting to explain their coloring properties by conjectures, formed respecting their component parts, while these properties ought rather to be ascertained by direct experiment than explained by an imaginary composition. It was also departing from true theory, to ascribe to laws purely mechanical, the adhesion of the coloring particles to the substances dyed, the action of the mordants, the difference between the true or durable, and the false or fugitive dyes.

10. Hellot, who has written an excellent treatise on dyeing, seems to have erred on this subject; and Macquer, who was amongst the first who entertained just notions respecting chemical attractions, seems to have been led astray by his ideas. It appears, however, that Dufay had before observed, that the coloring particles were naturally disposed to adhere more or less firmly to the filaments which receive them; and had very justly remarked, that without this disposition, stuffs would never assume any color but that of the bath, and would always divide the coloring particles equally with it: whereas the liquor of the bath sometimes becomes as limpid as water, giving off all the coloring particles to the stuff; which, he observes, seems to indicate that the ingredients have less attraction for the water than for the particles of the wool.

11. Bergman seems to have been the first who referred the phenomena of dyeing entirely to chemical principles. Having dyed some wool and some silk in a solution of indigo, in very dilute sulphuric acid, he explains the effects he observed in the operation, by attributing them to the precipitation, occasioned by the blue particles having a greater affinity for the particles of the wool and silk, than for those of the acidulated water. He remarks that this affinity of the wool is so strong, as to deprive the liquor entirely of the coloring particles; but that the weaker affinity of the silk can only diminish the proportion of these particles in the bath, and he shows that on these different affinities depend both the permanence and intensity of the color.

12. This is the true light in which the phenomena of dyeing should be viewed; they are real chemical phenomena, which ought to be analysed in the same way as all those dependent on the actions which bodies exert, in consequence of their peculiar nature. It is evident, that the coloring particles of bodies possess chemical properties, that distinguish them from all other substances; and that they have attractions peculiar to themselves, by means of which they unite with acids, alkalis, metallic oxides, or calces, and some earths, principally alumine or pure clay. They frequently precipitate oxides and alumine, from the acids which held them in solution; at other times they unite with the salts, and form supercompounds which combine with the wool, silk, cotton, or linen. And with these their union is rendered much more close by means of alumine or metallic oxide, than it would be without their intermedium.

13. The difference in the affinity of the coloring particles for wool, silk, and cotton, is sometimes so great, that they will not unite with one of these substances, while they combine very readily with another; thus, cotton receives no color in a bath which dies wool scarlet. Dufay prepared a piece of stuff, the warp of which was wool and the woof cotton, which went through the process of fulling, that he might be certain, that the wool and the cotton received exactly the same preparation; but the wool took the scarlet dye, and the cotton remained white. It is this difference of affinity which renders it necessary to vary the preparation and the process, according to the nature of the substance which is intended to be dyed of a particular color. And these considerations ought to determine the means to be pursued for the improvement of the art of dyeing. It is highly proper to endeavour to ascertain what are the constituent principles of the coloring particles. And in this enquiry, the most essential circumstances are, to determine the affinities of a coloring substance; first, with the substances which may be employed as menstrua; secondly, with those which may, by their combinations, modify the color, increase its brilliancy, and help to strengthen its union with the stuff to be dyed; thirdly, with the different agents which may change the color, and principally with the external agents—air and light.

14. The qualities of the uncombined coloring particles are modified when they unite with a substance; and, if this compound unites with a stuff, it undergoes new modifications. Thus the

properties of the coloring particles of cochineal are modified, by being combined with the oxide of tin, and those of the substances resulting from this combination are again modified by their union with the wool or silk; so that the knowledge we may acquire by the examination of coloring substances in their separate states, can only inform us respecting the preparations that may be made of them; that which we acquire respecting their combinations with substances which serve to fix them, or to increase their beauty, may inform us what processes in dyeing ought to be preferred or tried; but it is only by direct experiment made with the different substances employed in dyeing, that we can confirm our conjectures, and properly establish the process.

15. These facts show, that the changes produced by acids and alkalis on many vegetable colors, such as the chemists employ, in order to discover the nature of different substances, are owing to the combinations, which take place between these coloring particles and the acids and alkalis. The compounds resulting from these may be compared to neutral salts, which possess qualities different from those of their component parts, but in which one of these parts may be in excess, and its qualities consequently predominant. This state of combination is observable between the coloring particles of cochineal and acidulous tartrite of potassa, or cream of tartar: by evaporating slowly a solution of this salt in a decoction of cochineal, crystals are formed, which retain a fine ruby color, much more bright and intense than that of the liquor which formed them.

16. It was the opinion of Berthollet that some of the acids, particularly the nitric, after combining with the coloring particles, changed the color which they at first produced, making it yellow, and finally destroying it; after which they act by means of one of their principles, viz. the oxygen. But this theory, Dr. Ure remarks, is not now tenable, since it is known that dry chlorine does not blanch dry litmus paper. When moisture intervenes, muriatic acid is formed, and oxygen evolved; to the action of which body on the color the bleaching effect is to be ascribed. Water is the source of the discoloration, both in the ancient and modern process of bleaching. Blue colors are not the only ones which become red by the addition of acids, and green by that of alkalis; most red colors, as that of the rose, for instance, are heightened by acids, and made green by alkalis; and some green colors, such as that of the green decoction of burdock, according to the experiments of Mr. Nose, and the green juice of Buckthorn, as is evident from the trials of Mr. Becker, are reddened by acids.

17. This property, which is common to most of the ordinary colors of vegetables, seems to prove that there is a close analogy between their coloring particles; and it is not without foundation, that Linnæus supposed, that the red in vegetables was owing to an acid, and indicated its presence; but there are also many vegetables which contain acid in a disengaged state, without their possessing a red color. It is therefore evident, that the coloring particles have affinities for acids, alkalis, earths, and metallic oxides, which constitute a part of their chemical properties; and in consequence of which, their colors are more or less varied; therefore these particles form, with the stuff on which they are fixed, a compound which retains only some of their original properties; they are also modified by their union with alumine, or pure clay, metallic oxides, and some other substances; as are also those new compounds, when they are further combined with the stuff.

Of Mordants.

18. The term mordant is derived from the French word mordre, which signifies to bite or corrode. In the art of dyeing, it is applied to designate all those substances employed for the purpose of facilitating or modifying the combination of the coloring particles with the stuff dyed. Dr. Bancroft, and Dr. Henry of Manchester, proposed to denominate these substances by the term basis, since the action of many of them does not depend on the acid or corroding principle; but this alteration has not been adopted. Mordants deserve the greatest attention; as by their means colors are varied, brightened, made to strike, and rendered more durable. We shall, therefore, examine the nature of the action of the principal bases or mordants, and endeavour to determine how their attractions serve to unite the coloring particles with the stuff, and how they affect the qualities of the colors.

19. A mordant is not always a simple agent, for new combinations are sometimes formed by the ingredients that compose it; so that the substances employed are not the immediate agents, but the compounds which they have formed. Sometimes the mordant is fixed with the coloring particles, and sometimes the stuff is impregnated with it; on other occasions, both these modes are united; and we may dye successively with liquors containing different substances, the last of which only can act on the particles with which the stuff is impregnated. The art of printing linen affords many processes, in which it is easy to observe the effects of mordants; to elucidate this subject, therefore, we shall mention a few examples.

20. The basis employed for linens intended to receive different shades of red, is prepared by dissolving in eight pounds of hot water, three pounds of alum, and one pound of acetate of lead, or sugar of lead, to which two ounces of potassa, and afterwards two ounces of powdered chalk are added. The alum is decomposed by the acetite of lead, because the oxide or calx of lead combines with the sulphuric or vitriolic acid, and forms an insoluble salt which is precipitated; the base of the alum, alumine, at the same time combines with the acetous acid, or vinegar, and produces an acetite of alumine; and the chalk and potassa answer the purpose of saturating the excess of acid. One of the advantages which result from the formation of the acetite of alumine is, that the alumine is retained in it by a much weaker affinity than in the alum; so that it more easily quits its menstruum, to combine with the stuff and coloring particles. Another

advantage is, that the acid liquor, from which alumine is separated, has much less action on the color when it consists of the acetous, than when it consists of a stronger acid, such as the sulphuric. In short, the acetite of alumine not having the property of crystallising, the mordant, which is thickened with starch or gum, to prepare it for being applied to the block on which the design is engraved, does not curdle, as it would if it contained alum capable of crystallising. By attending to the operation performed upon a piece of linen cloth, we find, that when it has been impregnated by the mordant, in the manner determined by the design, it is put into a bath of madder; the whole of the cloth becomes colored, but the tinge is deeper in those parts which have received the mordant; there the coloring particles have combined with the alumine and the cotton, so that a triple compound has been formed, and the acetous acid separated from its basis remains in the bath.

Thus the coloring particles, combined with the alumine and the stuff, are much more difficultly affected by external agents, than when they are in a separate state, or combined only with the stuff, without any intermediate bond of union; and on this property the operations, to which the cloth is afterwards subjected, are founded. After it has been maddered, it is boiled with bran, and spread upon the grass; and these operations are alternately repeated until the ground becomes white. The coloring particles, which have not united with the alumine, are altered in their composition, dissolved, and separated, while those that have combined with it remain, and are preserved, without alteration; and thus, the design alone remains colored. It seems that this decomposition of the coloring particles, by exposure on the grass and boiling with bran, is accomplished in the same manner as that of the coloring particles of flax, and admits of the same explanation. The only difference consists in substituting bran for alkalis, because they would dissolve a part of the coloring matter, which is fixed by the alumine, and would change its color; instead of which, the bran, having a much weaker action on this substance, affects only the coloring particles, which, by the action of the air, have been disposed more easily to solution. If, however, instead of the mordant, a solution of iron be employed, similar phenomena are exhibited. The coloring particles decompose the solution of iron, and form a triple compound with the stuff; but, instead of red, we obtain from the madder, brown colors of different shades, down even to black; and, by uniting these two mordants, alum and iron, we have mixed colors, inclining to red on the one hand, and to black on the other, such as mordoré, and puce color. Other colors are also procured by substituting dyers-weed for madder; and by means of these two coloring substances, indigo, and the two mordants above mentioned, we obtain most of the different shades that are observable in stuffs which are printed.

21. The different substances which enter into the composition of a mordant remain in combination till a new action is induced by the application of another substance. Thus the affinity of the stuff for one of their constituent parts produces a decomposition and new combinations. But even this effect is sometimes incomplete, or does not at all take place without the action of another affinity, namely, that of the coloring particles. We have an example of this in the mixture of alum and tartar, which is one of the most common mordants in the dyeing of wool.

22. M. Berthollet, having dissolved equal weights of alum and tartar, found that the solubility of the tartar was increased by the mixture. By evaporation and a second crystallisation, the two salts were separated, so that no decomposition had taken place. Half an ounce of alum and one ounce of wool were then boiled together for an hour, and a precipitate was formed, which, being carefully washed, was found to consist of filaments of wool incrusted with earth. To this sulphuric acid was added, and the solution being evaporated to dryness, crystals of alum were produced, 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 crystallise. This being again dissolved, and precipitated by means of an alkali, the alumina which was thrown down was of a slate color, became black when placed on red-hot coals, and emitted alkaline vapors. From this experiment it appears that the alum was decomposed by the wool, and that 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 thus formed.

23. M. Berthollet made the same experiment with half an ounce of alum and two drams of tartar; no precipitation took place: he obtained by evaporation a small portion of tartar, and some very irregular crystals of alum; the remainder would not crystallise: this, on being diluted with water, and precipitated by potassa, gave by evaporation a salt which burned like tartar. The wool which had been boiled with the alum felt harsh, but the other retained its softness. The first had acquired from the madder a more dull, though lighter tint, but the color of the latter was more full and bright.

24. From these experiments it appears, in the first place, that the wool had begun a decomposition of the alum; that it had united with a part of the alumine; and that even the part of the alum which retained its alumine had dissolved some of the animal matter. In the second place, that the tartar and alum, which cannot decompose each other solely by their own affinities, become capable of acting on each other when their affinities are assisted by that of the wool. And, in the third place, that the tartar appears principally useful for moderating the too powerful action of the alum upon the wool, whereby it is injured; for tartar is not used in the aluming of silk and thread, which have less action on the alum than wool has. As the decomposition of alum by the tartar and wool takes place in consequence of affinities which nearly balance each other, and the process must therefore go on slowly, it is useful to keep the stuff impregnated with alum and tartar for some days in a moist

place, as is generally recommended. The final effect of aluming, in whatever manner performed, and whatever chemical changes may have taken place in it, consists in the combination of alumine with the stuff: this union has probably been imperfect, and the acids only partially separated, but becomes complete when the cloth has been boiled with madder, as in the case of printed stuffs. But an acid or an alkali may form a supercompound with the stuff, the coloring matter, and the alumine; for there are some colors which are changed by an acid, and restored by alkalis, or by calcarecus earths, which take the acid from them, or vice versa; but this supercomposition does not take place with respect to those colors which are esteemed durable, being unchangeable by alkalis or acids, which are not strong enough to destroy their composition.

25. The attraction of alumine for animal substances is not, however, merely indicated by uncertain appearances, nor supposed for the purpose of being employed in explanations, but is proved by direct experiment. M. Berthollet united them together, by mixing an animal substance with a solution of alum; a double exchange took place, the alkali entered into combination with the acid of the alum, and the alumine, combining with the animal substance, was precipitated. He also proved the affinity of alumine for animal substances by another experiment: having mixed a solution of glue with a solution of alum, he precipitated the alumine by an alkali, and the glue with which it had combined fell down along with it. This compound has the appearance of a semitransparent jelly, and dries with difficulty. Thus, in the preceding experiments, the alkali precipitated the alumine combined with the animal substance, from the uncrystallisable residue of the alum which had been boiled with the wool.

26. The affinity of alumine for most coloring substances, may also be shown by direct experiment. If a solution of a coloring substance be mixed with a solution of alum, a precipitation sometimes takes place; but if to the liquor we add an alkali, which decomposes the alum, and separates the alumine, the coloring particles are then precipitated, combined with the alumine, and the liquor remains clear: this compound has obtained the name of lake. In this experiment, too much alkali must not be added, because alkalis are capable of dissolving lakes in general. No direct experiment has however yet shown, that alumine attracts any vegetable substance except the coloring particles: its affinity for them seems much weaker than that which it has for animal substances; hence the acetite of alumine is a better basis for cotton and linen than alum is, and upon this depend the different means employed to increase the fixity of the coloring particles of madder in the dyeing of these substances.

27. Metallic oxides have so great an affinity for many coloring substances, that they quit the acids in which they were dissolved, and are precipitated in combination with them. On the other hand, all metallic oxides have the property of uniting with animal substances; and these different compounds may be formed by mixing an alkali, saturated with an animal substance, with metallic solutions. It is not surprising, therefore, that metallic oxides should serve as a bond of union between the coloring particles and animal substances; but, besides the attraction of the oxides for the coloring particles, and for animal substances, their solutions in acids possess qualities which render them more or less fit to act as mordants: thus, those oxides which easily part with their acids, such as that of tin, are capable of combining with animal substances, without the aid of coloring particles; it is sufficient to impregnate the wool or silk with a solution of tin, although they be afterwards carefully washed, which is not the case with other metallic solutions. Some metallic substances afford, in combination, only a white and colorless basis; and some by the admixture of their own color, modify that which is proper to the coloring particles; but in many metallic oxides, the color varies according to the proportion of oxygen they contain, and the proportion of this is easily liable to change, Upon these circumstances their properties in dyeing chiefly depend.

28. The affinity of metallic oxides for substances of vegetable origin, seems much weaker than that which they have for animal substances: metallic solutions are, therefore, not well adapted to serve as mordants for colors in cotton or linen, except iron, the oxide of which unites firmly with vegetable substances, as is shown by iron-moulds, which are owing to a real combination of this oxide. Whenever the coloring particles have precipitated a metallic oxide from its menstruum, the supernatant liquor contains the disengaged acid, which is commonly capable of dissolving a portion of the compound of the coloring substance and oxide, so that the liquor remains colored; but sometimes the whole of the coloring particles are precipitated, when the proportions have been accurately adjusted: this precipitation is facilitated, and rendered more complete, by the presence of the stuff, which assists, by the tendency it has to unite with the compound of oxide and coloring particles. Uncombined metallic oxides have also a very evident action on many coloring substances when boiled with them, and modify their color; the oxide of tin in particular increases the brightness and fixity of many.

29. The compounds of oxides and coloring substances are similar to many other chemical compounds, which are insoluble, when the principles of which they are formed are properly proportioned; but which are capable of being supersaturated by an excess of one of the principles, and thence of becoming soluble. Thus a metallic oxide, united with a coloring substance to excess, produces a liquor, the color of which will be modified by the oxides; whereas, when the coloring matter is not in excess, the compound will be insoluble, or nearly so; these effects are very evident in the combination of iron with the astringent principle. Neutral salts such as nitre, and particularly muriate of soda, or common salt, act as mordants, and modify colors; but it is difficult to ascertain the manner in which they act. M. Berthollet found that the muriate of soda was contained, in substance, in the precipitates produced by some species of

coloring particles, and that these precipitates retained a considerable degree of solubility; it would seem that a small part of the salt becomes fixed with the coloring particles and the stuff. Salts with calcareous bases also modify colors; but, as these modifications are nearly similar to those which would be produced by the addition of a small quantity of lime, it is probable that they are decomposed, and that a little of the lime enters into combinaation with the coloring particles and the stuff. By attention to this, we shall easily discern what combinations are formed by the agency of the different reactives, employed in the analysis of coloring substances; but we must not forget, that the mordants and the coloring particles have a mutual action on each other, which may change their properties. It is evident that, by varying the mordants, we may greatly multiply the shades obtained from a coloring substance; even to vary their mode of application may be sufficient: thus we shall obtain different effects by impregnating the stuff with the mordant, or by mixing the mordant with the bath; by applying heat, or using exsiccations, for we operate upon three elective attractions; that of the coloring particles, that of the stuffs, and that of the principle of the mordant; and many circumstances may cause variations in the result of these attractions; circumstances which merit further explanation. Exsiccation, or drying, favors the union of the substances which have an affinity for the stuff, and the decompositions which may result from that union; because the water which held these substances in solution, by its attraction, opposed the action of the stuff; but the exsiccation should be slow, in order that the substances may not be separated before their mutual attractions have produced their effect.

30. Considerable differences must be observed in the manner of employing the mordant, as the force of affinity between the stuff and the coloring matter is greater or less. When this affinity is strong, the mordant and the coloring substance may be mixed together; the compound thus formed, immediately enters into combination with the stuff. But, when the affinity between the stuff and the coloring particles is weak, the compound formed of the latter and the mordant may separate, and a precipitation take place, before it can be attached to the stuff; and hence it is, that the mordant which is to serve as the medium of union between the stuff and the coloring matter, must be combined with the former, before the application of the latter. It is from these differences that different processes must be followed in fixing coloring matters on animal and vegetable productions.

31. In judging of the effects of mordants, and the most advantageous manner of applying them, it is necessary to attend to the combinations which may be formed, either by the action of the ingredients of which they are composed, or by that of the coloring matter and the stuff. It is necessary, also, to take into consideration the circumstances which may tend to bring about these combinations with more or less rapidity, or that may render them more or less perfect. The action which the liquor in which the stuff is immersed may have, either on its color or texture, must also be considered; and to be able accurately to judge of the extent of this action, we must know the proportions of the principles of which the mordant is composed; which of these principles remains in an uncombined state in the liquor, and the proportion or quantity which is separated.

32. The coloring particles have been hitherto considered only as substances capable of forming different combinations, by which their properties are modified; but they may be altered in their composition, either by other external agents, or by the substances with which they unite. The stability of a color consists in its power of resisting the action of vegetable acids, alkalis, soap, and more especially that of the air and light; but this power varies exceedingly, according to the nature of the color and the species of the stuff; for the same durability is not required in the colors of silk as in those of wool. There is not much obscurity in the action of water, acids, alkalis, or soap: it is a solution brought about by these agents: and it appears that a small quantity of acid, or of alkali, sometimes unites with the compound which gives the color; because the color is not destroyed, but only changed, and may be restored by taking away this acid; for instance, by chalk and ammoniac, or volatile alkali. But this is not the case with respect to the action of air and light.

33. Scheele observed, that the oxygenated muriatic acid rendered vegetable colors yellow, and he attributed that effect to the property it had of taking up the phlogiston which entered into their composition. Berthollet has shown, that the properties of the oxygenated muriatic acid were owing to the combination of its oxygen with the substances exposed to its action; that it commonly rendered the coloring particles yellow; but that, by a continuance of its action, it destroyed their color; without determining in what this action consisted. Fourcroy afterwards made several observations on the action of oxygen on the coloring particles, which throw a great deal of light on the nature of the changes they undergo, chiefly when watery solutions of them are left exposed to the air, or have been subjected to a boiling heat. He observed that, in consequence of the action of the air, vegetable decoctions formed pellicles, which lost their solubility, and underwent successive changes of color; he marked the gradations of color thus produced, and concluded, from his observations, that oxygen entered into the composition of the coloring particles; that when it combined with them, their shade was changed; that the more they received, the more fixed did their color become; and that the best method of obtaining permanent unchangeable colors, for painting, was to choose such as had been exposed to the action of the oxygenated muriatic acid.

34. In considering the effects of air on colors, it is necessary to make a distinction between those produced by metallic oxides, and those produced by the coloring particles. Berthollet is of opinion that the modifications of the former are entirely owing to different proportions of oxygen, but from observation he has been led to

form a different opinion respecting the modifications of the latter. He observed, that the oxygenated muriatic acid exhibited different phenomena with the coloring particles; that sometimes it discharged their colors, and rendered them white; that most frequently it changed them to a yellow, fawn, or root-colored, brown, or black, according to the intensity of its action; and that, when their color appeared only discharged or rendered white, heat, or a length of time, was capable of rendering them yellow. He compared the effect produced by the oxygenated muriatic acid, when the particles are rendered yellow, fawn-colored, or brown, with the effect of a slight degree of combustion, and showed that they were the same; that they were owing to the destruction of the hydrogen, which, combining with the oxygen, more easily, and at a lower temperature than charcoal does, leaves it predominant, so that the natural color of charcoal is more or less blended with that which before existed. This effect becomes very evident, when sugar, indigo, or the infusion of the gall-nut, or of sumach, are exposed to the action of oxygenated muriatic gas; the sugar and the indigo assume a deep color, and afford indisputable marks of a slight combustion; the infusion of the gall-nut, and that of sumach, let fall a precipitate, which is not far from being pure charcoal or carbon. These appearances are analogous to those which are observed in the distillation of organised substances; in proportion as the hydrogen is extracted in the form of oil, or of gas, the substance grows yellow and at length there remains only a black coal. If the hydrogen be expelled from an oil, by heat, it grows brown, evidently in the same way.

35. Berthollet also found, by other experiments made on alcohol and ether, that the oxygen united to the marine acid, had the property of combining with the hydrogen, which abounds in these substances, and of thereby forming water. He therefore supposes, that when the oxygenated marine acid renders a color yellow, fawn-colored, or brown, the effect proceeds from the coloring matter having undergone a slight combustion, by which more or less of its hydrogen has been converted into water; and that the charcoal, thus rendered predominant, has communicated its own color. The art of bleaching linen by means of the oxygen of the atmosphere, of the dew, and of the oxygenated marine acid, he also supposes to depend on this change of the coloring matter. The coloring particles of the flax are rendered soluble in the alkaline lixivia, the action of which ought to be alternate with that of the oxygen. These coloring particles may be afterwards precipitated from the alkali, and by evaporation and drying become black, and prove the truth of this theory, both by the color they have acquired, and by the quantity of charcoal which they yield on being analysed. But the alkaline solution of the coloring matter of linen which is of a dark brown color, loses its color almost entirely, by the addition of a certain quantity of oxygenated muriatic acid; and the same effect is observable in many other substances, which have assumed a color originating from a commencement of combustion. A piece of linen, which appears white, may grow yellow in process of time, particularly if exposed to a certain degree of heat, if the oxygenated parts have not been removed by a sufficiently strong lixivium. In the same manner, the green parts of vegetables are rendered white by the oxygenated muriatic acid, but beome yellow when boiled.

36. From these facts it appears, that oxygen is capable of whitening, or rendering paler, the coloring matters with which it unites, perhaps by having produced the effects of a slight combustion upon them; or possibly these effects take place only afterwards in a gradual manner, but more rapidly, when the whole is exposed to a certain degree of heat. It is extremely probable, that in all cases a part of the oxygen unites with the coloring matter, without being combined with the hydrogen in particular, and that it is in this way that oxygen acts, in rendering the coloring matter of flax more easily soluble in alkalis. In many other cases oxygen has evidently an influence on the changes which take place in the coloring particles of vegetables; these particles are formed chiefly in the leaves, flowers, and inner bark of trees; by degrees they undergo a slight combustion, either from the action of the atmospheric air which surrounds them, or from that of the air which is carried by a particular set of vessels into the internal parts of vegetables.

37. Berthollet, therefore, supposes we may explain how the air acts upon coloring matters, of an animal, or a vegetable nature; it first combines with them, renders them weaker and paler, and by degrees occasions a slight combustion, by means of which the hydrogen which entered into their composition is destroyed; they change to a yellow, red, or fawn-color; their attraction for the stuff seems to diminish; they separate from it, and are carried off by water: all these effects vary, and take place more or less readily, and more or less completely, according to the nature of the coloring particles; or rather, from the nature of the properties which they possess, in the state of combination into which they have gone. The changes which occur in the colors, produced by the union of the coloring particles with metallic oxides, are effects compounded of the change which takes place in the coloring particles, and of that which is undergone by the metallic oxide.

38. The light of the sun considerably accelerates the extinction of colors. It ought, therefore, if this theory be well founded, to favor the combination of oxygen, and the combustion thereby induced. Sennebier, who has given many interesting observations on the effects of light on different substances, and particularly on their colors, attributes these effects to a direct combination of light with the substances. And the effects of light on the color of wood, have long ago been noticed; it preserves its natural appearance while kept in the dark, but when exposed to the light, it becomes yellow, brown, or of other shades. The same writer also remarked the varieties which occur in this particular in different kinds of wood, and found, that the changes are proportioned to the brightness of the light, and that they take place even under water, but that wetted wood underwent these changes less quickly than that which was dry;

that several folds of riband were required to defend the wood completely, that a single leaf of black paper was sufficient, but that, when paper of any other color was substituted, the change was not prevented; a single covering of white paper was insufficient, but two intercepted the action of the rays of light.

39. He extended his experiments to a great number of vegetable substances, in a manner that may serve to illustrate different phenomena of vegetation. If a well-made solution of the green parts of vegetables in alcohol, which has a fine green color, be exposed to the light of the sun, it very soon acquires an olive hue, and loses its color in a few minutes. If the light be weak, the effect is much more slow; and in perfect darkness, the color remains without alteration, or, if any change does take place, it requires a great length of time. An alkali restores the green color; but if the change of color in the liquor has been completed, the alkali has no effect. No change of color takes place in azotic gas, nor in a bottle which is exactly full. A bottle half full of this green solution was inverted over mercury, by Berthollet, and exposed to the light of the sun; when the color was discharged, the mercury was found to have risen in the bottle, and consequently vital air had been absorbed, the oxygen having united with the coloring matter. The precipitate which M. Sennebier mentions was not evident; the liquor had continued transparent, and retained a slight yellow tinge. On evaporating this liquor, its color was immediately rendered darker, and became brown; the residuum was black, and in a carbonaceous state.

40. Light, therefore, acts by favoring the absorption of oxygen, and the combustion of the coloring matter. At first, the marks of combustion are not evident; the liquor retains only a a slight yellow tinge; but, by the assistance of heat, the combustion is completed, the liquor becomes brown, and leaves a black residuum. If the vessel which holds the liquor contains no oxygen gas, the light has no effect on the coloring matter; azotic gas in this situation suffers no diminution. The observation, that ribands, or a single leaf of white paper, do not prevent the action of light, deserves attention, as it shows that light can pass through coverings which appear to be opaque, and exert its energy a considerable depth within. Beccaria and Sennebier have compared the effects of light on ribands of various colors; but the differences they have observed are rather to be attributed to the nature of the coloring matters, than to the colors; for a riband dyed with Brasil-wood will lose its color much sooner than one dyed with cochineal, though the shade should be exactly the same in each.

41. Although light greatly accelerates the combustion of the coloring particles, and seems even necessary for their destruction in some cases, in others it is not required. It was found, by putting some plants into a dark place, in contact with vital air, that that air was absorbed by some of them; and, also, that the rose suffers a change, and becomes of a deeper hue, when it is not in contact with vital air, probably because it contains a little oxygen, the combination of which then becomes more intimate. But many flowers, when in azotic gas, retain their color in perfection. The tincture of turnsole was placed in contact with vital air over mercury, both in the dark, and exposed to the light of the sun; the former continued unchanged for a considerable length of time, and the vital air had suffered no diminution; the other lost much of its color; became red; and the air was, in a great measure, absorbed, and a small quantity of carbonic acid was produced, which undoubtedly had occasioned the alteration of color from blue to red. From this we may form an idea of some of the changes of color, produced by a particular disposition of the component principles of vegetable substances, when, by their combination with oxygen, they undergo the effects of a slight combustion, which may generate an acid, as in the leaves in autumn, which grow red before they become yellow, and in the streaks which are seen in flowers, the vegetation of which is becoming weak.

42. On the whole it is evident, that coloring substances resist the action of the air more or less, according as they are more or less disposed to unite with oxygen, and thereby to suffer more or less quickly a smaller or greater degree of combustion. Light favors this effect, which in many cases is not produced without its assistance; but the coloring matter, in its separate state, is much more prone to this combustion, than when united to a substance, such as alumine which may either defend it by its own power of resisting combustion, or, by attracting it strongly, weaken its action on other substances, which is the chief effect of mordants. This last compound acquires still greater durability, when it is capable of combining intimately with the stuff upon which it is deposited. Thus the coloring matter of cochineal is easily dissolved in water, and its color is quickly changed by the air; but when united to the oxide of tin, it becomes much brighter, and almost insoluble in water, though it is still easily affected by the air, and by oxygenated muriatic acid; it resists the action of these better, however, when it has formed a triple compound with a woollen stuff. But still it is not to be inferred, that all yellow colors are owing to the carbonaceous part of the coloring substance; very different compounds are capable of producing the same colors; thus, indigo is very different from the blue of our flowers, from that of oxide of copper, and from that of Prussian blue. Berthollet does not even suppose, that oxygen may not unite in a small proportion with some coloring substances, without weakening their color, or changing it to yellow. Indigo becomes green by uniting with an alkali, with lime or a metallic oxide; but resumes its color, and quits these substances, when it recovers a small portion of the oxygen which it had lost. The liquor of the whelk, employed to dye purple, is naturally yellowish; but when exposed to the air, and more especially to the sun, it quickly passes through various shades, and at length assumes the exquisite purple color of the ancients; and which, according to the testimony of Eudocià, derived its lustre and perfection from exposure to the sun's rays.

43. It may then be considered as a general

fact, that colors become brighter by their union with a small portion of oxygen. It is on this account found necessary to air stuffs when they come out of the bath, and sometimes even to take them out of it from time to time, expressly for this purpose; but the quantity of oxygen which, thus becoming fixed, contributes to the brightness of the color, is very considerable in some cases and the deterioration of shade soon begins. But the action of the air affects not only the coloring matter and the stuff, but also metallic oxides, when they are employed as intermedia; because the oxides, which have at first been deprived of a part of their oxygen by the coloring particles, may absorb it again. Those then, the color of which varies according to their proportion of oxygen, have thereby an influence in effecting the changes which the stuff undergoes. It is undoubtedly to this cause that the change observable in the blue given to wool, by sulphate of copper, or blue vitriol, and logwood, is to be attributed. This blue soon becomes green by the action of the air: now copper, which has a blue color, when combined with a small proportion of oxygen, assumes a green one by its union with a larger quantity. The change which the coloring particles undergo, may indeed contribute to this effect; but the coloring particles of the logwood, which have themselves a dark color, should rather become brown by combustion, than grow yellow, which would be necessary in order to produce a green with the blue. It has been observed, that coloring particles in a state of combination were less disposed to be changed by the action of the air, than in an uncombined state. This is generally the case, but there are some exceptions; an alkali, for instance, produces a contrary effect. A matrass half filled with an infusion of cochineal, was exposed to the light, over mercury; a similar matrass contained an infusion of cochineal made with a little tartar; and in a third, a small quantity of alkali had been added to the infusion. The second matrass appeared least altered in the same space of time, and in it the absorption had been least considerable. In the third, the color of the liquor became first brown, and was then discharged; and the absorption of air, though inconsiderable, was greater than in the two others. On evaporation it assumed a brown color; and left a residuum of a yellowish brown.

44. Similar experiments having been made on different coloring substances, the alkali was found to darken their color, which grew more and more brown, and promoted the absorption of air. Madder appeared to be the only exception to this rule: its color, which became darker at first, stood better than that of the infusion made without alkali. The general effect of alkalis on the coloring particles is consonant to that which it produces on many other substances, such as sulphur; it favors the absorption of air, because it has a strong affinity for the substance which is the result of that absorption. From this effect of alkalis, a fact which has been observed by Becker may be explained; viz. that a vegetable infusion, rendered green by an alkali, becomes gradually yellow, if left exposed to the air, and that when the yellow is completely formed, acids cannot restore the original color: but that this is not the case, when a vegetable color, reddened by an acid, has been kept in like manner for some time. Those instances in which acids have been employed, which act by giving off their oxygen, must be excepted, for in these there is an extraction of the eolor.

45. From the above remarks on mordants it must appear very obvious that the practical dyer ought to be exceedingly careful in his selection of substances, giving the preference to those that most readily resist the action of the causes which we have specified.

46. It may not be improper to notice the action of these acids on animal substances, in consequence of its intimate connexion with the subject of mordants. It was observed by M. Brunwiser, that wood, on being exposed to the action of the air, assumed different colors: this led him to endeavour to ascertain whence those colors arose, and to produce them by artificial means. He remarked that on moistening the surface of wood, particularly young wood, with nitric acid, it assumed a yellow color; and that, by applying in the same way the muriatic and sulphuric acids, the wood assumed a violet color. Hence he inferred that, as all colors are produced by a mixture of yellow, blue, and red, all those colors which are seen in the leaves, fruits, and flowers of trees, are owing to the coloring particles which exist in the wood, and are there kept in a state of disguise, by the action of an alkali; that the mineral acids, by taking up this alkali, set the coloring particles at liberty; and that the fixed air, by penetrating the leaves, fruits, and flowers, produces naturally the same effect, by combining with the alkali which kept them disguised.

47. M. de la Folie informs us that having immersed a skein of white silk in nitrous acid of the strength generally used in commerce, the silk in three or four minutes assumed a fine jonquille yellow. He washed it several times in water, that it might not be affected by any adhering acid; the color sustained several trials to which he submitted it, and the silk preserved its lustre unimpaired. When dipped into an alkaline solution, a fine orange color was the result. Dr. Gmelin observes, that he has given a fine brimstone color to silk, by keeping it for a day in cold nitric acid, or some hours only, when the acid was warm. Boiling with soap and water diminished the brightness of this color; and it was changed to a fine lemon color, by being kept for twelve hours in an alkaline solution; but, when the solution was employed hot, a fine gold color was produced. The different solutions of metals in nitric acid communicated a more or less deep yellow to silk, as did also the solution of alumine in the same acid; but those of the calcareous earth and magnesia had no effect whatever.

48. M. Berthollet also found, that the oxygenated muriatic acid has the property of tinging animal substances yellow; but that it does not give them so deep a color as the nitrous acid, and it weakens them much more than that acid when properly diluted; so that the nitrous acid is far preferable for the different purposes of art. It, therefore, appears that the nitrous acid, diluted with a certain quantity of water, gives silk

a yellow color, which is more or less deep, according to the concentration of the acid, its temperature, and the time of immersion; that the silk must be carefully washed as soon as taken out of the acid; that this color possesses considerable brightness; and that it may be made deep without sensibly weakening the silk, which may render the process really useful. The color may also be modified by the use of alkalis. The solutions of calcareous earth and magnesia produce no effect upon silk, because they do not contain an excess of acid; but the solutions of alumine and of all metallic substances, produce a more or less deep yellow, because they all contain more or less excess of acid, which acts upon the silk like uncombined acid.

49. It appears likewise to have been the acid alone that dyed the animal substances yellow, in the experiments of M. Brunwiser, and not the matter extracted from the wood, as he supposed. Nor is the yellow color in these cases owing to iron, as De la Folie supposed; for the purest nitrous acid, which contains no iron, produces it, as well as that in which the presence of that metal may be supposed to exist. Silk, when put into concentrated nitrous acid, quickly assumes a deep yellow color, loses its cohesion, and is dissolved; during this solution, the azote, which enters into the composition of animal substances, is extricated, with a long continued effervescence; if heat be applied, it expels much nitrous gas, and the liquor immediately acquires a deep color and grows brown. At this time, the oxygen of the nitric acid combines with the hydrogen which abounds in animal substances, forming the oil which is obtained from them by distillation, and which renders them so inflammable. When the acid begins to act, and to render the silk yellow, the same effect should also begin to take place. M. Berthollet therefore supposes, that the yellow color arises from a commencement of combustion; but that this combustion being very slight, does not sensibly weaken the silk; if, however, the acid be a little too strong, or the immersion too long continued, or if the whole of it be not carried off by careful washing, the silk immediately becomes weak, and is burnt. It is, therefore, evident why the nitrous acid is preferable in this operation to that which is saturated with nitrous gas; for, in the former, the proportion of oxygen being greater, it is better fitted to produce the effects of combustion, than it becomes in the state of nitrous acid. The same explanation ought to apply to the action of the oxygenated muriatic acid on animal substances; it differs, however, in some essential circumstances, which are not easily explained.

50. Silk has been observed to receive a yellow color when the oxygenated muriatic acid is employed, which is much lighter than when the nitrous acid is made use of; the sulphurous acid discharges it in a great degree, but has no effect on the yellow produced by the diluted nitrous acid. The oxygenated muriatic acid has, however, a much stronger action on the silk; it soon weakens, and even dissolves it; and if it be left for some time in this fluid, the yellow which at first appeared grows lighter, agreeably to what has already been remarked, that oxygen, by accumulation, is capable of disguising the yellow color occasioned by the combustion, which it had originally induced. Berthollet has endeavoured to explain the effects which the sulphurous acid produces on colors, by the facility with which it gives off its oxygen, and has compared them to those of the oxygenated muriatic acid; but, although it be true that oxygen adheres much more weakly to the sulphurous than to the sulphuric acid, he does not believe that that explanation is founded in truth.

51. It appears from the observation of De la Folie, that roses, whitened by the vapor of burning sulphur, become green in an alkaline lixivium, and red in acids; and M. Berthollet has himself observed, that the sulphurous acid reddened the tincture of turnsole, which has a very fading color, but that it acted only like other acids, on infusions of fustic, Brasil-wood and logwood; and further, that silk which has been exposed to the vapor of sulphur, exhaled the smell of sulphurous acid, when moistened with sulphuric acid, although it could not be perceived before that odor existed. He therefore supposes, that the sulphurous acid commonly unites with the coloring particles, and with the silk, without giving off its oxygen to them, and consequently without producing any combustion; that the product of that combination sometimes loses its color entirely, which is probably owing to the semi-elastic state of the oxygen; but sometimes combustion may, and even commonly should take place by degrees, so that the coloring particles, which have been disguised for some time, ought ultimately to leave a yellow color.

Of Astringents.

52. Astringents deserve particular attention, not only from their great use in dyeing, but as possessing a property common to many vegetables. Perhaps, says Berthollet, there is no property in vegetables concerning which such vague ideas have been currently received. A slight relation in taste has frequently been deemed enough to rank them in the class of astringents; and every substance has been commonly regarded as astringent, or acerb, which turned a solution of iron black. This effect has been presumed to arise from one identical principle residing in all the bodies that produce it. Experience has subsequently shown, that two species of astringents ought to be admitted, viz. tannin and gallic acid. The gallic acid is obtained from gall-nuts, in which it is found in great plenty.

53. The gall-nut is an excrescence found on the young branches of the oak, and produced by the puncture of an insect. Different kinds of the gall-nut are met with, some inclining to white, yellow, green, brown, or red; others, ash-colored or blackish. They also differ greatly in magnitude, and are either round or irregular, heavy or light, smooth or covered with protuberances. Those which are small, blackish, knotted, and heavy, are the best; and are known by the name of Aleppo galls. These astringent substances are almost totally soluble in water by long ebullition. Sixteen drachms afforded Neumann fourteen of extract; from the remaining two drachms, only four grains could be extracted

by alcohol. And the same quantity treated first with alcohol, and then with water, afforded twelve drachms and two scruples of spirituous extract, and four scruples of watery extract; the residuum weighed half a scruple more than in the preceding experiment. In the spirituous extract, the taste is more strong and disagreeable than in the watery extract.

54. Many other very interesting observations have been made on astringent substances, by Messrs. Scheele, Monnet, and Berthollet. The latter seems to have proved, that it is not the gallic acid which communicates the astringent properties to the substances that possess it; that the acid itself possesses that property, in a degree inferior to other astringents; and that sumach, treated like the galls, in the manner described by Scheele, affords no gallic acid, though it possesses a high degree of astringency; walnut peels, treated in the same way, do not afford any. The property which the infusion of common galls has, of reddening certain vegetable colors, appears to proceed only from the gallic acid. The infusions of sumach, or of sloe-bark, which very readily produce a black precipitate, that of walnut-tree bark, or of quinquina, did not exhibit this property; and thence it is evident, that the gallic acid does not exist in white galls; for the infusion of these, though it deposit a copious sediment on exposure to the air, is not the gallic acid.

55. If the astringent property were owing to an individual principle distributed in different vegetables, the precipitates obtained by their means, from a solution of iron, would constantly form the same compounds, and exhibit the same appearances and properties; but the precipitate produced by galls is of a blackish blue: that by logwood has a different shade of blue; that by oak is of a fawn color, or blackish brown; that by quinquina, a blackish green. They fall down with different attendant circumstances, and when fixed on stuffs, are discharged by alum and tartar, some much more easily than others; and, probably, by multiplying experiments, many other remarkable differences may be discovered in the properties of these different precipitates. Astringents form with iron different species of compounds, and consequently do not derive their properties from one principle; but there must be a property common to different substances, to enable them to act uniformly on solutions of iron, and to produce precipitates more or less black, and thus appearing of the same nature.

56. The metallic oxides, which unite with the coloring particles, modify their colors; but some metallic oxides, and particularly that of iron, have colors which vary according to the quantity of oxygen they contain. Iron, when united with only a small quantity of oxygen, has a black color. If any substance, by uniting with the oxide of iron, had the property of taking from it a part of the oxygen, which it has when precipitated from its solution in an acid, this would be sufficient to give it a black color; and if the peculiar color of this substance were not predominant, or of itself inclining to black, the compound formed would have a black color; thus nitrous gas, either uncombined or weakly attached to the nitrous acid, renders solutions of iron black, and even precipitates the metal, by depriving it of a portion of its oxygen. By acting in the same manner, ammoniac produces a black precipitate with the solutions of iron; in this case, the hydrogen of the ammoniac forms water, by combining with the oxygen that is disengaged from the oxide of the iron. Galls precipitate gold and silver from their solutions, by reducing them to their metallic state; they, therefore, have the property of separating the oxygen from those metals, to which it adheres but slightly; and, from others, that portion which is retained in the weakest degree. Any infusion of galls, of itself, readily assumes a deep brown color, by exposure to the air; though it absorbs but a small quantity of vital air. The infusion of sumach, and that of woods and barks, also acquire a dark color by exposure to the air; so that when acting upon the oxide of iron, by separating a part of its oxygen, an astringent ought itself to acquire a darker color, by which the black should be assisted.

57. Various substances, which have in other respects different properties, produce black with solutions of iron. Among these, some are real coloring particles, and employed as such in dyeing. Logwood, and even most kinds of coloring particles, form brown or blackish precipitates with iron. Sometimes the astringent effect is not instantaneous; the color of the precipitate is at first light; it grows deeper gradually, being darkened in proportion as the iron loses its oxygen. The infusion of fustic produces, with the solution of iron, a yellow precipitate, that grows brown by degrees, and becomes black after a considerable time. But though the property of precipitating solutions of iron black, does not indicate the presence of the same individual principle in the substances which possess it, there can be no inconvenience in calling it by the name of astringent, provided by that term is meant only a property, which is common to a great number of substances, and which they may have in various proportions.

58. The astringent principle is found to precipitate iron from all acids. The acids of phosphorus and arsenic only have a stronger attraction than it has for iron. The phosphoric acid was known to have the property of separating iron from the sulphuric acid; but all acids, except the acetous, and probably some other vegetable acids which have not been tried, redissolve the precipitate, and make the color disappear, until they are saturated with an alkali. It is not surprising, that the astringent principle can unite with metallic oxides, without having the qualities of an acid; for animal substances, oils, even alkalis, and lime, have this property. It is well known, that it is the precipitate composed of iron and the astringent principle, which, by remaining suspended in the liquor, forms ink.

59. But although chemists considered the astringent principle as always the same, experience shows, that all astringent substances are not equally proper for producing a beautiful and durable black; it is of importance to determine which of them may be employed with the greatest success; it is, however, very difficult to make

comparative experiments on this subject with perfect accuracy, because some substances require much longer boiling than others to extract their astringency; because a difference in their coarseness or fineness, when subjected to ebullition, is sufficient to produce differences in the results; and because the coloring particles have a greater or less disposition to combine with the stuff, according to the proportion of sulphate of iron that has been made use of. Solutions of iron in different acids may produce differences in the results, according to the state of oxygenation of the iron in them, according as the proportion of that metal is greater or less, and according to the degree of strength which the different acids, when disengaged, are capable of exerting on the newly-formed compound.

60. In the dyeing of stuffs also some differences will be found to arise from their greater or less attraction for the coloring particles. Dr. Lewis has proved in his excellent observations on the process of making ink, that no known astringent, not even sumach, can be substituted for gall-nuts. If, says M. Berthollet, too large a proportion of sulphate of iron be added to the galls, the ink becomes speedily brown, and then passes to yellow, because the astringent is destroyed by the action of the oxygen, which the sulphate of the iron affords, or progressively attracts from the atmosphere; for we see that oxygen eventually destroys those coloring substances with which it is combined in too great quantities. When this accident happens from age, Dr. Lewis found that an infusion of galls passed over the faded characters restored them. According to Dr. Ure, the best restorative for faded writing is a solution of ferroprussiate of potash, faintly acidulated, or sulphuretted hydrogen water. Dr. Lewis ascertained, by repeated experiments, that the best proportion for ink is three parts of gall-nuts to one of sulphate of iron; that cherry-gum, and plum-tree gum, are as good as gum-arabic for giving the necessary consistence, and for keeping suspended the black molecules which tend to fall; and that decoction of logwood employed instead of water for the infusion of the galls improves the beauty of the ink.

61. Mr. Beunie made many experiments to determine the best process for giving cotton a durable black. He first tried what solution of iron gave the finest black to galled cotton; he afterwards combined different solutions, and examined the durability of the blacks which he produced; and made the same experiments on galled cotton, with other metals and semimetals; he employed in like manner a great number of astringents, and tried with them cotton which had received different preparations. He found that out of twenty-one species of astringents, oak saw-dust, the galls of the country, and yellow myrobolans, were the only substances which produced a fine black, but which was still neither so fine nor so durable as that obtained by the common galls. He also found that the oak saw-dust is preferable to the bark, employed by the dyers of thread, and, being cheaper, may be substituted with advantage.

62. Messrs. Lavoisier, Vandermonde, Fourcroy, and Berthollet, made experiments on galls, oak-bark, raspings of heart of oak, the external part of oak, of logwood, and sumach, for the purpose of forming a comparison of their qualities. To ascertain the portion of astringent principle contained in these different substances, they took two ounces of each separately, which they boiled half an hour in three pounds of water; after the first water they added a second, which underwent a similar ebullition; and continued these operations until the substances appeared exhausted: they then mixed together the decoctions that had been successively obtained. A transparent solution of sulphate of iron, in which the proportions of water and sulphate had been exactly determined, was used. They first estimated the quantity of the astringent principle, by the quantity of sulphate which each liquor could decompose, and afterwards by the weight of the black precipitate which was formed. In order to stop precisely at the point of saturation, they proceeded very slowly in the precipitation, and towards the end added the solution of sulphate only drop by drop, and ceased at the moment when the last added quantity no longer augmented the intensity of the black color. When the liquor is too opaque to allow its shade of color to be distinguished, a small quantity of it is largely diluted with water; and, by adding to this a little of the solution of sulphate of iron at the end of a glass tube, it is discovered whether or not the point of saturation has been attained: if we then wish to get the precipitate which is formed, the whole must be diluted with water very copiously.

63. This operation is an easy and accurate mode for manufacturers to determine the proper proportions of astringents, and solutions of iron. To saturate the decoction of two ounces of galls, three drachms and sixty-one grains of iron were required; the precipitate weighed seven drachms and twenty-four grains, when collected and dried. The color of the decoction of oak bark is a deep yellow; a very small portion of sulphate of iron gives it a dirty reddish color, and a larger one changes it to a deep brown. The quantity of sulphate required to saturate the decoction of two ounces of this bark, was eighteen grains. The precipitate, collected and dried, formed coarser and more compact grains, and weighed twenty-two grains; the inner bark of the oak afforded nearly the same result. But the decoction of the raspings of the heart of oak required for its saturation one drachm and twenty-four grains and the precipitate weighed one drachm and twenty-four grains; the decoction of the external wood of the oak produced very little precipitate. The decoction of sumach acquired a reddish violet color, when a small quantity of the sulphate of iron was added. The quantity required for its saturation was two drachms eighteen grains. The precipitate exactly resembled that afforded by the galls. And the decoction of logwood became of a sapphire blue color, by the addition of sulphate of iron: if the point of saturation be exceeded, the blue becomes greenish and dirty. The exact quantity required for saturation was found to be one drachm forty-eight grains, and the weight of the precipitate was two drachms twelve

grains. The different precipitations made by oak take place readily; that by logwood, a little more difficultly, but still more easily than that which is effected by galls.

64. It was next ascertained, by trials made with cloth, that the quantity of astringent substances required to give a black color of intensity, to an equal weight of the same cloth, was proportional to the quantities of astringent principle, which had been already estimated in each kind from the foregoing experiments; but the black obtained by the different parts of the oak does not resist proofs of color, nearly so well as that which is produced by galls. Logwood alone seems not capable of producing so intense a black as galls or oak; nor does the color which it produces stand the test of proofs so well as that produced by galls.

65. We shall now consider the astringent principle in regard to its property of combining with vegetable and animal substances, particularly the latter. Silk acquires by galling, which is an operation that consists in macerating a stuff in a decoction of some astringent substance, a weight which cannot be taken from it, or diminished beyond a certain degree, by repeated washing; after which operation the stuff when put into a solution of iron is dyed black, because the astringent principle, decomposing the sulphate of iron, forms a triple compound with the oxide of iron and the stuff which is dyed. A stuff that is galled is likewise capable of combining with other coloring particles, the colors of which thereby acquire fixity, if they do not naturally possess it; so that the astringent communicates its durability to the triple compound, or perhaps the more complex one which is formed; but by this union the color generally becomes of a deeper shade. The astringent principle, by combining with animal substances, renders them incapable of corruption, and tends to render their texture more compact; and in this the art of tanning consists.

66. It may be proper to take some notice here of the substance denominated tannin, which, while it has some properties in common with the gallic acid, differs from it in others. Seguin was the first who showed that astringents contained a peculiar substance, which, in combining with skin, gave it the properties of tanned leather, and that the tanning effect arose from the combination thus formed. Tannin may be procured by digesting gall-nuts, grape-seeds, oak-bark, or catechu, in a small quantity of cold water. The solution, when evaporated, affords a substance of a brownish-yellow color, highly astringent, and soluble in water and in alcohol. According to Mr. Brand, the purest form of tannin appears to be derived from bruised grape-seeds; but even here, he observes, it is combined with other substances, from which it is, perhaps, scarcely separable. I have never, says he, been able to obtain it of greater purity than by digesting powdered catechu in water at 33° or 34°, filtering and boiling the solution, which, on cooling, becomes slightly turbid, and is to be filtered again, and evaporated to dryness; cold water, applied as before, extracts nearly pure tannin. The most distinctive character of tannin is that of affording an insoluble precipitate when added to a solution of isinglass, or any other animal jelly. On this property the art of tanning depends, for which oak bark is generally employed; but the barks of many other trees are frequently employed for the same purpose. Professor Proust recommends the precipitation of a decoction of galls by powdered carbonate of potassa, for obtaining tannin, washing well the greenish-gray flakes that fall down with cold water, and drying them in a stove. This precipitate becomes brown in the air, brittle and shining like a resin, and yet remains soluble in hot water. In this state the tannin, he says, is very pure. According to Berzelius, tannin consists of hydrogen 4·186 + carbon 51·160 + oxygen 44·654.

67. M. Berthollet considers the abundance of charcoal as the essential characteristic of the astringent principle; the hydrogen, which it contains only in small quantity, is however very much disposed partially to combine with oxygen: Hence, when an infusion of galls is left in contact with vital air, a small quantity of the air only is absorbed, and yet the color of the infusion becomes much deeper; for, in conformity with the theory already laid down, the charcoal readily becomes predominant in consequence of the slight combustion, and the color is rendered deeper, and becomes brown.

68. Substances which contain much charcoal, and can undergo only a slight degree of combustion, ought to possess considerable durability, because charcoal does not combine with oxygen in the ordinary temperature of the air, unless its union be assisted by other attractions, and because slight variations of temperature produce no change in the dimensions of charcoal; but, on the contrary, substances which contain much hydrogen, and in which the particles of the hydrogen are in a state of division, ought to be easily decomposed, by the combination of the hydrogen with azote or oxygen. The disunion of their parts ought to take place from small variations of temperature, because hydrogen is dilatable by heat, which the carbonaceous particles are not. When, therefore, the astringent principle is combined with an animal substance, it communicates to it the properties which it derives from the charcoal; the animal substance becomes less liable to change from slight variations of temperature; instead of growing putrid, it suffers a slight degree of combustion, by the action of the air; for the process of tanning probably could not go on in a perfectly close vessel.

69. On examining the analyses that have been made of indigo, which may be looked upon as the coloring matter least liable to change of any with which we are acquainted, it will be found that this substance leaves, in distillation, a greater proportion of charcoal than even galls themselves. M. Berthollet supposes that it is also to this abundance of charcoal, that the durability of the color of indigo is to be attributed, and that the proportion of this principle is the chief cause of the difference observed in the durability of colors; but the force of adhesion may also have great influence, for a principle

which combines intimately with another substance, ought to form with it a more permanent compound, than one which has only a slight disposition to unite with it; now the astringent principle possesses a very strong disposition to form intimate combinations, especially with animal substances.

70. Upon the same principles may be explained the fixity communicated to coloring particles by alumine, and by those metallic oxides which are not liable to contain different proportions of oxygen, such as the oxide of tin, and some others. The different coloring substances, capable of uniting with metallic oxides, have an action upon them, analogous to that of astringents. The oxides are deprived of more or less of their oxygen, according to the force with which they retain it, the strength of attraction with which the coloring particles tend to combine with them, the proportions in which they meet with each other, and the greater or less disposition of the coloring particles towards combustion.

71. The coloring particles also suffer a change in their constitution from these circumstances: thus the solutions of iron render brown all the colors into which oxide of iron can enter, although it has only a green or yellow color in the state in which it is held in solution by acids, and this effect goes on increasing to a certain degree; but the alteration of the coloring particles may afterwards be carried so far as to spoil their color, and to diminish their tendency to combination; the oxide of iron is then brought back to the yellow color by the oxygen which it attracts, and is capable of retaining. The action of metallic oxides and the coloring particles on each other, explains the changes observed in solutions of the coloring particles, when mixed with metallic solutions. The effect is gradual, as has been shown with respect to fustic. It sometimes happens that the mixture does not even grow turbid immediately, but loses its transparency by degrees; the precipitation begins; the sediment is formed; and its color becomes gradually deeper. In producing these effects, light has sometimes a considerable share.

72. Upon the whole, we may conclude, that metallic colors should be distinguished from those which are peculiar to substances of the vegetable and animal kind: that the colors of metals are modified and changed by oxidation, and by the proportion of oxygen with which they are combined; and that vegetable and animal substances may themselves possess a peculiar color, which varies in the different states through which they pass, or they may owe their colors to colored particles, either combined, or simply mixed with them. These are the particles which are extracted from different substances, and which undergo different preparations, in order to render them proper for the various purposes of dying. And the coloring particles possess chemical properties which distinguish them from all other substances: the affinities which they have for acids, alkalis, earths, metallic oxides, oxygen, wool, silk, cotton, and linen, from the principal of these properties. In proportion to the affinity which the coloring particles have for wool, silk, cotton, and linen, they unite more or less readily and intimately with them: and thence arises the first cause of variation in the processes employed, according to the nature of the stuff, and of the coloring substance employed. And by the affinity which the coloring particles have for alumine and metallic oxides, they form compounds with these substances, in which their color is more or less modified, and becomes more fixed, and less affected by external agents than before. This compound being formed of principles which have separately the power of uniting with vegetable substances, and more especially with animal substances, preserves this property, and forms a triple compound with the stuff; and the color, which has been again modified by the formation of this triple union, acquires a greater degree of fixity, and of indestructibility, when exposed to the action of external agents.

73. The coloring particles have often so great an affinity for alumine and metallic oxides, that they separate them from acids which held them in solution, and fall down with them; but the affinity of the stuff is sometimes necessary, in order that this separation may take place. The oxides of metals, which combine with the coloring particles, modify their colors, not only by their own, but also by acting upon their composition by their oxygen. The change which the coloring particles thereby suffer, is similar to that occasioned by the air, which injures every color in a greater or less degree. In the two different principles which constitute the air or the atmosphere, it is only the oxygenous gas that acts upon the coloring particles. It combines with them, weakening their color, and rendering it paler; but presently its action is principally exerted on the hydrogen, which enters into their composition, and it then forms water. This effect, continues M. Berthollet, ought to be considered as a true combustion, whereby the charcoal which enters into the composition of the coloring particles becomes predominant, and the color commonly changes to yellow, fawn color, or brown; or the injured part, by uniting with what remains of the original color, causes other appearances of a different kind. The combustion of the coloring particles is increased by light, and frequently cannot take place without its aid; it is indeed in this way that it contributes to the destruction of colors. Heat promotes it also, but less powerfully than light, provided its intensity be not very great. The effects of the nitric acid, the oxygenated muriatic acid, and even the sulphuric acid, when they make the color of the substances upon which they act pass to a yellow and even to black, are to be attributed to a combustion of a similar nature.

74. The effects of combustion may, however, be concealed, by the oxygen combining with the coloring particles, without the hydrogen being particularly acted upon by it. But colors are more or less fixed, in proportion to the greater or less disposition of the coloring particles to suffer this combustion. There are some substances also capable of acting on the color of stuffs, by a stronger affinity, or by a solvent power; and in this consists the action of acids, alkalis, and soap

A small quantity of these agents, however, may sometimes form supercompounds with the stuff, and its color may be altered in that way. The oxides of metals produce in the coloring particles, with which they unite, a degree of combustion proportioned to the quantity of oxygen which these particles can take from them. Therefore the colors, which the compounds of metallic oxides and coloring particles assume, are the product of the color peculiar to the coloring particles, and of that peculiar to the metallic oxide: but the coloring particles and metallic oxides must be considered in that state to which they have been reduced by the diminution of oxygen in the oxide, and the diminution of hydrogen in the particles that produce the color. It follows from this, that the metallic oxides, to which the oxygen is only slightly attached, are not fit to serve as intermedia for the coloring particles, because they produce in them too great a degree of combustion; instances of this kind are the oxides of silver, gold, and mercury. The oxides which undergo considerable alterations of color, by giving off more or less of their oxygen, are also bad intermedia, particularly for light shades, because they produce changeable colors; examples of this kind are the oxides of copper, of lead, and of bismuth. The oxides which strongly retain their oxygen, and undergo very little change of color by the loss of a proportion of it, are the most suitable for this purpose; such is particularly the oxide of tin, which quits its menstruum easily, which has a strong affinity for the coloring particles, and which affords them a basis that is very white, and proper for giving a brightness to their shades, without altering them by the mixture of another color. The oxide of zinc is possessed of some of these properties in a considerable degree.

75. To account for the colors, which proceed from the union of the coloring particles with the basis which a mordant gives them, we must attend to the proportion in which the coloring particles unite to that basis. Thus the solution of tin, which produces a very copious precipitate with a solution of coloring particles, and which thereby proves that the oxide of tin enters in a large proportion into the precipitate, has a much greater influence on the color of the precipitate, by the whiteness of its basis, than the solution of zinc, or that of alum, which generally produce much less copious precipitates. The precipitates produced by these two last substances retain very nearly the natural tint which the coloring particles afforded. It is therefore necessary to distinguish, in the action of mordants, the combinations that may take place by their means, between the coloring particles, the stuff, and the intermedium; the proportions of the coloring substances and intermedium; the modifications of color, which may arise from the mixture of the color of the coloring particles, and of that of the basis to which they are united; and the changes which the coloring particles may suffer, from the combustion that may be produced by the substance that is employed as an intermedium. It is evident also, that astringents do not differ essentially from coloring particles; but the latter take this name, especially when employed to produce black with oxide of iron, by restoring this metal to the state of a black oxide, and by their assuming a dark color from the action of oxygen.

76. The notion of an astringent supposes, moreover, the property of combining in a certain quantity with animal substances, giving them thus solidity and incorruptibility; because these two properties are most commonly united. These again are derived from their large share of carbon, a circumstance in their composition which gives them increased tendency to solidity, and greater stability.

77. On this ingenious theory of Berthollet, Dr. Bancroft, an able writer on dyeing, has made some remarks that deserve attention. In his opinion M. Berthollet, in ascribing the decays of vegetable and animal coloring matters in general, to effects or changes similar to those of combustion, has gone much farther than is warrantable by facts. It cannot, he thinks, be his intention, that we should apply the term of combustion to alterations which result from a simple addition of oxygen to coloring matters, with a destruction or separation of any of their component parts; though many of the decays and extinctions of these colors evidently arise only from such simple additions of oxygen. The nitric, sulphuric, and other acids, containing oxygen, have the power not only of weakening, but of extinguishing, for a time, the colors of many tingent matters; not by any effect which can properly be denominated a combustion, but rather by a change in their several attractions for particular rays of light; but none of their parts being destroyed, or carried away, the addition of an alkali, or of calcareous carbonate, will generally undo such alteration, and restore the original color, by decomposing and neutralising the acid or oxygen which had caused the alteration.

78. Of this numerous instances might be given, it being the case of almost all vegetable or animal coloring matters. It will be sufficient to mention, that ink dropped into a glass of diluted nitric, vitriolic, or other acid, will lose its color, and that it may be again restored by adding a suitable portion of vegetable or fossil alkali; and that this may be done several times with the same ink, and therefore the change, or loss of color, could not have been the effect of combustion. If, however, this ink had not been fixed by dyeing in the substance either of wool, silk, linen, or cotton, and the substance so dyed had been dipped into a glass of diluted acid, a considerable part of the coloring matter would have been dislodged, aud separated from the dyed substance, by its affinity with the oxygen or acid; although no combustion had taken place, the color so separated and lost could not be again restored without a second dyeing. This loss of color would be similar to what frequently happens to colors from exposure to the sun and air, by which they are gradually weakened, many of them without any other change of tint than the simple diminution of their original quantity of coloring matter; and this continuing in the more fugitive colors, particularly that of turmeric, the cloth is soon left as white as before it had been

dyed, without any thing like combustion having ever taken place in it, or in the matter with which it was dyed. It may also be presumed, that colors are not generally impaired by any thing like combustion, from this fact, that there are but few of them which the common muriatic acid does not injure, as much as either the nitric or the sulphuric; and as there can be no combustion without oxygen, and as the common muriatic acid either contains none, or what it does contain is confessedly combined with it by an affinity too powerful to be overcome by any known substance or means, it follows, that the oxygen (if it contain any) cannot be liberated so as to act in the way of combustion upon any other matter; and therefore, when the common muriatic acid changes or destroys the colors, it changes or destroys the affinities upon which they depend, by producing effects different from those of combustion; and as the changes which it produces on colors are in most cases similar to those produced by the nitric, sulphuric, and other acids known to contain oxygen, it is reasonable to conclude, that these also act upon colors, by producing other effects than those of combustion.

79. M. Sennebier exposed a great variety of woods to the action of the sun and air, and found all their colors very soon affected. The white woods generally became brown, and the red and violet changed either to yellow or black. Guaiacum was rendered green; the oak and the cedar were whitened, as were the brown woods generally; effects which certainly do not resemble those of combustion, any more than the bleaching of wax or tallow by exposure to the air. It is therefore evident, argues Dr. Bancroft, that the color of each particular substance depends on its constitution, producing in it a particular attraction for certain rays of light; and a disposition to reflect or transmit certain other rays; and in this respect it may doubtless suffer very considerable changes from the action or combination of oxygen, without any effects similar to those of combustion. And, indeed, the changes of color which arise from the access of atmospheric air, seldom resemble those which the mere predominance of blackness (the supposed natural color of carbon) would produce; though this may have been the case with the coloring matter of brown or unbleached linen, upon which the experiments of M. Berthollet seem principally to have been made. But whether the action of vital air, or its basis, in promoting the decays and colors, ought to be denominated a combustion or not, Dr. Bancroft is confident, that at least some of them are liable to be impaired, not so much by an accession of oxygen, as by the loss of it. The difference of color in arterial and venous blood had been long noticed, and numerous experiments have shown that the fine vermilion color of the former is produced solely by vital air, which it is capable of acquiring through bladders, the coats of blood-vessels, &c. And Mr. Hassenfratz seems to have proved, that, as this fine red color is gained by a dissolution of oxygen in the arterial blood, so it is lost, and the dark color of the venous blood restored, by a separation of the oxygen, in consequence of its forming a new combination with the hydrogen and carbon of the same.

80. Dr. Bancroft is also of opinion, that the blue color of indigo depends upon a certain portion of oxygen, for he has found that a solution of indigo, by losing its oxygen, may become as pellucid, and, excepting a very slight yellowish tinge, as colorless as water, and afterwards speedily return through all the shades of yellow and green to its original deep blue, by exposure to atmospheric or vital air. Similar to this, he remarks, is the fact long since observed by the abbè Nollet, of the tincture of archil employed to color the spirit of wine used in thermometers, and which after some time loses its color, but recovers it again upon being exposed to atmospheric air. This also happens to the infusion of turnsole, and to syrup of violets, which lose their colors when secluded from air, and regain them when placed in contact with it. He has also observed various animal and vegetable colors, produced solely by the contact of atmospheric air; and some others, which, when given by dyeing or callico-printing to wool, silk, cotton, &c., though unable to sustain a single day's exposure to the sun and air without manifest injury, were found to receive none from the action of strong nitric or sulphuric acids, but, on the contrary, were perceived by being wetted with them, and even with oxygenated muriatic and sulphuric acids. But the same colors, if covered with linseed oil, were found to decay more quickly from exposure to the sun and air, than if uncovered. These colors, therefore, he contends, could not owe their decay to the contact or combination of oxygen, because they were not only unhurt, but benefited by its concentrated powers in the nitric, the oxygenated muriatic, and sulphuric acids; and also because they were soonest impaired when defended from the access of oxygen, by being covered with linseed oil. Probably the decays of these colors were occasioned by a loss of at least some part of the oxygen which was necessary to their existence, and which the linseed oil assisted in depriving them of, by the strong affinity it has with oxygen.

81. Dr. Bancroft further observes, that, in forming systems, we are apt to draw general conclusions from only a partial view of facts. This M. Berthollet seems to have done, not only in ascribing the decays of vegetable and animal colors, exclusively to effects similar to those of combustion, but also in representing the oxygenated muriatic acid, as an accurate test for anticipating, in a few minutes, the changes which these colors are liable to suffer by long exposure to the action of sun and air; for, says he, though it is true, that the oxygenated muriatic acid, in weakening or destroying colors, gives up to them more or less of the oxygen which it had received by distillation from manganese; and that, by this new combination of oxygen, those affinities for particular rays of light, upon which their colors depend, are liable to be destroyed; it is nevertheless true, that the changes of color so produced are no certain indication of those, which the combined influence of light and air will occasion upon colors in general; there being several colors which are very speedily destroyed by the latter of these causes, though they resist the strongest action of the oxygenated muriatic acid, without suffering any degree of

injury or hurt. The Dr. adds, that M. Berthollet well knows, since nobody has contributed more to ascertain, how much the properties of oxygen are diversified by each particular basis to which it unites; and that it does not, therefore, seem warrantable to imagine, that its action will not be modified by a basis so powerful as that of the common muriatic acid, or that the united properties of both should represent or resemble those of atmospheric air upon colors, any more than they do in the lungs by respiration; where, instead of supporting life, they would instantly put an end to it.

82. These observations were made in reference to the manner in which M. Berthollet had expressed himself on the subject in his Elemens de l' Art de la Teinture, published in 1791. A new edition of this work was published about the year 1804, in which the author has fully noticed Dr. Bancroft's arguments; refuted some of them; admitted the force of others in part; and, in some respects, has availed himself of the important improvements of Dr. Bancroft.

Of the Differences between Animal and Vegetable Substances.

83. Before we proceed to treat of the practice of dyeing, it will be necessary to consider some of the leading differences that exist between several of the substances to be dyed, and to point out the processes through which they must pass before they will receive the colors required. The following is the substance of M. Berthollet's opinion relative to this subject:—It is now known, that the composition of animal substances is distinguished from that of vegetables, by their abounding in a particular principle called azote, which is found only in small quantities in vegetables, as well as by their containing much more hydrogen, or base of inflammable air, than is found in the other. From these two causes, the differences observed in the distillation of animal and vegetable substances proceed: the former yield a large quantity of ammoniac or volatile alkali; the latter afford very little, and sometimes yield an acid: the former yield a great deal of oil, the predominant principle in which is hydrogen, which is very volatile and disposed to fly off by a small increase of temperature; while the latter sometimes do not yield it in the least sensible quantity.

84. Dr. Ure in a note, p. 151, vol. I. of his translation of Berthollet's treatise, has the following remarks on this theory. Modern researches do not justify this position of M. Berthollet. Sugar and starch, by the analyses of M.M. Gay Lussac and Berzelius, contain about as much hydrogen as fibrin does, and very little less than gelatin and albumen; while, by my analyses, wool and silk contain less hydrogen than cotton and flax. See *Phil. Trans.* for 1822.

I subjoin the results of my analytical experiments on the four principal subjects of dyeing.

	Carbon.	Hydrogen.	Oxygen.	Azote.
Wool	53·70	2·80	31·20	12·30
Silk	50·69	3·94	34·04	11·33
Cotton	42·11	5·06	52·83	
Flax	42·81	5·50	51·70	

The first two, independently of the azote, possess a marked difference of composition, from their excess of carbon and deficiency of oxygen.

85. In consequence of this composition, animal substances, when set on fire, produce a bright flame, which breaks out at the beginning, but is soon stifled by the charcoal which is formed, and which has peculiar properties; their combustion is accompanied with a penetrating odor, owing to the ammoniac and oil which escape unconsumed; they are liable to putrefaction, in which process ammoniac is produced, as well as in their distillation, by a more intimate union of the azote and hydrogen; while vegetable substances, on the contrary, undergo the vinous and acetous fermentation. It is evident, that, as animal substances contain a considerable quantity of principles disposed to assume an elastic form, they have less cohesive force among their particles than vegetables, and a greater disposition to combine with other substances; hence they are more liable to be destroyed by different agents, and are more disposed to combine with coloring particles.

86. The consequence of this action on animal substances is, that they cannot bear lies, and that alkalis should be used with great caution in the processes employed for dyeing them; whereas no danger is to be apprehended from the use of alkalis with substances of the vegetable kind. Nitric and sulphuric acids have also a considerable action on animal substances: the former decomposes them, extricates the azote, separates the fatty matter, and forms carbonic acid or fixed air, and oxalic acid or the acid of sugar with a part of the hydrogen and a part of the charcoal; the latter extricates the inflammable gas, probably azotic gas, and reduces the other principles to the state of carbon. Silk bears some resemblance to vegetable substances, from its being less disposed to combine with coloring particles, and by resisting the action of alkalis and acids more powerfully; which may arise either from the same principles being more intimately combined in it than in wool, or, more probably, from its containing less azote and hydrogen. But, though the action of alkalis and acids upon silk be weaker than upon wool, they should still be employed with great caution, because the brightness of color required in silk appears to depend upon the smoothness of its surface, which should, on that account, be preserved unimpaired, with every possible attention. Cotton withstands the action of acids much better than flax or hemp. Even the nitric acid does not destroy it without great difficulty.

Of Wool.

87. The value of wool, and its fitness for the different kinds of manufacture, depend upon the length and fineness of its filaments. Wool is naturally covered with a kind of grease, which preserves it from moths; so that it is not scoured until it is about to be dyed, or formed into yarn. To scour wool, it is generally put for about a quarter of an hour into a kettle, containing a sufficient quantity of water, mixed with one-fourth of putrid urine, heated to such a degree as the hand can just bear, and it must be stirred from time to time with sticks. It is then taken

out, put to drain, and carried in a large basket to a running water, where it is moved about until the grease is entirely separated, and no longer renders the water turbid; it is afterwards taken out, and left to drain. It sometimes loses in this operation more than a fifth of its weight. This operation should be conducted with much care, since the more correctly it is performed, the better is the wool fitted to receive the dye. In this process the ammonia or volatile alkali which exists in the urine, readily combines with the oil of the wool, and forms a soap, which, being soluble in water, is dissolved and carried off.

88. Wool is dyed in the fleece before it is spun, when it is intended to form cloths of mixed colors; it is dyed after being spun, when intended principally for tapestry: but it is most generally dyed after having been manufactured into cloth. If wool be dyed in the fleece, its filaments, from being separate, absorb a larger quantity of the coloring particles than when it is spun; for the same reason, woollen yarn takes up more than cloth: but cloths themselves vary considerably in this respect, according to their degree of fineness, or the closeness of their texture. Besides, the variety in their dimensions, the different qualities of the ingredients employed in dyeing, and a difference of circumstances in the process, prevent us from relying upon the precise quantities recommended for the processes. This ought in all dyes to be attended to. It is a fact well known to dyers and others, that the coarse wool from the thighs and tails of some sheep receives the coloring particles with great difficulty. The finest cloth is never fully penetrated with the scarlet dye, hence the interior of the cloth appears always of a lighter shade when cut, and sometimes almost white. For the generality of colors, wool requires to be prepared by a bath, in which it is boiled with saline substances, principally with alum and tartar; but there are some dyes for which the wool does not require such a preparation; then it must be well washed in warm water, and wrung out, or left to drain.

89. The surface of the filaments of wool or hair is not quite smooth; for, although no roughness or inequality can be discovered, yet they seem to be formed of fine laminæ placed over each other in a slanting direction, from the root of the filament towards the point, resembling the arrangement of the scales of a fish, which cover each other from the head of the animal to its tail. This peculiarity of structure is proved by a simple experiment. If a hair be held by the root in one hand, and drawn between the fingers of the other hand, from the root towards the point, hardly any friction is perceived, and no noise is heard; but if it be seized by the point, and passed in the same manner between the fingers from the point towards the root, a resistance is felt, and a tremulous motion is perceptible to the touch, while the ear perceives a slight noise. Thus it appears, that the texture is not the same from the root towards the point, as it is from the point towards the root. This is farther confirmed by another experiment. If a hair be held between the thumb and fore-finger, and they be rubbed against each other in the longitudinal direction of the hair, it acquires a progressive motion towards the root. This effect depends not on the nature of the skin of the finger, or on its texture, for if the hair be turned and the point placed where the root formerly was, the motion is reversed, that is, it will still be towards the root.

90. On this peculiarity of structure, which was observed by M. Monge, depend the processes of felting and fulling of hair and wool for different purposes. In the process of felting, the flocculi of wool are struck with the string of the bow, by which the filaments are detached, and dispersed in the air. These filaments fall back on each other in all directions, and, when a layer of a certain thickness is formed, they are covered with a cloth, on which the workman presses with his hands in all parts. By this pressure the filaments are brought nearer to each other; the points of contact are multiplied; the progressive motion towards the root is produced by the agitation; the filaments entangle each other; and the laminæ of each taking hold of those of the others, which are in an opposite direction, the whole is retained in a state of close contexture.

91. Connected with this operation is that of fulling. The roughness on the surface of the filaments of wool, and their tendency to acquire a progressive motion towards the root, produce great inconvenience in the operations of spinning and weaving. This inconvenience is obviated by covering the filaments with a coat of oil, which fills up the pores, 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 color with which it is to be dyed. For this purpose it is taken to the fulling-mill, where it is 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 in water, is carried off by fresh portions of water, conveyed to it. In this way the stuff is scoured; but this is not the sole object of the operation. By the alternate pressure of the beetles, an effect similar to that of the hands of the workman, in the operation of felting, is produced. The filaments composing a thread of warp or woof, acquire a progressive motion; are entangled with the filaments of the adjoining threads; those of the latter into the next, and so on, till the whole become 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 subjected to ravel; and, when employed to make a garment, requires no hemming. In a common woollen stocking web, after this operation, the stitches are 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 covering.

Of Silk.

92. Silk in its natural state is coated over with a substance which has generally been considered as a kind of gum or varnish. To this

substance the silk is supposed to owe its elasticity and stiffness. Besides this varnish, the silk usually met with in Europe is impregnated with a substance of a yellow color, and, for most of the purposes for which silk is required, it is necessary to free it from both the varnish and the coloring matter. To effect this, the silk is subjected to the operation of scouring; but it is very obvious that when the silk is to be dyed, the scouring need not be carried so far as is required where it is to remain white. Different colors, also, will require different degrees of scouring; and this difference is generally regulated by the quantity of soap employed: 100 pounds of silk boiled in a solution of twenty pounds of soap, for three or four hours, supplying a little water occasionally because of the evaporation, will be sufficiently prepared to receive the common colors. For blue colors the proportion of soap must be greater; and scarlet, cherry color, &c., require a still greater proportion, because for those colors the ground must be whiter.

93. When silk is to be employed white, it must undergo three operations. The first consists in keeping the hanks of silk in a solution of thirty pounds of soap to 100 of silk: this solution ought to be very hot, but not boiling; when any part of the hanks immersed is entirely free from its gum, which is known by the whiteness it acquires, the hanks are to be shaken over, as the dyers term it, so that the part which was not before immersed, may undergo the same process. They are then taken out and wrung, as the process is finished.

94. In the second operation the silk is put into bags of coarse cloth, each bag containing from twenty-five to thirty pounds. A solution of soap is prepared as in the former case, but with a smaller proportion of soap. In this the bags are boiled for an hour and a half; and that they may not receive too much heat by resting on the bottom of the vessel, they must be constantly stirred during the operation.

95. The third operation is to communicate to the silk different shades, that the white may be rendered more pleasing. These shades 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 by agitation. 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 required. In other whites, a blue tinge is given by adding a little blue to the solution of soap. The azure-white is produced by means of indigo. To prepare the azure, fine indigo is well washed in moderately warm water, after which 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.

96. 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 vapor of sulphur. But before the silk which has been thus treated is fit for receiving colors, and retaining them in their full lustre, the sulphur which adheres to it must be separated by immersion and agitation for some time in warm water, otherwise the colors are tarnished and greatly injured.

97. It has long been an object of considerable importance, to deprive silk of its coloring matter, without destroying the gum, on which its stiffness and elasticity depend. A process for this purpose was discovered by Beaumé, but, as it was not made public, others have been led to it by conjecture and experiment. The following account, given by Berthollet, is all that has transpired concerning this process. A mixture is made with a small quantity of muriatic acid and alcohol. The muriatic acid should be in a state of purity, and entirely free from nitric acid, which would give the silk a yellow color. In the mixture thus prepared, the silk is to be immersed.

98. One of the most difficult parts of the process, especially when large quantities are operated upon, is to produce a uniform whiteness. In dyeing the whitened silk, there is also some difficulty in preventing its curling; hence, it is recommended to keep it 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 coloring particles which are combined with it. The alcohol which has been impregnated with the coloring matter may be again separated from it and purified, and may thus serve in future operations, and render the process more economical. This may be effected by distillation with a moderate heat, in glass or stone-ware vessels.

The preparation with alum is a very important preliminary operation in the dyeing of silk. Without this process, few colors would have either beauty or durability. Forty or fifty pounds of alum, dissolved in warm water, are mixed in a vat, with forty or fifty pails of water; and, to prevent the crystallisation 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 after eight or nine hours is wrung out, and washed in a stream of water: 150 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 alum are to be added, and the addition repeated till the liquor acquires an offensive smell. It may then be employed in the preparation of silk intended for darker colors, till its whole strength is dissipated. This preparation of silk with alum must be made in the cold; for when the liquor is employed hot, the lustre is impaired.

Of Cotton.

99. Cotton is the down or wool obtained from the pods of the gossipium, a shrubby plant which

grows in warm climates. Cottons differ principally in the length of their filaments, their fineness, strength, and color. This substance has different shades, from a deep yellow to a white. The most beautiful is not always the whitest; it is necessary to bleach it, by processes similar to those employed in the bleaching of linen. Or, instead of these, oxygenated muriatic acid may be employed; and a more beautiful white thus produced, than by the ordinary way of bleaching. M. Berthollet succeeded in bleaching the yellow cotton of St. Domingo, which very obstinately retains this bad color. But, that cotton may be disposed to receive the dye, it must undergo scouring. Some boil it in sour water, but more frequently alkaline lie is used; the cotton must be boiled in it for two hours, and then wrung out; after which it must be rinsed in a stream of water, till the water comes off clear; it must then be carefully dried. The cotton stuffs, which are to be prepared, must be soaked for some time in water, mixed with at most one-fiftieth of sulphuric acid; after which, they must be carefully washed in a stream of water, and dried. M. Berthollet has observed, that the acid which had been used in this operation, had taken up a quantity of calcareous earth and iron, which would have injured the colors very much. Aluming and galling are generally employed in the dyeing of cotton and linen. In the preparation with alum, about four ounces of it are required to each pound of stuff; it must be dissolved with the precautions abovementioned. Some add a solution of soda in the proportion of one-sixteenth of the alum; others a small quantity of tartar and arsenic. The thread is well impregnated by working it pound by pound in this solution; it is then put altogether into a vessel, and what remains of the liquor is poured upon it. This is left for twenty-four hours, and then removed to a stream of water, where it remains for about two hours, to extract a part of the alum, and is then washed. Cotton, by this operation, gains about one-fortieth of its own weight.

100. In the operation of galling, it is usual to employ different quantities of galls or other astringents, according to their quality, or the effect to be produced. Powdered galls are boiled for about two hours, in a quantity of water proportioned to that of the thread to be galled; the liquor is then allowed to cool to a temperature which the hand can bear, after which it is divided into a number of equal parts, that the thread may be wrought pound by pound; and what remains is poured upon the whole together. It is then left for twenty-four hours, when intended for black, but for other colors twelve or fourteen hours are sufficient. It may then be wrung out, and carefully dried. When stuffs are galled, which have already received a color, the operation is to be performed in the cold, that the color may suffer no injury. M. Berthollet found that cotton which had been alumed, acquired more weight in the galling than that which had not undergone that process; although alum adheres but in a small quantity to cotton, it communicates to it a greater power of combining, both with the astringent principle and with the coloring particles of different substances.

Of Flax.

101. Flax must undergo several preparations before it be fit to receive the dye. Of these, the watering is an operation of much consequence, from its influence on the quality and quantity of the product, and from its deleterious effects on the air. In this operation, a glutinous juice, which holds the green coloring part of the plant in solution, undergoes a greater or less degree of decomposition, according to the mode of conducting the operation. This matter seems to resemble the glutinous part, that is held dissolved in the juice procured from green plants by pressure, which is separated along with the coloring particles by a heat approaching to that of ebullition, which becomes putrid, and which affords ammonia by distillation; but it is probable, that water alone cannot sufficiently separate it from the cortical parts: whence the hemp, which has been watered in too strong a current, is deficient in its softness and pliability, &c. But if the water employed be stagnant and putrid, the hemp acquires a brown color, loses its firmness, and emits highly noxious vapors. This process is therefore performed to the greatest advantage, in watering pits situated on the banks of rivers, where the water may be changed often enough to prevent a putrefaction, that would injure the hemp, and be prejudicial to the workmen; yet not so often as to hinder the degree of putrefaction which is necessary to render the water capable of dissolving the glutinous substance. To prepare flax for the dye, it must also be subjected to the operations of scouring, aluming, and galling, in the same manner as cotton.

PART II.

THE PRACTICE OF DYEING.

102. Before we proceed to give directions for the various processes to be observed in the practice of dyeing, we shall take a brief view of M. Berthollet's observations on dyeing operations in general, which cannot fail to be interesting to the practical dyer.

103. 'It may be regarded,' says he, 'as a general principle, that processes performed in a great manufactory are more advantageous than those which are insulated, since, from the subdivision of labor, each workman, occupied with a single object, acquires celerity and perfection in his employment, by which means the saving of time and labor becomes very considerable.

104. This principle is particularly applicable to the art of dyeing, as the preparation which remains after one operation may often be advantageously employed in another. A bath from which the coloring matter has been nearly extracted in the first operation may be used as a ground for other stuffs, or, with the addition of a fresh portion of ingredients, may form a new bath. The galls which have been applied to the galling of silk may answer a similar purpose for cotton or wool. From this it is evident that the limitations under which the art of dyeing labors

in some countries must tend to obstruct its progress and improvement.

105. A dye-house should be situated as near as possible to a stream of water, and should be spacious and well lighted. It should be floored with lime and plaster; and proper means should be adopted to carry off water or spent baths by forming channels or gutters, so that every operation may be conducted with the greatest attention to cleanliness.

106. The size and position of the boilers are to be regulated by the nature and extent of the operations for which they are designed. Excepting for scarlet and other delicate colors, in which tin is used as a mordant, in which case tin vessels are preferable, the boilers should be of brass or copper. Brass, being less apt than copper to be acted on by means of chemical agents, and to communicate spots to the stuffs, is fitter for the purpose of a dyeing vessel. It is scarcely necessary to say that it is of the greatest consequence that the coppers be well cleaned for every operation; and that vessels of a large size should be furnished at the bottom with a pipe and stop-cock for emptying them; there must also be a contrivance above each copper to support the poles for the purpose of draining the stuffs which are immersed, so that the liquor may fall back into the vessel, and prevent waste.

107. Dyes for silk, where a boiling heat is not necessary, are prepared in troughs or backs, which are long copper or wooden vessels. The colors which are used for silk are extremely delicate. They must therefore be dried quickly, that they may not be long exposed to the action of the air, and 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, which by the dyers is called a shaker. This is hung up in the heated chamber, and kept in constant motion to promote the evaporation.

108. For pieces of stuffs, a winch or reel must be used; the ends of which 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 dyeing are neither difficult nor complicated. Their object is to impregnate the stuff to be dyed with the coloring particles, which are dissolved in the bath. For this purpose, the action of the air is necessary, not only in fixing the coloring particles, but also in rendering them more vivid; while those which have not been fixed in the stuff are to be carefully removed. In dyeing 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 it, and, by turning it 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 by this means the coloring matter will be communicated as equally as possible.

109. In dyeing wool in the fleece, a kind of broad ladder with very close rounds, called by the dyers of this country a scraw, or scray, is used. This is placed over the copper, and the wool is put upon it for the purpose of draining and exposure to the air, or when the liquor is to be changed.

110. To separate the superabundant coloring particles, or those which have not been fixed in the stuff, after being dyed, it must be wrung out. This operation is performed with a cylindrical piece of wood, one end of which is fixed in the wall, or in a post. This operation is often repeated a number of times successively, for the purpose of drying the stuffs more rapidly, and communicating a brighter lustre. When, after a certain quantity of fresh ingredients is added to a liquor, and it is stirred about, it is said to be raked, because it is mixed with the rake. In dyeing, one color is frequently communicated to stuffs, with the intention of applying another upon it, and thus a compound color is produced. The first of these operations is called giving a ground. When it is found necessary to pass stuffs several times through the same liquor, each particular operation is called a dip. A color is said to be rosed, when a red color, having a yellow tinge, is changed to a shade inclining to a crimson or ruby color; and the conversion of a yellow red to a more complete red, is called heightening the color.

111. In addition to these general remarks, we might give more minute details of the different operations which are employed in dyeing; but, as we cannot presume that they would be of much advantage to the practical dyer, we shall not indulge in useless description. Although the manipulations of dyeing are not very various, and appear extremely simple, 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 color, 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.

112. We shall here make a few observations on the qualities and effects of different kinds of water, which may be considered as one of the most essential agents in the art of dyeing. It is almost unnecessary to remark that water which is muddy, or contains putrid substances, should not be employed; and, indeed, no kind of water which possesses qualities distinguished by the taste, ought to be used. Water which holds in solution earthy salts, has a very considerable action on coloring matters, and it is chiefly by means of these salts. Such, for instance, are the nitrates of lime and magnesia, muriate of lime and magnesia, sulphate of lime, and carbonate of lime and of magnesia.

113. These salts, which have earthy bases, oppose the solution of the coloring particles, and by entering into combination with many of them cause a precipitation, by which means the color is at one time deeper, and at other times duller than would otherwise be the case. Waters impregnated with the carbonates of lime and magnesia, yield a precipitate when they are boiled; for the exeess of carbonic acid which held them in solution is driven off by the heat; the earths are thus precipitated, and adhering to the stuffs

to be dyed, render them foul, and prevent the coloring matter from combining with them.

114. It is of much consequence to be able to distinguish the different kinds of water which come under the denomination of hard-water, that they may be avoided in the essential operations of dyeing; but to detect different principles contained in such waters, and to ascertain their quantity with precision, require great skill, and very delicate management of chemical operations, which the experienced chemist only can be supposed to possess.

115. One of these tests is the soap solution, by which it may be discovered whether water contain so large a portion of any of these saline matters as may be injurious to the processes. Salts which have earthy bases have the property of decomposing soap by the action of double affinity. The acid of the salt combines with the alkali of the soap, and remains in solution, while the earth of the salt and the oil of the soap enter into combination, and form an earthy product which is insoluble in water, and produces the curdling appearance which is the consequence of this new combination. Water, then, which is limpid, which has no perceptible taste or smell, and has the property of dissolving soap without decomposition, is sufficiently pure for the processes of dyeing. All waters which possess these qualities will be found equally proper for these purposes.

116. But, as it is not always in the power of the dyer to choose pure water, means of correcting the water which would be injurious, and particularly for the dyeing of delicate colors, have been proposed. Water in which bran has been allowed to become sour, is most commonly employed for this purpose. This is known by the name of sours, or sour water. The method of preparing sour water is this: Twenty four bushels of bran are put into a vessel that will contain about ten hogsheads. A large boiler is filled with water, and when it is just ready to boil, it is poured into the vessel. Soon after the acid fermentation commences, and in about twenty hours the liquor is fit for use. Water which is impregnated with earthy salts, after being treated in this way, forms no precipitate when boiled.

117. Mucilaginous plants are sometimes boiled in the water for the purpose of correcting it, when a froth forms that is to be carefully skimmed off as it rises. The mucilage coagulates, carrying with it the earths which separate on the volatilisation of the carbonic acid, as well as those that are merely mixed with the water and which render it turbid.

The salts, however, which have an earthy base, and which are in general injurious to dyeing, do, in certain cases, serve to modify the colors when the object of the dyer is to obtain deep shades. In this way, for example, a crimson hue is given to the color produced by cochineal.

Of Dyeing Black.

118. We now proceed to give an account of the most useful and advantageous processes for dying different colors, and begin with the method of dying black.

It has been justly observed, by an able writer on this subject, that absolute black being a complete privation of all color, can scarcely be ascribed to any body in nature, since it must then become invisible. The color so named, as communicated by dye-stuffs, is, indeed, rather an intense blue or brown, and is generally produced by the union of these coloring matters with a ferruginous mordant, and hence it may not improperly be termed a compound color. The juice of the cashew nut communicates a black that will not wash out, and which resists boiling with soap or alkalis. The anacardium occidentale and the toxicodendron afford a durable dye, but it is of a brownish hue. The juice of the sloe affords a pale tint of a brownish cast, which becomes deeper after having been repeatedly washed with soap, and afterwards wetted with a solution of alkali. On boiling sloes, their juice becomes red, and the red tinge, which in that state it imparts to linen, is converted by washing with soap into a bluish color of some durability. But these methods of obtaining a black color cannot be employed in dyeing, because these substances are not to be obtained in sufficient quantity, and the black which they afford is not equal to that formed by the common processes. All black colors, therefore, are the effects of combination. To produce them, the black particles formed by the union of the astringent principle with the oxide of iron, held in solution by an acid, are fixed on the stuff that is intended to be dyed.

119. There are very few substances which have the property of producing of themselves a permanent black color. The juice of some plants is found to produce this effect on cotton and linen.

120. When the particles are precipitated from the mixture of an astringent and a solution of iron, they have only a blue color; if they be then left exposed to the air, and moistened with water, their color becomes deeper, but still the blue is distinguishable. The stuff itself then contributes to increase the intensity of the black, whether it be that in this state of combination it undergoes a slight combustion, or that the coloring particles undergo a further degree of combustion, from presenting a larger surface to the air. Without the action of the air, however, a fine black cannot be produced; on which account the operations are performed at different intervals, during which the stuff is taken out of the bath, that it may be exposed to the air. M. Berthollet has ascertained, that black stuffs placed in contact with pure air diminish its volume, and consequently absorb a certain portion of it.

121. *Of Dyeing Woollen Black.*—From the process described by Hellot, woollen cloth, to be dyed black ought to receive the deepest blue tint, or mazarine blue, to be washed in the river as soon as taken out of the vat, and afterwards cleansed by the fulling mill.

For every hundred pounds of stuff, ten pounds of logwood, and ten pounds of galls reduced to powder, are put into a bag, and boiled with a sufficient quantity of water, for twelve hours. A third of this liquor is put into another copper, with two pounds of verdigris. The stuff is immersed in this, and continually stirred for two hours. The liquor should be kept hot, but it ought not to boil. At the end of two hours the stuff is taken out, and a similar portion of the liquor is put into the copper, with eight pounds of sulphate of iron. During the solution of the copperas, the fire is diminished, and the liquor is allowed to cool for half an hour, stirring it well the whole time. The remainder is then to be added, and, after making this addition, the bag containing the astringent matters should be strongly pressed, to separate the whole. A quantity of sumach, from fifteen to twenty pounds, is now to be added, and the liquor is just raised to the boiling temperature; and when it has given one boil, it is to be immediately stopped with a little cold water. A fresh quantity of sulphate of iron, to the amount of two pounds, is then added, and the stuff is kept in it for another hour, after which it is taken out, washed and aired; it is again put into the copper, and constantly stirred for an hour. It is then carried to the river, well washed, and fulled. To soften the black color, and make it more firm, another liquor is prepared with weld. This is made to boil for a moment, and when it is cooled the stuff is passed through it. By this process, which is indeed somewhat complicated, a beautiful black color is produced.

122. But the methods usually followed for dyeing black, are more simple. Cloth, which has been previously dyed blue, is merely boiled in a vat of galls for two hours. It is then kept two hours, but without boiling, in the vat of logwood and sulphate of iron, and afterwards washed and fulled. According to Hellot's process, a liquor is to be prepared of a pound and a half of yellow wood, five pounds of logwood, and ten pounds of sumach, for every fifteen yards of deep blue cloth; and, the cloth having boiled in this 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 and aired, after which it is again returned to the vat for an hour, and then washed and fulled.

When stuffs are to be dyed at less expense, instead of the blue ground, a brown or root-colored ground may be substituted. This brown or fawn color is communicated by means of the root of the walnut-tree, or green walnut-peels. The stuffs are then to be dyed black, according to some of the methods already described.

123. The proportions of the ingredients employed by the English dyers are, for every hundred pounds of cloth previously dyed a deep blue, about five pounds of sulphate of iron, five pounds of galls, and thirty of logwood. The first step in the process is to gall the cloth, after which it is passed through the decoction of logwood, to which the sulphate of iron has been added.

124. As a substitute for galls, the leaves of the arbutus, uva ursi, have been recommended, and employed. The leaves must be carefully dried, so that the green color may be preserved: 100 pounds of wool are boiled with sixteen pounds of sulphate of iron, and eight of tartar, for two hours; the following day the cloth is to be rinsed as after aluming; 150 pounds of the leaves 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, it is said, that blue cloth receives a tolerably good black, but white cloth becomes only of a deep brown.

125. After the operations for dyeing the cloth have been finished, it is washed in a river, and fulled, till the water runs off colorless. Soap suds are recommended by some in fulling fine cloths, but it is rather difficult to free the cloth entirely from the soap. After the cloth has come from the fulling mill, some propose to give it a dip in a bath of weld, by which it is said to be softened, and the color better fixed; but, according to Lewis, this operation, which in other cases is of advantage, is useless after the cloth has been treated with the soap suds.

126. *Of Dyeing Silk Black.*—In communicating a black color to silk, different operations are necessary, such as boiling, galling, repairing the vat, dyeing, and softening. To give a deeper shade to silk, it is necessary to deprive it of the gummy substance of which we have already spoken. This is done by boiling it four or five hours with one-fifth of its weight of white soap, and afterwards beetling and carefully washing it. The gummy substance, before mentioned, which silk in its natural state contains, does not increase the strength of the silk, which is then called raw; but renders it more liable to wear out, from the stiffness it imparts to it: and though raw silk takes a black color with more facility, than silk which has been scoured or divested of its gum, that black is much less perfect, and resists the re-actives calculated to dissolve the coloring matter, in a much less forcible manner.

127. In the process of galling silk, three-fourths of its weight of galls are to be boiled for three or four hours, but the proportion must depend on their quality. 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, or tan, from which it receives a considerable increase of weight, it is allowed to remain for a longer or shorter time, as the silk is required to have more or less additional weight. Hence to communicate to silk, what is called a heavy black, it is allowed to remain longer in the gall-liquor; the process is repeated oftener, and the silk is dipped in the dye a greater number of times

128. While silk is preparing for the process of dyeing, the vat is to be heated, and should be occasionally stirred, that the grounds which fall to the bottom may not acquire too much heat. It should always be kept 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 liquor 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 vat, is now immersed in it. Each part is then to be three times wrung, and, after each wringing, hung up to air. The silk, being thus exposed to the action of the air, 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 is finished, the silk is rinsed in a vessel with some cold water, by turning or shaking it over.

129. Silk, after it has been taken out of the dye, is extremely harsh, to remove which it is subjected to the operation of softening. A solution of four or five pounds of soap for every 100 pounds of silk, is poured through a cloth into a vessel of water. The solution being completed, the silk is immersed, and allowed to remain in it for about fifteen minutes; it is then to be wrung out and dried.

130. When raw silk is to be dyed, that which has a natural yellow color is preferred. The galling operation must be performed in the cold, if it be desired to preserve the whole of the gum, and the elasticity which it gives to the silk; but if part only of it is wished to be preserved, the galling is to be performed in the warm vat.

131. The dyeing is also performed in the cold. 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. It is then washed, beetled once or twice, and dried without wringing, that its elasticity may not be destroyed. Raw silk may 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 stuff, the operation may be completed. It is then to be washed and dried as before.

132. The method of dyeing velvet at Genoa, which has been simplified and improved in France, is thus described by Macquer. 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, pierced with holes in all directions. This vessel is suspended by means of two rods passed through its handles, in the boiler, but so as not to touch the bottom. The gum is left for an hour to dissolve, but must be stirred occasionally. If after this time the gum has not all left the pierced copper, it is a proof that the liquor is saturated with it; but if, on the contrary, the whole has disappeared, from two to four pounds more may be added. This cullender should remain constantly suspended in the boiler, except when the dyeing is going on, during which time it must be removed. During these operations the boiler must be kept hot, but not allowed to boil. The galling of the silk is performed with one-third of its weight of Aleppo galls. The silk is allowed to remain in the liquor for six hours the first time; then for twelve; and for the rest, *secundum artem*.

133. Dr. Lewis remarks, that though white silk may be dyed a good black, without using either logwood or verdigris, the addition of those two ingredients contributes greatly to improve the color both in silk and in wool. But as the great use of galls in dyeing silk black renders it very expensive, it is of consequence to find some method of diminishing their quantity. M. Anglès proposes the following process:—When the silk has been carefully boiled and washed in the river, it is to be immersed in a strong decoction of green walnut-peels, and left in it till the color of the bath is exhausted. It is then taken out, slightly wrung, dried, and washed in the river. The decoction of walnut-peels is made by boiling a full quarter of an hour, when it is taken from the fire, and suffered to subside before dipping the silk, which has been previously immersed in warm water. A blue ground is next given by means of logwood and verdigris. For every pound of silk, an ounce of verdigris is dissolved in cold water: the silk is left in this solution two hours; it is then dipped in a strong decoction of logwood, wrung out slightly, and dried before it is washed at the river. For light blacks, galling may be altogether omitted; but for a heavy black, half a pound of galls must be employed for every pound of silk intended to be dyed. To prepare the liquor, two pounds of galls and three of sumach are macerated in twenty-five gallons of water over a slow fire, for twelve hours. After straining, three pounds of sulphate of iron, and as much gum arabic are dissolved in it. In this solution the silk is dipped at two different times, leaving it in two hours each time, taking care to air it after the first dipping, and to dry it before giving the second fire, when it is to be again aired and dried: it is then beetled twice at the river; after which a third fire is given it, in the same manner as before, except that it is left in the liquor four or five hours. When drained and dried, it is again beetled twice at the river. The heat during the operation must not exceed 120° of Fahrenheit's thermometer; and before the last two fires, an addition of half a pound of sulphate of iron and as much gum arabic is to be made.

For removing the harshness that silk acquires from the black dye, M. Anglès proposes that a decoction of weld should be preferred to a solution of soap; and observes that if silk be dyed blue with indigo, previous to its being dipped for black, it will take only a mealy black, but that a velvety black will be obtained, if it be prepared with logwood and verdigris; and that green walnut-peels soften the silk.

134. *Of Dyeing Cotton and Linen Black.*—To impart to cotton and linen a deep black dye that will resist the action of soap, is attended with considerable difficulty. Several methods have been proposed as improvements on the old process; the following, practised at Rouen, is thus described by M. d'Apligny. The stuffs are first dyed sky-blue in the usual manner, and are then wrung out and dried. After this they are galled for about twenty-four hours, allowing four ounces

of galls to every pound of stuff; they are then again wrung, and well dried.

The liquor, known among dyers by the name of the black cask, is then poured into a tub, five quarts for every pound of stuff, and in this the stuffs are worked by the hand, in small portions, for about a quarter of an hour, when they are again wrung out and dried. This operation is repeated twice; adding each time a fresh quantity of the black liquor, well scummed. After this it is again aired, wrung out, washed at the river, and dried carefully. For the finishing process, a pound of alder bark for every pound of stuff is boiled for an hour, in a sufficient quantity of water. About half the liquor that was used for the galling, and half as much sumach as alder bark are then added, and the whole boiled together for two hours, and then strained through a sieve. When the liquor is cold, the stuffs are worked through it for some time, occasionally airing them; after which they are suffered to remain immersed in it for twenty-four hours, when they are wrung out and dried.

For softening them, when dry, it is customary to soak and work them in the remains of a weld bath that has been used for other colors, adding to it a little logwood. From this they are taken out and wrung, and instantly put into a tub of warm water, into which has been poured an ounce of olive oil for every pound of stuff. They are then wrung out and dried carefully.

The same author has described another process for imparting to cotton and linen stuffs a fine and durable black. In this process the stuffs are first to be scoured as usual, galled, then alumed, and afterwards dipped in the weld bath. When taken out of this bath, they are to be dyed in a decoction of logwood, to which a quarter of a pound of sulphate of copper has been added for every pound of stuff. After this they must be washed in the river, wrung several times but not too hard; and dyed in a madder bath, in the proportion of half a pound to each pound of stuff. That the black may not be liable to be discharged, the thread must be dipped in a bath of a solution of soap.

135. The following method practised at Manchester is given by Mr. Wilson. A galling is made with galls or sumach; after which the stuff is dyed with the liquor of the bath, consisting of a solution of iron in vegetable acid, frequently composed of alder bark and iron, and then dipped in a decoction of logwood with a little verdigris. This process is repeated till a deep black is obtained; and it is necessary to wash and dry after each of these different operations.

136. Dr. Bancroft, says Berthollet, had announced that the acid of tar was employed at Manchester for black dyes on cotton. Chaptal, in his dyes, used pyrolignous acid; but to Bosc we owe the details of the operation by which he himself obtained a fine black by means of that acid.

137. Fill, says he, a cast-iron boiler with pyrolignous acid; add to it old iron, well oxidised, and boil. The solution of the oxide will take place rapidly. When the iron grows clean, and the solution becomes black as ink, throw the whole into a cask to be employed at need. Prepare your cotton as usual, by giving it a blue ground. Gall; turn the hanks of cotton through a bath of a solution of pyrolignite of iron, diluted with tepid water.

Renew the gallings, and the turnings through the bath of pyrolignite of iron, till you have obtained a deep and brilliant black. Finish by passing your cotton through olive oil. This operation is simple. Throw on some tepid water a little olive oil; pass the cotton through this bath; it absorbs the oil; but it must be worked for a long time in the bath to diffuse the oil equally. This process softens and gives suppleness to the cotton, as well as a great deal of brilliancy. Dry in the shade. The cottons are now of a perfect and very durable black. Every time that the bath of pyrolignite of iron has been employed, it must be thrown away as useless, and the old baths are never to be added to the cask.

Bosc intimates, that the stuffs dyed by means of pyrolignous acid, retain, with much tenacity, the odor of this acid, and that they must be exposed to the air for some time to rid them of it, before folding them up for packing.

The application of oil, which heightens the black, and imparts softness to the stuffs, is given to those which are woven, for example, to cotton velvet, by means of brushes, which are slightly imbued with it at their surface.

Hermstadt recommends a process of Vogler, which consists in making use for a mordant of a solution of nitrate of lead, in turning the stuff through a solution of glue, and in dyeing it in a bath composed of gall-nuts, logwood, and sulphate of iron, for which last the acetate may be substituted.

Of Dyeing Gray.

138. Gray colors are properly the shades of black from the deepest to the lightest. They may be produced in several ways; the two following are the most approved methods.

In the first method a decoction of bruised galls, and a solution of sulphate of iron are used. These ingredients must be prepared separately; and then a part of it added to a quantity of water of a sufficient degree of heat, such as the hand can bear; and in this the cloth or wool is to be dipped.

When it has attained the shade desired, it is taken out, and more of the decoction and solution must be added to the same bath. Into this the cloth is dipped, to give it a deeper shade. In the same manner the operator proceeds to the deepest shades, always adding some of each of the liquors: though, for black-gray and other deep shades, it is best to give the cloth previously a blue ground, more or less deep according to circumstances.

139. The second process for dyeing gray, and which is, by Hellot and others, preferred to the preceding, in consequence of the stuff taking the decoction of galls more firmly, is this. Such a quantity of powdered galls as may be thought requisite is enclosed in a linen bag and boiled in water for two hours. In this decoction the stuffs must be boiled for an hour and then taken out. Some solution of iron is then added to the

liquor, and the stuff passed through it, so as to produce a light shade; more solution of iron is then to be added to produce a deeper shade, and so on till the stuff acquire the requisite color.

If in this operation we go beyond the mark, the color must be darkened as before; but repeating these operations is prejudicial to the stuff, so that we should endeavour to catch the proper shade at once, by taking it occasionally out of the bath. Care must be taken that the bath do not boil, and that it be rather warm than too hot.

In whatever manner grays are dyed, they should be immediately washed in a large body of water, and the darkest may even require soap to cleanse them. It is sometimes required to give grays a tint of another color, as a nut, agate, or reddish cast. In this case, having given a tint more or less blue according to the object intended, the stuffs are dipped in the remains of some cochineal liquor, that has served for dyeing either scarlet or violet, adding galls, logwood, madder, &c.; they are then browned more or less deep with a solution of iron. For the nut gray, yellow wood and logwood are added to the galls, and the stuff is to be dyed from white.

140. *Silk* takes all grays, except black-gray, without previous aluming. The bath is composed of fustic, logwood, archil, and sulphate of iron. These ingredients are varied according to the tint to be given. Thus more archil is employed for grays that are to have a reddish cast, more fustic for those that should incline to a russet or green, and more logwood for those that are to be of a darker gray. For iron-gray logwood and solution of iron are only employed. But black-gray requires aluming; after which the silk is taken to the river, and then dipped in the weld bath. A part of this bath is thrown away, and its place supplied with logwood liquor. When the silk is impregnated with this, a sufficient quantity of solution of iron is added, and, as soon as it has acquired the proper shade, it is to be washed and wrung carefully. If the gray should happen to be too dark, the silk is dipped in a solution of tartar, and afterwards in warm water; and, if by these means the color be weakened too much, the silk is again dipped in a bath of dye that is quite fresh.

141. *Linen* and *Cotton* should have a blue ground imparted to them for black-gray, iron-gray, and slate-gray, but for no other. All the shades require a galling proportionate to the gray to be produced. Gall baths that have before served for other purposes are often employed. When the stuff has been galled, wrung, and dried, it is dipped in a vessel of cold water, to which is added a proper quantity of the bath from the black cask, and of a decoction of logwood. The stuff is worked in separate portions, and afterwards washed and dried properly. Two other processes for dyeing gray are given by M. Pileur d'Apligny, which, according to him, produce a more permanent color. They are these. 1. The yarn is galled, dipped in a very weak bath of the black cask, and then maddered: 2. The yarn is dipped in a very hot solution of tartar, wrung gently and dried. It is then dyed in a decoction of logwood. After this operation it appears black; but, on working it attentively in warm soap suds, the surplus of the dye is discharged, and it remains of a durable slate-gray.

142. A process, says M. Berthollet, the success of which is known to us, consists in taking a very diluted solution of acetate of iron (it is sufficient to add a little of this acetate to a quantity of water), and a decoction of sumach, also very dilute. The cotton is passed in succession from one liquor to the other, till the wished for shade be attained. The finish is given by passing through a water slightly acidulated by sulphuric acid, otherwise the sumach gives a russet hue. By the same process may be obtained with nut-galls less lively grays; and the alder bark affords an agreeable one, which borders on hazel.

A skilful manufacturer of Rouen has communicated to us the following process, which he makes use of successfully for cotton velvets. A galling is given with an equal quantity of gall-nuts and logwood, after which a bath of cold water is administered, and next another bath of water, in which there has been dissolved a weight of sulphate of iron, equal to the one-half of the preceding ingredients. After working the cotton about a quarter of an hour in this bath, it is rinsed in cold water, and brightened.

For this purpose a bath of tepid water is used, to which one-eightieth of decoction of weld, and a little alum, are added. The cotton is left about twenty minutes in this bath, after which it is washed in cold water, and dried.

By modifying the doses of the ingredients, grays, from pearl-gray to the deepest gray, may be thereby obtained.

For grays on printed goods, the same mordant is impressed as for a clear violet, and sumach or gall-nuts are employed according to the shade that is desired.

Of Dyeing Blue.

143. *Of Dyeing Wool Blue.*—There are various processes employed for dyeing wool, silk, &c., of blue color, but the principal coloring matters made use of are indigo and woad. Archil, cochineal, turmeric, and logwood, are occasionally used as auxiliaries. Prussian blue also has, in some cases, been successfully employed in producing some very beautiful but fugitive shades of blue.

The vessels in which blue is dyed are called vats; they were formerly made of wood; in many instances they are still constructed of that material; lead, however, has been found superior, and in modern practice, cast iron is generally used. When the vat is made of wood, the liquor must be raised to the requisite heat in another vessel, and then transferred to it, a process attended with many inconveniences; when made of lead it is surrounded with brick work, of a single brick in thickness, which admits of a fire being placed under it for the purpose of warming the liquor.

144. Some dyers make use of iron vats which are warmed by steam, applied to the exterior of the vat; but the more common method is to use a vessel of cast iron, and to apply a gentle fire under it as occasion may require.

Before the introduction of indigo, blue was dyed with woad, this produced a color which was tolerably permanent, but rather faint; a very rich blue however is now obtained by the union of the two substances. The proportions in which these are used, vary according to the depth of shade required. The following is the process of preparing a vat as given by Quatremere.

145. Into a vat of about seven feet and a half deep, and five and a half in diameter, are thrown two bales of pastel or woad, previously broken, and together about 400 pounds weight; thirty pounds of weld are boiled in a copper for three hours, in a sufficient quantity of water, to fill the vat. To this decoction are added twenty pounds of madder and a basket of bran. The boiling is then 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.

146. The vat is then covered, and allowed to stand for six hours, when it is uncovered, and raked again for half an hour. The same operation must be repeated every three hours. When the appearance of blue streaks is perceived on the surface, eight or nine pounds of quick lime are added; the color then becomes of a deeper blue, and the vat exhales more pungent vapors. Immediately after the lime, or along with it, the indigo, which has been previously ground in a mill, with a small quantity of water, is put into the vat. The quantity is to be regulated by the intensity of the shade required. If, on striking the vat with a rake, a fine blue scum arises, no other 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.

147. Vats of this description are sometimes liable to accidents. A vat is said to be repelled, when, having previously afforded fine shades of blue, it appears black, without any blue streaks; and if on being stirred the black color becomes deeper, the vat at the same time exhales a pungent odor; and the stuff dyed in it comes out of a dirty gray color. These effects are ascribed to an excess of lime.

148. Different means are employed to recover a repelled vat. Some merely reheat it; while others add tartar, bran, urine, or madder. Hellot recommends bran and madder as the best remedy. If the excess of lime be not very great, it is sufficient to leave it 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 with the rake.

149. When it begins to afford a tolerable pattern, the bath must be reheated. In general this revives the fermentation; or it may be excited with bran and madder, and even with a basket or two of fresh pastel.

Hecquet d'Orval and Ribacourt advise to rest satisfied without raking up, if the bath be but slightly thrown back; but if the evil has made more progress, to put into it some pounds of bran enclosed in a bag, and to diffuse through it at the same time three or four pounds of tartar in powder. The bag, after five or six hours, begins to float and is withdrawn, and the rake is used. If the vat be not yet restored, the same operation is repeated.

Quatremere says, that he has re-established a vat which he had thrown back by a surcharge of lime; and that for this effect he contented himself with heating twice, and leaving it then in repose for two days, after which it afforded a well characterised flower or bloom. He left it again in repose for three days; and lastly, heating it for the third time, he found it to be restored.

150. The second accident, to which the pastel vat is subject, is putrefaction. When this accident occurs, the veins and the bloom disappear, its color becomes russet, the paste which is at the bottom rises up, the smell becomes fetid.

Quatremere asserts, that, if a pattern of a dark blue be plunged into a vat thus deteriorated, its color becomes several shades lighter. Putrefaction takes place in a vat, because it has not been sufficiently furnished with lime. Whenever the marks of putrefaction appear, we must hasten to correct it, by adding lime and raking up. This operation must be repeated till the vat be restored; but great care is required to avoid the opposite extreme.

It appears, adds M. Berthollet, that a just distribution of lime is the object which demands most attention in the conduct of a pastel vat. It moderates the fermentation of the pastel, and of the other substances that serve to disoxygenate the indigo; for this effect, pushed too far, destroys the coloring particles. But too strong an action of the lime becomes too great an obstacle. It is therefore proper to wait till the excess of lime disappears, undoubtedly by the successive formation of carbonic acid, or the source of the fermentation must be increased, or a portion of the lime be saturated by a vegetable acid. Another use of the lime is to hold in solution the coloring particles of indigo and of the pastel, which are disoxygenated. Woad is employed as well as pastel, but it appears that the preliminary preparation, to which both are subjected, is not essential. We have seen a skilful dyer of Rouen employ for his vat the plant of woad simply dried; and assert that he derived more advantage from it than from ordinary woad.

151. The vat must be raked about two hours before dyeing, and to prevent the sediment, called paste, from occasioning inequalities in the color, a kind of lattice formed of large cords, termed a cross, is introduced; and when wool is to be dyed in the fleece, a net with small meshes is placed over this.

The wool or cloth being thoroughly wetted with clear water, a little warm is pressed out, and dipped into the vat, where it is moved about a longer or shorter time, according as the color is required to be more or less deep, taking it out occasionally to air. The action of the air is necessary to change the green color given by the bath to a blue. In a rich bath it is difficult to give a uniform color to light blues: the best method of obtaining such shades, therefore, is to use vats nearly exhausted, and of a low temperature. Wool and cloth dyed blue, should be washed with great care, to carry off the particles not fixed in the wool, and those which are of a somewhat deep blue, ought even to be carefully cleansed, by fulling with soap, which does not alter the color. Those designed to be dyed black, ought to be treated in the same manner; but it is not so necessary for those which are to be green, to be thus prepared.

152. The indigo vat is that which contains neither pastel nor woad. The vessel used for this preparation is a copper, which, being of a conical figure, leaves between it and the brick-work that surrounds it, and on which its brim rests, an empty space sufficient to admit of the action of the fire. Into this copper are poured about forty pails of water, in which have been boiled six pounds of salt of tartar, twelve ounces of madder, and six pounds of bran. This liquor is to be put into the vat, grounds and all: six pounds of indigo ground in water are then to be put in, and after raking it carefully the vat is to be covered. A slow fire is to be kept up round it. Twelve hours after it is filled, it is to be raked a second time; and so on every twelve hours, till it become blue, which it will be in forty-eight hours. If the bath be well managed, it will be of a fine green, covered with copper colored scales, and have a blue scum or flower at the top. It may be observed, that the theory of this vat is the same as that of the foregoing, except that the indigo is here dissolved by alkali instead of lime. When this vat, which is much more easily managed than that of pastel, is in a proper state, it may be used for dyeing in the same manner as that described above.

153. M. Hellot describes two vats in which the indigo is dissolved by urine. Madder is added to it, and in the one vinegar, in the other alum and tartar, of each a weight equal to that of the indigo. The quantity of urine ought to be considerable. The solution of indigo, deprived of its oxygen by the urine and madder in fermentation, is due to the ammonia formed in the urine, either by the action of heat or fermentation. Hellot remarks, that an effervescence takes place on pouring in the solution of alum and tartar, which probably tends to stop the putrefaction. These vats are by no means comparable with those of pastel, or indigo; much less work being despatched by them; so that they are adapted only for small dye-houses.

154. *Of Dyeing Silk Blue.*—Silk is dyed blue with indigo alone, without any proportion of woad. The proportion of indigo mentioned in the preparation of the indigo vat, and sometimes a larger, is employed, with six pounds of bran, and about twelve ounces of madder. According to Macquer, half a pound of madder for each pound of potassa, renders the vat greener, and produces a more fixed color in the silk. When the vat is come to, it should be refreshed with two pounds of potassa, and three or four ounces of madder; and, after being raked, in the course of four hours it is fit for dyeing. The temperature should be so moderated that the hand may be held in it.

155. The silk, after being boiled with soap, in the proportion of thirty pounds of soap to 100 of silk, and well cleaned by repeated beetlings in a stream of water, must be dyed in small portions. When it has been turned once, or oftener, in the bath, it is wrung out and exposed to the air, that the green color may change to a blue. When the change is complete, it is thrown into clear water, and afterwards wrung out. Silk dyed blue 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 employ vats that are nearly exhausted: but it ought to be observed, that the color thus obtained is less beautiful and less permanent than when fresh vats, containing a smaller quantity of indigo, are employed.

156. Some addition is required to be made to the indigo, to give silk a deep blue. A previous preparation is necessary, by giving it another color or ground. For the Turkey blue, which is the deepest, a strong bath of archil is first prepared. Cochineal is also sometimes used, instead of archil, for the ground, to render the color more permanent. A blue is given to silk by means of verdigris and logwood, but possesses little durability. It might be rendered more permanent, by giving it a lighter shade in this bath, then dipping it in a bath of archil, and, lastly, in the indigo vat.

157. When raw silk is to be dyed blue, such as is naturally white should be selected. Being previously soaked in water, it is put into the bath in separate hanks, as already directed for scoured silks; and, as raw silk combines more readily with the coloring matter, the scoured silk, when it can be conveniently done, should be first put into the bath. If archil, or any of the other ingredients, are required to give more intensity to the color, the mode of application is the same as that directed for scoured silk.

There are various other methods of conducting this part of dyeing, described by M. d'Apligny, Quatremere, Bergman, Scheffer, &c., which we omit as not being of material importance to the practical dyer.

158. *Of Dyeing Cotton and Linen Blue.*—In communicating the blue color to these substances, the principal ingredient employed is indigo; but Prussian blue has been found to answer extremely well. According to Le Pileur d'Apligny, says M. Berthollet, the vat for dyeing cotton and linen is capable of holding about 120 gallons. The quantity of indigo employed is usually from six to eight pounds, finely ground, and boiled in a lee drawn off from double its weight of potassa, with a quantity of lime equal in weight to the indigo. During the boiling, which is to be continued till the indigo is thoroughly penetrated with the lee, the solution must be constantly stirred, to prevent the indigo from being injured by adhering to the bottom of the vessel.

159. During this process, another quantity of quick-lime, equal to the indigo, is to be slaked. Twenty quarts of warm water are added, in which

is to be dissolved a quantity of sulphate of iron, equal to twice the weight of the lime. The solution being completed, it is poured into the vat, which is previously half filled with water. To this the solution of indigo is added, with that part of the lie which was not employed in the boiling. The vat must now be filled up nearly to the top. It must be raked twice or thrice every day till it is completely prepared, which is generally the case in forty-eight hours, and sometimes sooner, as it depends on the temperature of the atmosphere. A small proportion of bran, madder, and woad, is recommended by some to be added to this vat.

160. The process which is followed at Rouen, and described by Quatremere, is more simple. The vats, which are constructed of a kind of flint, are coated within and without with fine cement, and are arranged in one or more parallel lines. 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 lie, 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, and 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 dyeing.

161. In extensive manufactories, it is necessary to have vats set at different times. In conducting the process of dyeing, the stuffs are first dipped in the most exhausted vat, and then regularly proceeding from the weakest to the strongest, if they have not previously attained the desired shade. The stuffs should remain in the bath only about five or six minutes, for in that time they combine with all the coloring matter they can take up. After they 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.

162. After the stuffs have been dipped three or four times in a vat, it becomes black, and no blue or copper-colored 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. In this way 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.

163. A vat which is still more simple and more easily prepared, has been recommended by Bergman. The proportion of the ingredients which he has directed to be employed is the following:—To three drachms of indigo reduced to powder, three drachms of copperas, and three of lime, add two pints of water. Let it be well raked, and in the course of a few hours it will be in a proper state for dyeing.

164. Haussmann employs a still less proportion of indigo. For about 500 gallons of water he takes thirty-six pounds of quick-lime, slaked in about twenty-five gallons of water, with which the indigo is to be mixed in the proportion of from ten to twenty pounds, well ground. He then dissolves thirty pounds of sulphate of iron in about fifteen gallons of water. The whole is left at rest for fifteen minutes; the vat is then filled, and gently and constantly stirred. When a deeper shade is wanted, and particularly when linen is to be dyed, the proportion of indigo should be greater; but the shade depends very much on the time the stuffs remain in the vat, and the times it has been used. When the vat becomes turbid, the process of dyeing must be interrupted, till it has been again raked, and the supernatant liquor become transparent. If the effects of the lime fail, a new quantity must be added; and, if the iron cease to produce the effect on the indigo, a new portion must be also added, observing to have a greater quantity of lime than is necessary to saturate the sulphuric acid.

165. When the indigo appears to be exhausted, fresh portions are to be added; the vat is to be raked several times, and allowed to settle, after which it is again fit for use. In this way Mr. Haussmann says he preserved a vat for two years; and had it not been for the accumulation of sediment, which prevented the stuffs from being immersed to a sufficient depth, it might have been continued in use for a much longer time. It is proper to add, that Mr. Haussmann found, that a pattern of cloth dipped in water acidulated with sulphuric acid, immediately after it was taken out of the bath, became of a much deeper blue than a similar pattern exposed to the air, or another dipped in river water.

166. A remarkably fine blue is produced from a solution of indigo in sulphuric acid, to which the name of Saxon blue is given, from the circumstance of its having been discovered at Grossenhayn in Saxony, by counsellor Barthi, about the year 1740.

167. The following, according to Berthollet, is the process of preparing this dye by Bergman. He employed one part of indigo to eight parts of acid, keeping the mixture in a temperature of between 86° and 104° of Fahrenheit, and he reckoned that one part of indigo, thus dissolved, was sufficient to give a deep blue color to 260 times its weight of wool. Poerner used one part of indigo to four of sulphuric acid. To prepare the wool or cloth for this bath, it is first boiled with alum and tartar. The wool receives the finest as well as fullest color during the first immersion; but lighter, though duller shades, may be given to other portions by the same bath when partially exhausted. The deeper shades are most advantageously given by adding the solution of indigo to the bath, in successive portions, and raising the stuffs on the winch previously to each addition.

Of Dyeing Red.

168. Red colors are known by different names, according to their degrees of intensity, as crimson, scarlet, &c., besides innumerable shades that fall under no particular denomination. The substances usually employed in dyeing red, are cochineal, madder, kermes, lac, carthamus, Brasil-wood, archil, and logwood. All these, with

other substances which give a red color, are denominated by Dr. Bancroft *adjective* colors, from their requiring the aid of mordants to give them permanence.

169. *Of Dyeing Wool Red.*—When woollen stuffs are to be dyed, they are first boiled for two or three hours with alum and tartar: they are then left to drain, slightly wrung out, put into a linen bag, and carried into a cool place, where they must remain for some days. The quantities and proportions of the alum and tartar are varied according to the object of the dyer, and the shade of color which is wanted. Some recommend five ounces of alum, and one ounce of tartar to each pound of wool. By increasing the proportion of tartar to a certain degree, a deep and permanent cinnamon color is produced. This arises from the yellow tinge induced by the acid on the coloring particles of the madder. Others propose to diminish the proportion of tartar, and to use only a seventh part. In conducting the process of dyeing with madder, the bath should not be brought to a boiling heat, because, at that temperature, the fawn-colored particles would be dissolved, and a different shade obtained from that which is desired. When the water is at such a temperature as the hand can bear, Hellot recommends the addition of half a pound of grape madder for every pound of wool to be dyed. It must then be well stirred before the wool is introduced, which must remain for an hour without boiling, excepting for a few minutes towards the end of the process, that the combination of the coloring particles with the stuff may be more certain.

170. Madder reds are sometimes rosed, as it is called, with archil and Brasil wood. In this way they become more beautiful and velvety, but this brightness is not permanent. But madder reds, even when at best, are far inferior to those obtained from lac and cochineal, and even to that produced by kermes; but, as the expense of the materials is comparatively small, they are employed for coarse stuffs.

171. Different authors recommend different proportions of madder. Poerner proposes to employ one-third of the weight of the wool, while Scheffer limits the quantity to one-fourth. Poerner 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 obtained a fine red. On another occasion 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 says that he obtained an orange red by boiling wool with a solution of tin, and one-fourth of alum, and then dyeing with one-fourth of madder. A cherry color, says Bergman, is obtained by using one part of a solution of tin, and two of madder, without previously boiling the wool. By exposure to the air, this color 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 boiling it again for an hour, the result is a coffee color. 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 color is a brown approaching to red.

172. When sulphate of copper is employed as the mordant, the madder dye yields a clear brown, inclining to yellow; and a similar color may be produced by dyeing 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 somewhat more obscure, inclining to green; and in both these instances, exposure to the air does not produce a darker color. Berthollet says that he employed a solution of tin in various ways, both in the preparation and the application of the madder; and, by the use of different solutions of tin, he found that, although the tint was a little brighter than what is obtained by the common process, it was always more inclined to yellow or fawn color.

173. *Of Dyeing Silk Red.*—The red color obtained from madder has not been found of sufficient brilliancy for dyeing silks; M. De la Folie, however, has given the following process for employing it for this purpose:—Half a pound of alum is to be dissolved in each quart of hot water, to which two ounces of potassa are to be added; after the effervescence is over, and the liquor has begun to grow clear, the silk must be soaked in it for two hours; it is then to be washed and put into the madder bath. Silk dyed in this way, he says, becomes more beautiful by the application of the soap proof. Another process is described by Mr. Gulichie, of which the following is the substance.—

174. 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 must 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 color thus produced is said to be very permanent; and, if the galls are omitted, its brilliancy is improved.

175. The color obtained when Brasil-wood is used, is denominated *false crimson,* to distinguish it from that produced by cochineal, which is much more durable, and which is styled *grain crimson.* This very beautiful color is obtained by the following process:—The silk, being well cleansed from the soap, is to be immersed in an alum bath of the full strength, and to remain for a night. It is then to be 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 for 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 ingredients 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 appear to be of a uniform color. The fire is then increased, and the bath is kept boiling for two hours, observing to turn the silk occasionally. The fire is afterwards put out, and the silk put into the bath, where it is allowed to remain for a few hours longer. It is then taken out, washed at the river, twice beetled, wrung, and dried.

176. Carthamus, says M. Berthollet, is used for dyeing silk poppy, a bright orange red, cherry, rose color, and flesh color. The process differs according to the greater or less tendency to flame color that is wanted. The following is his account of the preparation of the carthamus bath: The yellow matter of the carthamus having been first extracted, the cakes containing the red coloring matter are broken down and put into a trough of fir-wood, where they are several times sprinkled with finely powdered soda in the proportion of six pounds of soda to every hundred pounds of carthamus. The whole is then put into a small trough lined with closely woven cloth, and having a grated bottom; this small trough is then placed over the larger one, and water is poured on the mixture till the larger trough is full. Fresh water is poured over the carthamus and suffered to run into another trough, and so on successively, adding a little fresh soda till all the red color is extracted. These liquors are then mixed, and lemon-juice is added to give a fine cherry color, which the liquor imparts to the silk that is dipped in it. Poppy-color, given in this way, requires that the silk be immersed in a second bath, and that the colors be brightened by turning the silk several times through a bath of hot water impregnated with lemon-juice. The lighter hues of red are given by the weaker solutions of carthamus, and the lightest shades require the addition of a little soap. In dyeing silk with carthamus the silk, after being scoured, should, for poppy or fire color, receive a ground of annotto. The carthamus bath should be prepared at the time of using, and the process of dyeing should be conducted as speedily as possible.

177. Those who have made the nearest approach towards producing a scarlet on silk, says Berthollet, begin with dyeing the silk crimson. It is then dyed with carthamus, and after that dyed yellow in a cold bath. By this process a fine color is produced, but it is not permanent, as the dye of the carthamus is affected by the action of the air. The following is the process given by Dr. Bancroft in his Philosophy of Permanent Colors. 'In a solution of murio-sulphate of tin, diluted with five times its weight of water, the silk is to be soaked for two hours; and, after being taken out, it is to be wrung and partially dried. It is then to be dyed in a bath prepared with four parts of cochineal, and three of quercitron bark. In this way a color approaching to scarlet is obtained. To give the color more body, the immersion may be repeated both in the solution of tin and in the dyeing bath; and the brightness of the scarlet is increased by means of the addition of carthamus. A lively rose-color is produced by omitting the quercitron bark, and dyeing 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 color.'

178. *Of Dyeing Cotton and Linen Red.*—Madder is employed for dyeing linen and cotton red, and even for giving them several other colors, by means of different mixtures. It is the coloring drug most useful for this kind of dyeing. It is proper therefore to show, in sufficient detail, the different methods by which this dye may be rendered more permanent, beautiful, and diversified in its effects. Linen takes the color of madder with more difficulty than cotton: but the processes which succeed best, with the one, are also preferable for the other.

179. Two species of madder red, on cotton, are distinguished; the one called simply madder red, the other, possessing far more lustre, is called Turkey-red, or Adrianople-red, because it was for a long time obtained from the Levant.

Vogler tried the effect of a great number of the substances employed as mordants, or in the dyeing bath, and he found that those which produced the best effect were glue, ox-gall, and other animal matters, as sheep's dung. Muriate of soda rendered the color faster, but more dull. Galling likewise procured a richer color. Other astringents, sumach and pomegranate rind, for instance, produced a similar effect. A little alkali added to the alum improves it. When the stuff has passed through the different preliminary operations, it must be dyed with the best madder that can be procured, in the proportion of three-quarters of a pound to each pound of stuff.

The temperature of the madder bath must be raised in a gradual manner, that may require about an hour to boil after the stuff has been immersed in it; and, when it has boiled a few minutes, the stuff is taken out, slightly rinsed, and dyed a second time in a second bath, with the same quantity of madder; after the second dyeing, and subsequent rinsing and drying, the stuff is commonly steeped in a solution of white soap, made just milk-warm, in the proportion of two ounces of soap to one pound of stuff. The effect of this process is to remove all the uncombined coloring matter, and, as is supposed, to give a higher degree of brilliancy to what remains. This process is completed by rinsing and drying.

180. Of all the reds produced by the use of madder, the Adrianople or Turke -red is by far

the most beautiful: it possesses a brilliancy which can be communicated to cotton by none of the common processes of dyeing, and has, moreover, the property of more effectually resisting the action of the different re-agents, as alkalis, soap, alum, and acids. For many years the dyeing of this color was confined to the east, and came to us through our Levant trade only. In process of time the art found its way from India to the western parts of Asia, and to Greece; and from Greece to France, whence it was brought to this country by one of the French dyers, M. Papillon, who settled at Glasgow, where, for a considerable time, he carried on with great success the business of dyeing Turkey-red.

181. M. Papillon communicated his process to the commissioners and trustees for manufactures in Scotland, to be by them published at the expiration of a certain term of years. For this he received a handsome premium; and the process was made public in the year 1803.

We need hardly mention the celebrity of the manufactory of Messrs. Monteith and Co. of Glasgow, since it is known to the world at large. The excellency and beauty of their cotton fabrics will not soon be surpassed; the madder-reds which they dye rival, in brilliancy and in solidity, any ever produced at Adrianople; and the white figures, distributed over the cloth by the discharging process, surpass in purity, elegance, and precision of outline, the original Bandana outlines.

182. The art of dyeing Turkey-red has been described by different writers, who vary a little from each other in some particulars, but who agree in the leading features of the process. We prefer inserting here the account of it as given by Dr. Bancroft, as it affords us an opportunity of following it up by the insertion of some of his truly valuable remarks upon the subject in reference to the process observed at Rouen in France.

The process is very tedious, and is divided by the dyers into nine different steps.

Step 1. Cleaning. For 100 pounds of cotton take an equal weight of Alicant barilla, twenty pounds of pearl-ashes, and 100 pounds of quicklime. The barilla must be mixed with soft water in a deep tub, which has a small hole near the bottom of it, 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 passing through it or stopping it up while the lie filters through it.

Under this tub is another to receive the lie; and pure water is repeatedly passed through the first tub to form lies of different strength, which are kept separate at first until their strength is examined. The strongest required for use must swim an egg, and is called the lie of six degrees of the French hydrometer, or peseliqueur. The weaker are afterwards brought to this strength, by passing them through fresh barilla. But a certain quantity of the weak, which is of 2° of the above hydrometer, is reserved for dissolving the oil and gum, and the salt, which are used in subsequent parts of the process. This lie of 2° 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.

Let all the liquors stand till they become quite clear, and then mix ten pails of each.

Boil the cotton in the mixture five hours, then wash it in running water and dry it.

Step 2. Take a sufficient quantity, say ten pails (of four gallons each), of the strong barilla water in a tub, and dissolve or 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, tramp or tread down the cotton into it, until it is well soaked; let it steep twenty-four hours, and 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, after which wring and dry it, and lastly wash it well and dry it.

Step 3. This part of the process is precisely the same with the last, except that the sheep's dung is omitted in the composition of the steep.

Step 4. 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.

As soon as 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.

Then wring it carefully and equally, and dry it well without washing.

Step 5. Dissolve twenty-five pounds of Roman alum in fourteen pails of warm water, without making it boil; skim the liquor well, and add two pails of strong barilla water, and then let it cool until it be lukewarm.

Dip the cotton, and handle it hank by hank, and let it steep twenty-four hours, and wring it equally and dry it well without washing.

Step 6. Is performed in every particular like the last; but after the cotton is dry, you steep it six hours in the river, and wash and dry it.

Step 7. The cotton is dyed by about ten pounds at once, for which take two gallons and a half of ox blood, and 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, and move and turn it constantly one hour, during which you gradually increase the heat, until the liquor begin to boil at the end of the hour. Then sink the cotton, and boil it gently one hour longer; and, lastly, wash it 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 up a dyeing liquor as above, for the next ten pounds of cotton.

Step 8. Mix equal parts of the gray steep liquor, and of the white steep liquor, taking five or six pails of each. Tread down the cotton into this mixture, and let it steep six hours, then wring it moderately and ecually, and dry it without washing.

Step 9. Ten pounds of white soap must be dissolved most carefully and most completely in sixteen or eighteen pails of warm water; 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 your cotton in this liquor, keeping it down with cross sticks, and cover it up and boil it gently two hours, then wash and dry it, and it is finished.

Such is the process of M. Papillon, on which Dr. Bancroft makes the following observations.

Step 1. At Rouen two courses of operations are practised to produce the Turkey-red. One is called the gray course, and the other the yellow course. In the former, the cotton, after being alumed, receives no more oil, but goes to the dyeing vessel, retaining the gray color, which naturally results from its being impregnated with alum and galls in combination. But, in the yellow course, the cotton, after being alumed, is again immersed in the oleaginous mixtures or steeps, by which it acquires a yellow color. The gray course may consist either of fifteen steeps or of nineteen, and the yellow of twenty. The first of these courses has most similitude to that of M. Papillon. At Rouen, the cleansing operation is performed with a very weak lie of soda, of only one degree of the areometer, employing 150 gallons to 100 pounds of cotton, which is to be boiled therein six hours, then drained, well rinsed in running water, and afterwards dried. This operation is intended to free the cotton from all impure or extraneous matter; but not to produce effects like those of bleaching by exposure upon the grass, which, until lately, it was believed, would lessen the durability of the colors to be subsequently dyed.

Step 2. The steep here described contains three ingredients not employed by any other person; and one of these, the sulphuric acid, seems to indicate a want of chemical knowledge in M. Papillon, because, by neutralising the soda, it must obstruct the effect which the latter is intended to produce (that of rendering the oil miscible with water), or at least render a greater proportion of it necessary in order to obtain that effect. In regard to the other two ingredients, viz. the gum and sal ammoniac, the quantity of the former is by much too small to produce any considerable effect, and it is not easy to form any conjecture what purpose the latter is to answer. At Rouen, this steep is prepared by steeping twenty-five or thirty pounds of sheep's dung several days in a lie of soda, marking four degrees, which is to be diluted until it amounts to forty gallons; and the dung being squeezed and broken by the hands, is afterwards made to pass through a copper pan, provided with numerous small holes, into a tub containing twelve pounds and a half of fat oil, and in this the oil and dung are, by sufficient stirring, to be well mixed with the lie and with each other; and, in the mixture, which contains but half the quantity of oil prescribed by M. Papillon, the cotton is to be steeped, &c., as directed by the latter. It is highly important that, after this and each of the succeeding operations, the cotton should be thoroughly and completely dried by a stove heat.

Step 3. At Rouen this steep is prepared by mixing thirty-eight gallons of lie of soda with ten pounds of olive oil, stirring until the mixture becomes uniformly milky; which it will do without any separation of the oil, if the quality of the oil be suited to this use; this they add to what may have been left of the former steep, and, after mixing them properly, they impregnate the cotton by the usual treatment, drying it, after an interval of twelve hours, first in the open air, and afterwards by a stove heat. This steeping and subsequent drying must be repeated once, twice, or three times, according to circumstances.

Between this white steep and the following gall steep, it is the practice at Rouen to employ three salt steeps and one cleansing operation. In the first, twenty-four gallons of the lie of soda, marking two degrees and a half, are mixed in a tub with the remnant of the white steep; and the cotton is impregnated and dried, as in the former operations. In the next the remnant of the last steep is mixed with twenty gallons of the lie of soda, marking three degrees; and the cotton is steeped and dried as before. In the third, the remnant of the preceding steep is mixed with twenty-four gallons of the lie of soda, marking three degrees and a half, and with this the cotton is impregnated and dried as before. The residuum of this steep is preserved to be used in the brightening operation.

In the cleansing operation, the cotton is steeped one hour in lukewarm water, then wrung by hand, and afterwards washed in a stream of water to remove any superfluous oil which might obstruct the equal application and uniform effect of the following gall-steep, and thereby render the color unequal. After being so washed, the cotton is dried first in the open air, and afterwards by a stove-heat.

Step 4. This constitutes the eighth operation in the gray course at Rouen, where, as well as in M. Papillon's process, galls, in sorts, seem now to be employed. At Rouen, the cotton, as soon as it has sufficiently imbibed the soluble matter of the galls, and been very moderately wrung, is spread as expeditiously as possible in the open air, if the weather be dry, or, if not, under cover; but the drying is always finished by a stove heat.

Step 5. At Rouen, thirty or thirty-five pounds of the purest alum are commonly employed for this steep, with only seven pails of hot-water, adding, when the alum has been dissolved, two gallons only of the lie of soda, marking four degrees. But when these proportions are employed, the cotton is not subjected to a second steep with alum. Sometimes, however, at Rouen, two steeps with the aluminous mordants are employed; and in that case twenty pounds of alum are dissolved for the first, and fifteen for the second, leaving an interval of two days between them, during which the cotton should retain its moisture after being slightly wrung from the first steep. It should, however, be well dried before it goes into the second.

Step 6. At Rouen, the cotton is dyed in parcels of twenty-five pounds each, and the dyeing vessel is of a quadrangular form, containing about 100 gallons of liquor. One quart of ox-blood is employed for each pound of cotton, with two pounds of Provence madder, or one pound of this with one of Smyrna madder. Some persons, however, think it best to effect the dyeing by two separate operations, employing half the above proportion of madder for one dyeing, and half for the other; but always taking care not to dry the cotton between the dyeings. There are some at Rouen who give cotton another alum steep between these dyeing operations, employing for that purpose half as much alum as was used for the first steep, and afterwards washing, &c.

Step 8. For this steep they employ at Rouen the residuum of the third salt-steep before mentioned; but the application of it is considered a part of the following step.

Step 9. This constitutes the fourteenth operation in the first set of gray courses at Rouen; where, after having macerated the cotton with the sikiou, they boil it for the space of five or six hours with six or eight pounds of white soap, previously dissolved in 145 gallons of water, in a vessel covered at the top, so as to leave only a very small opening for the necessary escape of the steam, which might otherwise occasion an explosion. The effect of this boiling with soap, is to dissolve and separate from the cotton all the yellowish-brown matter of the madder color which may have been applied to it in the dyeing operation, and thus to change the color from the dull brownish-red which it would otherwise retain, to a bright lively color, nearly equal to that of the finest cochineal scarlet. It is only by the singular degree of fixity which the pure red part of the madder color acquires, in consequence of the operations just described, that this beautiful red can be obtained. Such, indeed, is the stability of the Turkey-red when well dyed, that it is said to sustain boiling with soap for thirty-six hours without injury.

In addition to the steps prescribed by M. Papillon, they employ another at Rouen, which is intended to make the red incline more to the rose color, and at the same time increase its vivacity. For this operation, with the former quantity of 100 pounds of cotton they dissolve, in 145 gallons of water, sixteen or eighteen pounds of white soap, and as soon as the liquor begins to boil, they add to it from one pound and a half to two pounds of the crystallised muriate of tin, previously dissolved in two quarts of water, and mixed with eight ounces of single aqua-fortis; and having equally dispersed this mixture through the boiling solution of soap, by stirring, &c., the cotton is put in and boiled with the same precautions as in the brightening operation, till the desired effect has been obtained, which is to be discovered by frequent examinations. Care must be taken not to employ more nitric acid or aqua-fortis than the quantity here mentioned, lest it should decompose the soap, and cause the oil to separate and rise to the surface of the liquor.

183. We cannot leave this truly important branch of dyeing without noticing the ingenious remarks of Mr. Thomson of Glasgow, published in the eighth volume of the Annals of Philosophy, on the theory of the Turkey-red process.

He observes that silk and worsted have a natural varnish which cotton does not possess. To supply this defect, the repeated immersions, followed by exposure to the atmosphere, and to the heated air of a stove, may give the oil the proper consistency, by the absorption of oxygen, for forming a varnish, with which the coloring matter unites, and through which it may be said to shine, which causes that superior brilliancy which the goods attain when they are cleared, or, as it may be called, polished. I therefore presume, that the fixedness and brilliancy of the color will depend on the quantity of oil imbibed, as every repetition of drying presents new fibres to be varnished with an additional quantity; for I have always found, that the permanency was in proportion to the number of manipulations in the saponaceous liquor, and a proportionable freedom could also be used in reducing or clearing. The white immersions, omitting the sheep's dung, are just applying successive coats of varnish. Clearing is never attempted from the madder copper, without immersing the goods again in soda and oil, and drying them in a stove, which I consider to be also supplying them with an additional coat.

The alkaline lie occasions a greater separation in the particles of the oil, by which it combines more closely with the fabric of the cloth. The sheep's dung in the first immersions may serve as a covering, to keep the goods moist for a considerable time, that they may more fully imbibe the liquor, by preventing the evaporation from being too quick in the great heat to which they are exposed.

After the frequent immersions the cloth feels like leather, no doubt from a superfluity of liquor. It is then steeped in a lie of carbonate of soda, and afterwards well washed and dried, as a preparation for the galling and aluming. The astringent principle has been long known for darkening and fixing common red colors on cotton, by uniting with the earth of alum, and strengthening the basis. To the use of blood in the madder copper I attribute nothing; as in the rancid and putrid state in which I have seen it used, were it not for the prejudice of the operator, it might be safely dispensed with.

In proof of the above idea, that it is only the oil uniting with the earth of alum that is of use, I may refer to the mode of dyeing that color in the east, quoted by Dr. Bancroft, viz. soaking their cotton in oil (no matter of what description), during the night, and exposing it to the sun and air during the day, for seven successive days, rinsing it only in running water, and then immersing it in a decoction of galls and the leaves of sumach previous to aluming.

I would therefore request the practical dyer, who wishes to arrive at a knowledge of this unaccountable process, to give up the idea of animalisation, if by it be meant impregnating the cloth with an animal matter, and by the power of the microscope, or any better method, look for the whole truth from some other source than chemical analysis. I am at present inclined to believe that it is a mechanical operation united to a chemical, and that the frequent immersions in the imperfect soap are equivalent to laying on the first, second, third, &c., coats, preparatory to finishing a fine painting in oil. A very eminent calico manufacturer, whom I consulted on the Turkey-red process, assured me that the only essential mordants are oil and alumina; and that bright and fast reds, equal to any produced by the usual complicated process with sheep's dung, galls, and blood, may be obtained without these articles.

Of Dyeing Scarlet.

184. Scarlet may be regarded as one of the compound colors arising from a mixture of the red and yellow coloring matters. Scarlet is the finest and most splendid of all the colors, and the great demand for it has excited several chemists of distinction to improve and facilitate the process of producing it. We shall here briefly notice the old method of dyeing scarlet, which is still practised by some dyers, both in this country and on the continent, and then give the improved method proposed by Dr. Bancroft in his excellent treatise already mentioned.

185. We cannot, says M. Berthollet, expect to obtain the desired shade from the doses prescribed in the processes, from variations in the quantity of the coloring particles contained in the different kinds of fine cochineal, and particularly from the solutions of tin that are used differing considerably from each other; but the just proportions of the ingredients to be employed may be readily determined by trials in the small way, so as to obtain the shade called for; and, if the pieces which are dyed be above or below this shade, it is not difficult to find the suitable proportions.

186. In the process of dyeing scarlet two operations are observed, viz. the boiling, and the reddening. The first or boiling operation is thus conducted:—For 100 pounds of cloth, a quantity of soft water is heated in a tinned boiler, till it be rather more than lukewarm, after which six pounds of cream-of-tartar are dissolved in it. When the water is a little warmer, half a pound of finely powdered cochineal is added and well mixed with the solution of tartar. Immediately after, five pounds of very clear solution of tin are poured in, and carefully mixed. When the bath begins to boil, the cloth is put in, and rapidly turned two or three times with the winch, then more slowly, and is left to boil for two hours, after which it is taken out, drained, exposed to the air, and washed in the running stream.

187. In preparing for the second bath the boiler must be emptied, filled again with fresh water, and, when this is near the boiling heat, five pounds and three quarters of powdered cochineal are put in and carefully mixed, and when, on ceasing to stir the liquor, a crust forms on the surface, and begins to break, thirteen or fourteen pounds of solution of tin are poured in. Sometimes, after this, the liquor begins to rise above the brim of the boiler, which must be prevented by putting in some cold water. When the solution is well mixed in the bath, the cloth is immersed, taking care to turn the winch rapidly for the first two or three turns. It is then to be boiled for about an hour, pressing it down as often as it rises to the surface. After this it is taken out, exposed to the air to cool, washed in the stream, and dried.

188. On examining the proportions of cochineal and of solution of tin, used either in the boiling, or in the reddening, it appears that they are by no means fixed. There are some dyers, who, according to Hellot's account, succeed very well by putting two-thirds of the composition, and a fourth of the cochineal, into the boiling, and the remaining third of the composition, with the remaining three-fourths of the cochineal, into the reddening. He also asserts that it does no harm to use tartar in the reddening, provided not more of it than half the weight of the cochineal be put in; and he thinks, that it even renders the color more permanent. Some dyers do not take the cloth out of the boiling, but simply refresh it to make the reddening in the same bath, by pouring in an infusion of cochineal, which they have made apart, and with which they have mixed the proper quantity of composition. In this way they save time and fuel: and they affirm that the scarlet is equally fine.

189. Different authors recommend different proportions of the materials used in the boiling process. Scheffer prescribes one part of solution of tin for ten parts by weight of cloth, with an equal quantity of starch and of tartar as of solution. He remarks, that the starch tends to make the color more uniform, and he recommends to throw into the water, when it boils, $\frac{1}{128}$ of cochineal; to agitate well; to let the wool boil in it for an hour, and then to wash it. He prescribes next, the boiling for half an hour in the bath, which serves for the reddening, with $\frac{1}{32}$ of starch, $\frac{1}{24}$ of solution of tin, $\frac{1}{32}$ of tartar, and $\frac{1}{18}$ of cochineal.

It appears, that Scheffer employs a much smaller quantity of solution of tin than Hellot; but what he does employ contains much more tin.

190. Poerner describes three principal processes, according as the shade is to be more or less deep, or more or less of an orange hue, which he wishes to give to the scarlet. He varies the proportions of the solution of tin, of cochineal, and tartar, or omits the last ingredient.

For conducting the process of the scarlet dye in the most beneficial manner, and for varying its results, according to the end in view, the effect of each of the ingredients employed in it must be ascertained. We need not however proceed with a detail of processes which have been superseded by others that are from experience found to be much superior; we shall therefore pass on to notice the important improvements in this branch of dyeing made by Dr. Bancroft, and which have obtained the approbation of the most eminent chemists, British and foreign.

191. Dr. Bancroft was struck with the thought that for a whole century no improvements had

been made in the art of dyeing scarlet. On this object he seems to have fixed his mind, and, about the year 1786, he instituted a set of experiments which were attended with the most gratifying success.

192. Having, by frequent affusions of boiling water, extracted the whole of the coloring matter from powdered cochineal, he found that the addition of a little potash to the sediment, and a fresh quantity of boiling water, extracted a new portion of coloring matter, equal to about one-eighth of what had been given out to the pure water. He repeatedly extracted this coloring matter by means of potassa, and afterwards dyed small pieces of cloth scarlet with it, which he found similar to others dyed with cochineal. It was in the course of these enquiries that he perceived scarlet to be a compound color, consisting of about three-fourths of pure crimson, 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 coloring matter of cochineal from its natural crimson to a yellow color. From this he concluded that there might be a great saving of cochineal, by substituting a cheaper substance, which, at the same time, might yield a better yellow color. It was therefore his object to combine with this crimson or rose color, a suitable portion of a lively golden yellow, capable of being permanently fixed, and reflected by the same basis. This yellow Dr. Bancroft found in quercitron bark; and ascertained that it possessed the advantage of being not only the cheapest, but the brightest of all the yellows he had tried.

193. For the purpose of diminishing the quantity of cochineal employed in producing a scarlet dye, Dr. Bancroft made a number of experiments under the authority of government. In these experiments, the mordant used was the common dyers' spirit, or the nitro-muriate of tin, but he found that they were not attended with the advantages which he expected. In some of his earliest experiments, he remarks, that the solution of tin by means of sulphuric acid destroys the cochineal color, and this led him to reject the use of this acid, 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 dyeing, was not accompanied with the corrosive effects of the muriate and nitro-muriate which he had employed in the experiments, and which proved unsuccessful. 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 upon a quantity of granulated tin in a suitable vessel, and the sulphuric acid is added by degrees. This solution is more quickly effected by means of a sand heat; it is perfectly colorless, and may be kept for years without precipitation. It has double the power of the common dyers' spirit; and is produced at about one-third of the expense. It also raises the colors more than even the tartrate of tin; and does not incline the cochineal crimson to the yellow shade.

194. In using this solution as a mordant, to produce the compound scarlet color, Dr. Bancroft advises the following process. Nothing, says he, is necessary, but to put the cloth, suppose 100 pounds, into a proper tin vessel, nearly filled with water, in which has been mixed eight pounds of the murio-sulphuric solution of tin; and, having brought the mixture to a boiling heat, about 100 pounds of cloth are immersed and turned through it as usual, by the winch, for a quarter of an hour. Then the cloth is removed, and four pounds of cochineal and two pounds and a half of quercitron-bark, both powdered, are introduced and well mixed. After this, the cloth is returned into the bath, the liquor is made to boil, and the cloth is turned as usual for fifteen or twenty minutes, by which time, in general, the color will be properly raised and the bath exhausted, when the cloth is taken out and rinsed in the ordinary way.

By this method the time, labor, and fuel, necessary for filling and heating the boiler a second time are saved, the process finished much sooner than in the common way, and there is 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 dyeing 100 pounds of wool, commonly amount to ten shillings, whereas eight pounds of the murio-sulphuric solution cost only about three shillings. There is, besides, a saving of at least one-fourth of the cochineal usually employed, and the color produced does not prove inferior in any respect to that dyed with much more expense and trouble in the ordinary way.

195. When a rose color is wanted, it may be readily obtained in this way, only omitting the quercitron bark, instead of the complex method of first producing a scarlet, and then changing it to a rose by the volatile alkali contained in stale urine, set free by potash or by lime; and should any one still choose to continue the practice of dyeing scarlet without the quercitron bark, it is only necessary to employ the usual proportions of tartar and cochineal, with a suitable quantity of the murio-sulphate of tin, which, while it is cheaper, is much more effectual than the dyers' spirit.

196. The scarlet, produced from cochineal crimson and quercitron, is also attended with this advantage, that it may be dyed upon wool and woollen yarn, without any danger of its being changed to a crimson color by the process of fulling, which always happens to scarlet dyed in the common way. Indeed, this last is nothing but a crimson or rose color, rendered yellow by some particular action of the tartaric acid; and is hence liable to be reduced to crimson by many chemical agents, especially by soap, alkaline salts, salts of lime, &c. But where the coloring matter of cochineal is applied and fixed merely as a crimson or rose color, and is rendered scarlet by adding a very permanent yellow, capable of resisting the strongest acids and alkalis, when used with solutions of tin, no such

change takes place, because the color given by cochineal, 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 scarlets dyed according to the ordinary practice. There is also a remarkable property attending the compound scarlet dyed with cochineal and quercitron bark, viz. that if a piece of cloth dyed in this way be compared with another piece dyed by the usual process, both will by day-light appear exactly of the same shade; but, if they be afterwards compared together by candle-light, the former will appear 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 colors are worn and exhibited by candle-light, during a considerable part of the year.

197. To illustrate more clearly, continues Dr. Bancroft, the effects of the murio-sulphuric solution of tin with cochineal in dyeing, 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.

1st, I boiled 100 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 time it had nearly imbibed all the color of the dyeing liquor, and received a very good, even, and bright scarlet. Similar cloth dyed of that color 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.

2d, To see whether the tartrite of tin would, besides yellowing the cochineal crimson, contribute to raise and exalt its color more than the murio-sulphate of that metal, I boiled 100 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 color, 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 coloring matter. To bring back this aurora to the scarlet color, 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 potassa; 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 color rather more advantageously than the potassa. 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 color 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.

3d, I boiled 100 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 coloring 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.

4th, I dyed 100 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 color, 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 colors, by only increasing or diminishing the proportion of bark. It has indeed been usual at times, when scarlets approaching nearly to the aurora color were in fashion, to superadd a fugitive yellow either from turmeric, or from what is called young fustic; but this was only when the cochineal color had been previously yellowed as much as possible by the use of tartar, as in the common way of dyeing 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 color, which may be so much more cheaply obtained than the quercitron bark. By sufficient trials, I have satisfied myself that the cochineal colors, 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 lie somewhat longer, and therefore I cannot avoid earnestly recommending its use for dyeing rose and other cochineal colors, as well as for compounding a scarlet with the quercitron bark.

Of Dyeing Crimson.

198. The different processes employed for obtaining the various shades of crimson, from the deepest to the lightest, may be reduced to two. Either the shade of crimson required is given to cloth previously dyed scarlet, or the cloth is at once dyed crimson. Alum, salts with earthy bases, and fixed and volatile alkalis, have the property of changing the color of scarlet to crimson, which is the natural color of cochineal. Nothing more, therefore, is necessary, than to boil cloth dyed scarlet for about an hour in a solution of alum, proportioned in strength to the deepness of the color desired. But as other salts with earthy bases have the same property, and water contains more or less of these salts, whence it gives a proportionate rosy tinge to scarlet passed through it, particularly if it be worn, the quantity of alum necessary to obtain a crimson varies according to the nature of the water employed; and, when well charged with these salts, it will answer the purpose of itself, without the addition of alum. If a piece of scarlet have any defects, it is most convenient to convert it into a crimson.

199. Hellot says, that he has tried soap, soda, potassa, and crude potassa; that all these substances produced the crimson desired, but saddened it, and gave it less lustre than alum. Ammonia, on the contrary, produced a very good effect; but, as it evaporates quickly, a considerable quantity must be put into the bath a little more than warm, a little ammoniacal muriate, or sal ammoniac, and common potash. By this method the cloth instantly took a very bright rosy color. He thinks that it heightens the color so much as to render less cochineal necessary. But M. Poerner, who gives the same process, directs the scarlet to be left twenty-four hours in a cold solution of potassa and ammoniacal muriate.

200. To dye crimson at once, a solution of two ounces and a half of alum, and one ounce and a half of tartar, to every pound of cloth, is used for the boiling: and the cloth is afterwards dyed with an ounce of cochineal. Solution of tin is commonly added, but in less proportion than for scarlet. The processes employed vary greatly, according as the shade required is deeper or lighter, or more or less distant from scarlet. Common salt is also used for the boiling by some dyers. For saddening crimsons, and giving them more bloom, archil and potassa are frequently used, but the bloom thus imparted is not permanent. Sometimes the boiling for crimson is made after a scarlet reddening, by adding tartar and alum: and it is said, that the wine soup color has more bloom, if both its boiling and reddening be made after scarlet, than when it is dyed in a fresh bath. For these colors the wild cochineal may be used instead of the fine, but in greater quantity. The reddening which has been used for crimson may also be employed for purples, and other compound colors.

Both scarlets and crimsons in half-grain are made by substituting madder for half the quantity of the cochineal, giving the same boiling as for scarlet in grain, and following in other respects the processes for reddening the scarlet or crimson. Other proportions of madder may be used instead of half, according to the effect desired. The common madder red also acquires a greater lustre, when its boiling is made after a reddening for scarlet.

201. In silk the grain crimson, produced by cochineal, is distinguished from false crimson, which is obtained by Brasil-wood. Silks that are intended to be dyed crimson with cochineal, should not be boiled with more than twenty pounds of soap to 100 pounds of silk, as the slight yellow cast which silk has, when only so far scoured, is advantageous to the color. After the silk has been well cleansed from the soap, it is to be put into an alum liquor of the full strength. In this it is commonly left from the evening till the next morning; it is then washed, and twice beetled at the river. In preparing the bath, an oblong boiler is filled with water, to about one-half or two-thirds; and, when the water boils, white galls powdered are thrown in, from half an ounce to two ounces for every pound of silk. After boiling a few moments, from two to three ounces of cochineal, powdered and sifted, for every pound of silk, according to the shade required, are put in, adding afterwards an ounce of tartar, to every pound of cochineal; and, when the tartar is dissolved, an equal quantity of the solution of tin. This solution ought to contain more tin than that used for scarlet, otherwise the colors will be too bright. Macquer directs this solution to be made with sixteen parts of nitric acid, two of ammoniacal muriate, as much fine grain tin, and twelve of water These ingredients are mixed and the boiler is filled up with cold water. In this the silk is immediately dipped, and turned on the skein sticks till it appears to be of a uniform color. The fire is then increased, and the bath made to boil for two hours, turning the silk from time to time. After this the fire is put out, and the silk put into the bath, where it is kept a few hours longer. The silk is afterwards washed at the river, twice beetled, wrung and dried. When crimsons are to be browned, they must be passed, after having been washed, through a solution of sulphate of iron, more or less strong according to the shade required. If it should have a yellow tinge, the solution must be charged with a greater or less proportion of decoction of fustet or Venus's sumach. White galls should be chosen, because black ones would dull the color of the crimson; and even too large a quantity of the white will produce the same effect. Macquer says, that the galls serve only to increase the weight of the silk: yet their general effect is to render colors

more permanent, and they are essentially necessary for crimsons that are intended to be browned. Vinegar is employed as a test in distinguishing grain crimsons from false: but it will not detect colors obtained from Brasil-wood, if they be fixed by means of solution of tin; for in this case they resist vinegar as well as those made with cochineal. A very small quantity of solution of tin is, therefore, put into the bath for dyeing silk crimson. If the same process as that for dyeing wool scarlet were employed, the silk would lose its bloom, and acquire only a faint color. Macquer and Scheffer have, however, detailed processes which differ from it only in a few circumstances, for dyeing silk rose and poppy colors by solution of tin, used cold, that its action on the silk might not be too powerful.

202. Brasil-wood is used for dyeing silk what is called false crimson, to distinguish it from that produced by cochineal, which is much more permanent. For this process the silk should be boiled with soap, in the proportion of twenty pounds of the latter to 100 pounds of the former, and afterwards alumed. Less aluming is required for this than for grain crimson. Having washed it in running water, it is dipped in a bath, more or less charged with Brasil juice, according to the shade to be given. In the preparation of the bath hard water is preferable to soft, as it produces with the dye-stuffs a fuller crimson. Washing the silk in hard water will produce nearly the same effect. In order to make false crimson deeper, or dark red, a decoction of logwood is added to the Brasil bath, after the silk has been impregnated with the latter. A little alkali may also be put in according to the shade required. But to imitate poppy or fire color, the silk must have an anotta ground, even deeper than when it is to be dyed with carthamus: after which it is washed, alumed, and dyed with the decoction of Brasil-wood, to which a small portion of soap is generally added. We might here enumerate several other processes for imparting the crimson color, but the above, with what we have said respecting the dyeing of reds in general, and of scarlet in particular, render it unnecessary to enlarge.

Of Dyeing Yellow.

203. *Of Dyeing Wool Yellow.*—The yellow communicated to wool by weld has little permanency, if the wool be not previously prepared by some mordant. For this purpose alum and tartar are used, by means of which this plant gives a very pure and durable yellow. For the boiling, which is managed in the common way, Hellot advises four ounces of alum to every pound of wool, and only one ounce of tartar; many dyers, however, use half as much tartar as alum. Tartar renders the color paler, but more lively. The weld is boiled in a fresh bath, enclosing it in a bag of thin linen, and keeping it from rising to the top by a heavy wooden cross. Some dyers boil it till it sinks to the bottom of the copper, and then let a cross down upon it: others, when it is boiled, take it out with a rake, and throw it away. From three to four pounds of weld, and, in some instances less, are allowed for every pound of stuff; but the quantity must be regulated by the depth of shade required. Some dyers add a little quick-lime and ashes, which are found to promote the extraction of the coloring matter, and at the same time heighten the color; but they thus render it more liable to the action of acids.

204. Both lighter and brighter shades may be obtained by dyeing after deeper ones, adding water at each dipping, and keeping the bath boiling: but light shades procured in this way are not so lively as when fresh baths are used, proportioning the quantity of weld to the depth of the shade intended to be procured. If common salt be added to the weld bath, it renders its color richer and deeper: sulphate of lime, or gypsum, also deepens it: but alum renders it paler and more lively; and tartar, still paler. Sulphate of iron or vitriol makes it incline to brown.

205. According to Scheffer, by boiling the stuff for two hours with one-fourth of its weight of a solution of tin, and the same proportion of tartar, and then washing it and boiling it for about a quarter of an hour with an equal weight of weld, it will assume a fine yellow, which, however, will not penetrate the substance of cloth.

206. Poerner recommends a process similar to that used in dyeing scarlet, by which means the color is brighter and more permanent.

207. Since the introduction of the use of quercitron bark, the process of dyeing yellow has been much simplified, as may be seen from the following directions of Dr. Bancroft on the subject. He proposes that the bark should be boiled with about its own weight, or one-third more of alum, in a suitable quantity of water, for about ten minutes.

208. The substances to be dyed are previously scoured, and then immersed in the bath, observing to give the higher colors first, and afterwards the paler straw colors. By this cheap and expeditious process, colors which are not wanted to be of a full or bright yellow, may be obtained. The color 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 a pound and a half for every 100 pounds of stuff has been previously added. The bark, when used in dyeing, 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 coloring matter more equally.

209. But although this method possesses the advantages of cheapness and expedition, and is sufficient for communicating pale yellows; to obtain fuller and more permanent colors, the common mode of preparation ought to be preferred. The stuff should be boiled for about one hour, or an hour and a quarter, with one-sixth, or one-eighth of its weight of alum, dissolved in a proper proportion of water. The stuff is then to be immersed, without being rinsed, into the dyeing 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 color 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 dyeing bath, and the operation continued for eight or ten minutes longer, for the purpose of raising and brightening the color.

210. To communicate a beautiful orange yellow to woollen stuffs, ten pounds of quercitron bark, tied up in a bag, for every hundred pounds of stuff, are to be put into the bath with hot water. At the end of six or eight minutes, an equal weight of murio-sulphate of tin is to be added, and the mixture well stirred for two or three minutes. The cloth, previously scoured, and thoroughly wetted, is then immersed in the dyeing liquor, and quickly turned for a few minutes. By this process the coloring matter fixes on the cloth so effectually, that, after the liquor begins to boil, the highest yellow may be produced in less than fifteen minutes.

211. High shades of yellow, similar to those obtained from quercitron bark by the above process, are frequently given with young fustic and dyers' spirit; but this color is much less beautiful and permanent, while it is more expensive than what is obtained from the bark.

212. A fine bright, or golden yellow is obtained by employing ten pounds of quercitron bark, for each 100 pounds of cloth, the bark being first boiled a few minutes, and 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. Bright yellows of less body are produced by employing a smaller proportion of bark, as well as by diminishing the quantity of murio-sulphate of tin and alum. And indeed every variety of shade of pure bright yellow may be given by varying the proportions of the ingredients.

213. The lively delicate green shades, so much admired, are produced by the addition of tartar, with the other ingredients. The tartar must be added in different proportions, according to the shade which is wanted. For a full bright yellow, delicately inclining to green, 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 fulness or body. Ten pounds of bark, with an equal quantity of the other ingredients, are sufficient to dye 300 or 400 pounds of stuffs.

214. *Of Dyeing Silk Yellow.*—Weld is seldom employed to give a yellow dye to silk, but when this is desired, the process differs a little from the former. The silk being scoured, alumed, and rinsed in the manner usual for dyeing bright colors, a bath is prepared, by boiling weld in water, in the proportion of double the weight of the silk for a quarter of an hour, and straining off the liquor into a vat, where it is suffered to cool till the hand can be held in it. Then the silk is dipped and turned, till the color is found uniform. While this is going on, the old weld is boiled with a fresh quantity of water, and, after the silk has been dipped, one half of the exhausted bath is taken out, and the vat filled up with the second decoction. The temperature of the fresh bath may be a little higher than that of the former, but should not be too great, lest the color already fixed be dissolved. The stuff is to be turned as before, and then taken out of the bath. Some soda is to be dissolved in a part of the second decoction, and a larger or smaller quantity of the solution is to be added to the bath, according to the intensity of the shade wanted. The color is examined by taking out a skein, and wringing it.

215. To produce shades having more of a gold color, anotta is added in proportion to the depth of color required. Lighter shades, such as pale lemon color, are obtained by previously whitening the silk, and regulating the proportion of the ingredients of the bath by the shade required. To give a yellow, with a green tinge, a little indigo is added to the bath, if the silk has not been previously azured; to prevent the greenish shade being too deep, the silk should be more slightly alumed than usual.

216. Dr. Bancroft informs us that all the shades of yellow can be given at a cheaper rate by quercitron bark than by weld. To dye with this bark, a quantity of it powdered, and enclosed in a bag, in proportion to the shade wanted, from one to two pounds for every pound of silk, is put into the vat while the water is cold. Heat is applied, and when the bath is rather more than blood-warm, or of the temperature 100°, the silk, after being first alumed, is immersed and dyed in the usual way. A deeper shade may be given by adding a small quantity of chalk or pearl-ashes towards the end of the operation. To produce a more lively yellow, a small portion of murio-sulphate of tin may be employed, but it should be used cautiously, as it is apt to diminish the lustre of the silk.

217. To dye silk of an aurora or orange color, after having been properly scoured, it may be immersed in an alkaline solution of anotta, the strength of which is to be regulated by the shade required. The temperature of the bath should be between that of tepid and boiling water. When the desired shade is obtained, the silk is to be twice washed and beetled, to free it from the superfluous coloring matter, which would injure the beauty of the color. 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 color by anotta, but if a redder shade be wanted, it is procured by alum, vinegar, or lemon juice. These colors are beautiful, but do not possess permanency.

218. *Of Dyeing Cotton and Linen Yellow.*—The process commonly observed in dyeing cotton and linen yellow, is by scouring it in a bath prepared in a lie with the ashes of green wood. It is afterwards washed, dried, and alumed, with

one-fourth of its weight of alum. After remaining in twenty-four hours, it is taken out of the aluming and dried, but not washed. The cotton is then dyed in a weld bath, in the proportion of one pound and a quarter of weld for each pound of cotton, and turned in the bath till it has acquired the desired color.

219. After being taken out of the bath, it is soaked for an hour and a half in a solution of sulphate of copper, in the proportion of one-fourth of the weight of the cotton, and then immersed, without washing, for nearly an hour, in a boiling solution of white soap, after which it is well washed and dried.

220. A deeper yellow is communicated to cotton, by omitting the process of aluming, and employing two pounds and a half of weld for each pound of cotton. To this is added a dram of verdigris, mixed with part of the bath. The cotton is then to be dipped and worked till the color become uniform. It is then taken out of the bath, and a little solution of soda added, after which it is returned, and kept for fifteen minutes. It is then wrung out and dried.

221. Other shades of yellow may be obtained by varying the proportion of ingredients. Thus, a lemon color is dyed by using only one pound of weld for every pound of cotton, and by diminishing the proportion of verdigris, or using alum as a substitute.

222. Dr. Bancroft recommends a superior process, and less expensive. He also objects to the use of salts of copper, as deepening the yellow. One pound of acetate of lead, and three pounds of alum, are to be dissolved in a sufficient quantity of warm water. The cotton or linen, after being properly rinsed, is to be soaked in this mixture, heated to the temperature of 100°, for two hours. It is then taken out, moderately pressed over a vessel, to prevent the waste of the aluminous liquor. It is then dried in a stove heat, and, after being again soaked in the aluminous solution, it 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 in the lime water. After it has been soaked for the last time, it should be well rinsed in clean water, to separate the loose particles of the mordant, which might injure the application of the coloring matter. By the use of the lime-water, a greater proportion of alumina combines with the stuff, besides the addition of a certain proportion of lime.

223. In the preparation of the dyeing bath, from twelve to eighteen pounds of powdered quercitron bark are enclosed in a bag, for every 100 pounds of stuff, varying the proportion according to the depth of shade required. The bark is put into the water while it is cold; and, immediately after, the stuff is immersed and turned for an hour, or 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, and the dyeing liquor brought to a boiling temperature; but at this temperature the stuff must remain in it only for a few minutes. It is then taken out, rinsed, and dried.

224. Dr. Bancroft remarks, that, when the aluminous mordant is employed without the addition of water, one soaking only, and an immersion in lime water, may be sufficient; but he is of opinion that greater advantage is derived from the application of a more diluted mordant at two different times, or even by a more frequent immersion of the stuff alternately in the aluminous mordant, and lime water, and drying it after each immersion. By this treatment he found that the color always acquired more body and durability.

225. Chaptal proposes a process for communicating to cotton a nankeen yellow, which, while it affords a durable color, has the advantage of being cheap and simple. When cotton is immersed in a solution of any salt of iron, it has so strong an affinity for the oxide, that it decomposes the salt, combines with the iron, and assumes a yellow color. The process recommended by Chaptal is this:—The cotton to be dyed is put into a cold solution of sulphate of iron, of the specific gravity of 1·02. It is afterwards wrung out, and immediately immersed in a lie of potassa of the specific gravity of 1·01. This lie must previously have been saturated with a solution of alum. When the stuff has been kept for four or five hours in this bath, it may be taken out, washed, and dried. By varying the proportion of sulphate of iron, every variety of shade may be obtained.

226. The following curious process for dyeing linen of a durable yellow, as practised in the east, is given in the Encyclopædia Britannica. The object of this process, which is tedious, is to increase the affinity between the alumina and the stuff, so that it may adhere with sufficient force to produce a permanent color. For this purpose three mordants are employed: these are oil, tan, and alum. The cotton is soaked in a bath of oil, mixed with a weak solution of soda. Animal oil, as it is found to answer best, is preferred. Glue has also been tried, and is found to answer very well. The soda must be in the caustic state, as it then combines with the oil, and produces on the cloth an equal absorption. The stuff is then to be washed, and afterwards put into an infusion of nut-galls of the white kind; the infusion should be used hot. The tan combines with the oil, while the gallic acid carries off any alkali which may adhere to the cloth. When the stuff is removed from the bath, it should be quickly dried; too great an excess of galls beyond a proper proportion with the oil should be avoided, as it is apt to darken the color. After this preparation the stuff is to be immersed in a solution of alum; and, in consequence of the affinity which exists between tan and alumina, the alum is decomposed, and its earth combines with the tan

OF DYEING BROWN.

227. The substances employed in dyeing browns are very numerous, but those chiefly used are sumach, walnut-peels, and walnut-roots.

On separating the bark from the ligneous substance of the walnut-root, says Berthollet, in relating some experiments on the subject, the former yielded in equal weight a liquor much more charged with color. The bark of the wood of walnut also exhibited properties approaching to those of walnut-peels, but its decoction formed a blackish precipitate with sulphate of iron.

Walnut-peels exercise a lively action on oxide of iron, dissolving it, and forming a liquor as black as ink. If boiled along with clean filings they do not attack them; but, if left exposed to the air, the liquor becomes soon black.

The coloring matter of walnut-peels has a great disposition to combine with wool. It gives it a very durable walnut or dun color, and mordants appear to add little to its permanence, but they may vary its shades, and give them more lustre. By preparing the stuff with alum, a richer and livelier color may be obtained.

Walnut-peels are of excellent use, because they give agreeable and very durable shades, and, being employed without any mordant, they preserve the softness of the wool, and require but one simple, and not expensive, operation. Walnut-peels are gathered when the nuts are entirely ripe. Large casks or tubs are filled with them, and a sufficiency of water is poured on them to cover their surface. In this state they may be kept a year and upwards. At the Gobelins, where a very extensive and varied use is made of this ingredient, it is kept for two years before it is employed. It is found then to furnish much more color. It has a very unpleasant putrid odor.

The peels may also be used which are taken from the nuts before they are ripe; but they do not keep so long.

228. The following are the results of M. Berthollet's experiments on sumach (rhus coriaria):—

The infusion of sumach is of a dun color, bordering on green. It speedily becomes green in the air. When it is recent, the solution of potassa produces little change on it. The acids clear up its color, and render it yellow. Solution of alum makes it turbid, producing a scanty yellow precipitate, while the liquor remains yellow.

Acetate of lead forms instantly an abundant yellowish precipitate, which takes a brown color on its surface; the liquor remains of a clear yellow.

Sulphate of copper affords a copious yellowish-green precipitate, which, after some hours, changes to a brown-green. The liquor remained clear, and a little yellow.

Sulphate of zinc of commerce rendered the liquor turbid, blackening it, and forming a deep blue precipitate.

Pure sulphate of zinc deepened the color much less; only a slight dun deposite, verging on brown, took place.

Muriate of soda produced no sensible change at first; but, after some hours, the liquor was a little turbid, and its color had become somewhat clearer.

Sumach acts like nut-galls on solution of silver, whose metal it reduces; a result promoted by the action of light. We have already dwelt at sufficient length on the explanation of this phenomenon, as well as the general properties of astringents. Sumach affords of itself a fawn-color bordering on green; but it communicates to cotton stuffs several very permanent colors, when they are combined with mordants.

229. Sanders, or sandal-wood, is also employed for the purpose of giving a fawn-color. There are three kinds of this 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 dyeing. By exposure to the air it becomes of a brown color; when employed in dyeing, it is reduced to fine powder, and it yields a fawn-color with a brownish shade, inclining to red.

The quantity of coloring matter, however, which it yields of itself is small, and it is said that it gives harshness to woollen stuffs. When it is mixed with other substances, as sumach, walnut-peels, or galls, the quantity of coloring matter is increased; it gives a more durable color, and produces considerable modifications in the coloring matter with which it is mixed. Sandal-wood yields its coloring matter to brandy, or diluted alcohol, more readily than to water.

230. Soot communicates to woollen stuffs a fawn or brown color, of a lighter or deeper shade, in proportion to the quantity employed; but the color is fading, and its affinity for wool is not great; and, besides leaving a disagreeable smell, it renders the fibres harsh. In some manufactories, it is employed for browning certain colors, and it produces shades which could not otherwise be readily obtained.

231. In dyeing with walnut-peels, a quantity proportioned to the quantity of stuff, and the intensity of shade wanted, is boiled for fifteen minutes in a copper. All that is necessary in dyeing with this substance is, to moisten the cloth or yarn with warm water, previously to their immersion in the copper, in which they are to be carefully stirred till they have acquired the proper shade. This is the process, if the aluminous mordant be not employed. In dyeing cloth, it is usual to give the deepest shades first, and the lighter ones afterwards; but, in dyeing woollen yarn, the light shades are given first, and the deeper ones afterwards. A fresh quantity of peels is added each time.

232. Berthollet made a number of experiments to ascertain the difference of color obtained from the simple decoction of walnut-peels, and the addition of metallic oxides as mordants. The oxide of tin, he informs us, yielded a clearer and brighter fawn-color than that of the simple decoction. The oxide of zinc produced a still clearer color, inclining to ash or gray. The color from oxide of lead had an orange cast, while that from oxide of iron was of a greenish brown.

233. A fawn-color, which has 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.

234. Vogler employed the tincture of sanders-wood for dyeing patterns of wool, silk, cotton, and linen, having previously impregnated them with a solution of tin, and afterwards washing and drying them. Sometimes he used the solution unmixed, and at other times added six or ten parts of water, and in whatever way he em-

ployed it, he obtained a poppy color. When the mordant employed was solution of alum, the color was a rich scarlet; with sulphate of copper it was a clear crimson, and with sulphate of iron a beautiful deep violet.

Of Dyeing Compound Colors.

235. On this branch of dyeing, M. Berthollet remarks, that simple colors form, by their mixture, compound colors; and if the effects of the coloring particles did not vary, according to the combinations which they form, and the actions exercised on them by the different substances present in a dyeing bath, we might determine with precision the shade that ought to result from the mixture of two other colors, or of the ingredients which afford these colors separately: but the chemical action of the mordants, and of the liquor of the dye bath, often changes the results; theory, however, may always predict these effects to a certain degree.

It is not the color peculiar to the coloring matters which is to be considered as the constituent part of compound colors, but that which they must assume with a certain mordant, and in a certain dye bath. Hence, our attention ought to be principally fixed on the effects of the chemical agents employed.

It is in this department of dyeing that the intelligence of the operator may be most useful, by enabling him to vary his processes, and to arrive at the proposed end by the simplest, shortest, and least expensive way.

The processes for compound colors are very numerous. We shall mention only those which most merit attention, and shall establish the principles on which they ought to be conducted by particular examples.

236. *Of Dyeing Wool Green.*—Green is obtained by the mixture of yellow and blue; and it is distinguished into many different shades; but it requires experience to obtain this color uniform and without spots, especially in the light shades. It is possible to produce green by beginning either with the yellow or the blue dye; but the first method is attended with some inconveniences; for the blue soils the linen, and a part of the yellow being dissolved in the vat, changes and makes it green; the second method is, therefore, preferable. It is common to employ the pastel vat, but for some kinds of green, solution of indigo in the sulphuric acid is used; and then the blue and yellow are either dyed separately, or all the ingredients are mixed together, to dye by a single operation.

237. Solutions of copper with yellow substances may also be employed. The blue ground must be proportioned to the green which is desired; thus, for the green like that of a drake's neck, a ground of deep royal blue is given; for parrot green, a ground of sky-blue; for verd naissant, a ground of white-blue is necessary. After the cloths have received the proper ground, they are washed in the fulling-mill, and boiled as for common welding, but for the lighter shades the proportion of salts is diminished. Most commonly the cloths intended for the light shades are boiled first; and, when these are taken out tartar and alum are added.

238. The process of welding is conducted in the same manner as for yellow; but a larger quantity of weld is employed, except for the lighter shades, which, on the contrary, require a still smaller proportion. For the most part, a succession of shades from the deepest to the lightest is dyed at the same time, beginning with the deepest and proceeding to the lightest; between each dip, which lasts half an hour, or three quarters, 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 light ones; in that case, each parcel should remain a shorter time in the bath: for the very light shades, care should be taken that the bath does not boil. A browning with logwood and a little sulphate of iron is given to the very deep greens.

The green obtained by means of the solution of indigo in sulphuric acid, is denominated Saxon green, from its having been first practised in Saxony. We shall here give the process directed by Dr. Bancroft for this color.

239. The most beautiful Saxon greens 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 dissolved in sulphuric acid, as for dyeing the Saxon blue.

To produce this combination most advantageously, the dyer, for a full-bodied green, should put into the vessel after the rate of six or eight pounds of powdered bark in a bag, for every hundred pounds 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, so as to bring the heat of the liquor down to what the hand is able to bear. 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.; and this being done, the cloth, being 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 color 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 greatly 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 color very fugitive. 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 color 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 greatly 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 dyeing it in the common way, the sulphate of indigo being the same in both cases. But in dyeing 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 labor 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 color of the fustic; and after all, the dyeing 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 color obtained from bark will not only prove superior in beauty, but in cheapness, to that dyed with old fustic.

240.—*Of Dyeing Silk Green.*—In communicating to silk the green color, it requires very great caution to prevent the stuff from being spotted and striped. Silk intended for greens is boiled as for the ordinary colors; for light shades, however, it should be boiled thoroughly as for blue.

Silk is not first dyed blue like cloth; but, after a strong aluming, it is washed slightly in the river, and distributed into small hanks, that it may take the dye equably; after which it is turned carefully round the sticks, through a bath of weld. When it is thought that the ground is sufficiently deep, a pattern is tried in the vat, to see if the color has the wished-for tone; if it has not ground enough, decoction of weld is added; and, when it is ascertained that the yellow has reached the proper degree, the silk is withdrawn from the bath, and passed through the vat as for blue.

To render the color deeper, and at the same time to vary its tone, there are added to the yellow bath, when the weld has been taken out, juice of Brasil-wood, decoction of fustet, and anotta. For the very light shades, such as apple-green and celadon-green, a much weaker ground is given than for the other colors. For the light shades, if not for sea-green, it is preferable to dye yellow in baths which have already been used, but in which there is no Brasil-wood or fustet, because the silk, perfectly alumed, dyes too rapidly in fresh baths, and is thence subject to take an uneven color. Dr. Bancroft recommends the following process for producing Saxon green at one operation, as the most commodious and certain:—

241. A bath 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 in temperature till the hand can bear it, it is fit for dyeing. By adding different proportions of sulphate of indigo, various and beautiful shades of green may be obtained, and the color thus produced is both cheap and uniform. Care should be taken to keep the bath constantly stirred, to prevent the coloring 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.

242. To produce what is called an English green, and which is more beautiful than the ordinary greens, and more durable than Saxon green, Guhliche recommends the following process:—He gives the silk, first of all, a clear blue in the cold vat; he steeps it in hot water; washes it in running water; passes it through a weak solution of alum; prepares a bath with the sulphuric solution of indigo, a little of the solution of tin, and a tincture of Avignon berry, made with a vegetable acid. He keeps the silk in this bath till it has assumed the wished-for shade; he then washes and dries in the shade. The lighter hues may be dyed in the sequel. The shades may be varied with more or less blue, or more or less yellow, by the proportions of the indigo solution, and of the yellow substance. When it is wished to give a goslin-green to silk, a light blue is communicated to it, either in the hot vat or in the cold; it is passed through hot water, washed in running water, and while moist it is passed through a bath of anotta.

243. *Of Dyeing Cotton and Linen Green.*—To give a green color to linen and cotton yarns, it is proper to begin with scouring them well; then they must be dyed in the blue vat, cleansed in water, and passed through the weld process.

The strength of the blue and the yellow is proportioned to the color that is wanted. As it is difficult to give uniformity to the cotton velvets in the ordinary blue vat, they are usually dyed yellow with turmeric, and the green is produced with solution of indigo in sulphuric acid.

244. To dye beautiful greens upon cotton, Chaptal recommends that it be first dyed of sky-blue color with indigo, dissolved by potassa and orpiment, then macerated in a strong solution of sumach, then dried and soaked in a solution of acetate of alumina, dried again, rinsed, and finally dyed with quercitron bark, in the proportion of twelve pounds to every fifty pounds of cotton. The quercitron is preferred to weld for this purpose, because the color of the former combines better with that of sumach.

245. M. D'Apligny recommends a method of dyeing cotton and linen of a fine sea or apple-green by means of a single bath; it is in substance as follows:—The liquor is prepared by mixing verdigris with a sufficient quantity of vinegar, and keeping the mixture in a bottle well stopped for fifteen days in the heat of a stove, and adding to it, about four hours before using it, a solution of potassa equal in weight to that of the verdigris, keeping it still hot. The cotton goods are first soaked in a warm solution, made by dissolving one ounce of alum in five quarts of water for every pound of cotton. The goods are again taken out, and, after adding the verdigris mixture, they are returned, and passed through the bath till sufficiently dyed.

Linen is dyed of the shades of olive and drake's neck green, by first giving it a blue ground, then galling and dipping it in a bath of acetate of iron; afterwards passing it through a bath of weld, combined with verdigris; and through another containing sulphate of copper, finally brightening the color by immersion in a solution of soap.

246. The green, says M. Berthollet, obtained by giving a yellow color to a stuff which has been previously dyed blue, and afterwards washed, presents nothing obscure. The color inclines more or less to yellow, or to blue, according to the tint of blue given, and the strength of the yellow bath. The intensity of the yellow is increased by alkalis, by sulphate of lime, by ammoniacal salts. It is diminished by acids, alum, and solution of tin. The shades vary likewise from the nature of the yellow substance employed.

These different effects will be obtained with the same ingredients in the formation of the Saxon green, according to the process adopted. If the Saxon blue be first dyed, and the yellow color be next given separately, the effects will be analogous to those just mentioned. But if solution of indigo be mixed with the yellow ingredients, the results are not the same, because the sulphuric acid acts in this case on the coloring particles, impairing the intensity of the yellow. If a succession of shades be dyed in a bath composed of yellow and the solution of indigo, the last approach more and more to yellow, because the particles of indigo become attached to the stuff in preference to the yellow ones, which therefore become predominant in the bath.

Of Dyeing Violet Color, &c.

247. *Of Dyeing Wool Violet, &c.*—From the mixture of red and blue are obtained violet, purple (columbine), dove-color, pansy, amaranth, lilac, mallow, and a great many other shades, determined by the nature of the substances, whose red color is combined with a blue color, of which one becomes more or less predominant over the other, according to the proportions of the ingredients, and the other circumstances of the process. Hellot observes, that stuff which has been dyed scarlet, takes an unequal color when blue is to be united with it. The blue is therefore given first, which, even for violet and purple, ought not to be deeper than the shade distinguished by the name of sky-blue; a boiling is given with alum mixed with two-fifths of tartar; the stuff is then dipped in a bath composed of nearly two-thirds as much cochineal as for scarlet, to which tartar is always added.

248. The circumstance which distinguishes the process for purple from that for violet, is that for the former a lighter blue ground is given, and a larger proportion of cochineal is employed. These colors are frequently dyed after the reddening for scarlet, such quantities of cochineal and tartar being added as are necessary; the operation is managed in the same way as for scarlet. But lilacs, pigeon's necks, &c., are commonly dipped in the boiling, which has served for violet, after alum and tartar have been added to it: the blue ground having been proportioned to the shade required, the quantity of cochineal is also adjusted in a similar manner; a little solution of tin is added for some reddish shades, snch as peach blossom. It is to be observed, that, though the quantity of cochineal is diminished according to the lightness of the shade required, the quantity of tartar is not lessened, so that the proportion of it, compared with that of the cochineal, is so much the greater, as the color required is lighter.

249. M. Poerner is of opinion, that, to procure the colors composed of red and blue, it is advantageous to employ the solution of indigo in sulphuric acid, because a great variety of shades is thus more easily obtained, and the process is not so long or expensive. But the colors thereby obtained are less durable than when the blue vat is employed. He says, however, that they have sufficient permanence, if a solution of indigo be used to which some alkali has been added.

The effects may be easily varied, by giving a preparation to the stuff with different proportions of alum and tartar, or with solution of tin; and by dyeing with different proportions of cochineal and solution of indigo.

250. A process for dyeing wool of a purple color is given by M. Berthollet, as having been communicated to him by Descroizilles. It is this:—If it be wool in the fleece which is to be dyed, one-third of its weight of mordant is required; if it be a woven stuff, only a fifth is necessary. A bath is prepared at a temperature which the hand can bear; the mordant is well mixed with it; and the wool or stuff is then immersed. It is to be properly agitated, and the same degree of heat is to be kept up for two hours, which may be even increased a little towards the end. It is then lifted out, aired, and very well washed. A new bath of pure water at the same heat is prepared; a sufficient quantity of violet wood is added to it; the stuff is then let down, and agitated; and the heat is urged to the boiling point, at which it is maintained for a quarter of an hour. The stuff is then lifted out, aired, and carefully rinsed. The dye is now completed. If a decoction of one pound of logwood has been used for three pounds of wool, and proportionately for the stuffs which require a smaller dose, a beautiful violet is obtained, to which a sufficient quantity of Brasil-wood gives the shade known by the name of prune de monsieur.

251. The ingenious author from whom we quote the above, thus endeavours to explain the process:—

If we may venture an opinion, without having made direct experiments on a complicated process, such as that communicated by Descroizilles, and which is still employed advantageously in some manufactories with modifications which we do not know, we would suggest the following explanation.

The muriate of soda is decomposed by the sulphuric acid, and the muriatic acid set at liberty dissolves the tin.

A portion of the tin is precipitated by the tartaric acid, whence the deposite is occasioned. But a portion which remains in solution serves to modify the effect, as we have seen with regard to cochineal. The oxide of copper, present in this preparation, forms blue with the coloring particles of the indigo; the oxide of tin with the same wood gives violet, and red with the coloring matter of Brasil-wood.

252. *Of Dyeing Silk Violet, &c.*—There are two kinds of violet colors given to silk, these are, by the French writers on dyeing, distinguished into the fine and the false. The fine violet may be given by dyeing the silk with cochineal, and afterwards passing it through the indigo vat. The preparation and dyeing of the silk with cochineal are the same as for crimson, with the omission of tartar and solution of tin, by means of which the color is heightened. The quantity of cochineal made use of is always proportioned to the required shade; but the usual proportion for a fine violet color is two ounces of cochineal for every pound of silk. When the silk is dyed, it is washed at the river, twice beetled, dipped in a vat of a strength proportioned to the depth of the violet shade, and then washed and dried with precautions similar to those which all colors require that are dyed in a 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.

253. When silk has been dyed with cochineal, as above directed, a very light shade of blue must be given it for purple. Only the deepest shades are passed through a weak vat. For those which are less so, cold water is had recourse to, into which a little of the blue vat is put, because they would take too much blue in the vat itself, however weak it may be. The light shades of this color, such as pink, gridelin, and peach-blossom, are made in the same manner, with a diminution of the proportion of cochineal.

254. The spurious violets are given to silk in various ways. The most beautiful, and those most in use, are prepared with archil. The strength of the archil bath is proportioned to the color wished for: the silk, to which a beetling in the river has been given on its coming out of the soap, is turned through it round the skein sticks. When the color is thought to be deep enough, a trial is made on a pattern in the vat, to see if it takes the violet that is wanted. If it is found to be at the proper pitch, a beetling is given to the silk at the river, and it is passed through the vat as for fine violets. Less blue, or less archil, is given, according as the violet is wished to incline to red or to blue.

255. A violet color may be imparted to silks by immersing them in water impregnated with verdigris, as a substitute for aluming, and then giving them a bath of logwood, in which they assume a blue color; which is converted into a violet, either by dipping them in a weaker or stronger solution of alum, or by adding it to the bath; the alum imparts a red shade to the coloring matter of the logwood. This violet possesses but little beauty, or permanence, but if the alumed silk be immersed in a bath of Brasil-wood, and next in a bath of archil after washing it at the river, a color is obtained possessing a much higher degree of beauty and intensity. M. Decroizilles' process, above related, for dyeing wool, was found to succeed equally well, according to his account, in communicating a violet color to silk.

256. *Of Dyeing Cotton and Linen Violet, &c.*—The process in most common use for dyeing cotton and linen of the violet colors is the following:—The stuffs have first a blue ground communicated to them in the indigo vats according to the shade required; they are then dried. After this they must be galled in the proportion of three ounces of galls to a pound: they are left for twelve or fifteen hours in the gall bath, after which, they are wrung and dried again. They are then passed through a decoction of logwood, and when well soaked are taken out, and two drachms of alum, and one of dissolved verdigris, for each pound of stuff are added to the bath; the skeins are then redipped on the sticks, and turned for a full quarter of an hour, when they are taken out to be aired; after which they are again completely immersed in the bath for a quarter of an hour, then taken out and wrung. The vat which has been employed is then emptied; half of the decoction of logwood which had been reserved is poured in; two drachms of alum are added, and the stuff dipped afresh, until it is brought to the shade required. The decoction of logwood ought to be stronger or weaker according to the shade required; this violet stands the action of the air tolerably well, but is not so durable as that obtained by madder.

257. Permanent purple and violet colors may be given to cotton stuffs that have been dyed a Turkey-red, by adding to the alum steep a proportion of sulphate of iron suited to the shade required. Cotton also that has been dyed a light blue with indigo, may be changed to purple or violet by passing the stuff through a bath prepared with the aluminous mordant, and dyeing with madder.

Of Dyeing Orange.

258. *Of Dyeing Wool Orange.*—Orange colors are produced by the mixture of red and yellow; and, by varying the proportions of the ingredients, an almost endless variety of shades may be obtained.

Poerner describes a great many varieties which he obtained by employing weld, saw-wort, dyers' broom, and some other yellow substances; as also by introducing into the preparation of the cloth, or into the bath, tartar, alum, sulphate of zinc, or sulphate of coppet.

Different colors may in like manner be procured from the madder, which is associated with yellow substances. It is thus that the mordores and the cinnamons are dyed; colors commonly formed in two baths. The maddering is first given, preceded by a bath of alum and tartar as for ordinary maddering; and then a bath of weld is employed.

For cinnamon a weaker maddering is given, and commonly a bath is used which had served for the mordore. The proportions are varied according as the red or the yellow is wished to predominate. Sometimes nut-galls are added, and sometimes the color is deepened by a browning.

Occasionally the sole object is to give a reddish tone to the yellow; the stuff just dyed yellow may, in this case, be passed through a bath of madder, more or less charged according to the intention.

Brasil-wood is likewise employed along with the yellow substances, and sometimes it is associated with cochineal and madder.

When, instead of weld or other yellow substances, root of walnut, walnut-peels, or sumach, are used, tobacco, snuff, chestnut, musk colors &c., are produced.

259. *Of Dyeing Silk Orange.*—Morrones, cinnamons, and all the intermediate shades are given to silk, by logwood, Brasil, and fustic · a bath is prepared by mixing decoctions of these three woods made separately; the proportion of each is varied according to the shade required, but that of fustic ought to prevail; the bath should be of a moderate temperature; and the silk, after being scoured and alumed in the usual manner, is immersed in it. The silk is turned on the skein sticks in the bath, and when taken out, if the color be uniform, it is wrung and dipped in a second bath of the three ingredients, the proportions of which are regulated according to the effect of the first bath, in order to obtain the shade required.

For some colors blue is united to red and yellow, it is thus olives are produced: a blue ground is first given, then the yellow dye, and lastly, a slight maddering. Olive may be dyed without using the blue vat, by dipping the silk in a very strong weld bath, after being first alumed; to this a decoction of logwood is afterwards added, and, when the silk is dipped, a little solution of alkali is put in, which turns it green, and gives the silk the olive color. The silk is repeatedly dipped in this bath until it has acquired the proper shade.

260. For the color termed russet olive, or rotten olive, fustet and logwood, without alkali, are added to the bath after the welding. If a more reddish color be wished for, only logwood is added. A kind of reddish olive is also made by dyeing the silk in a bath of fustet, to which more or less sulphate of iron and logwood are added.

261. *Of Dyeing Cotton and Linen Orange.*—The usual combinations of scarlet and orange, are produced with difficulty. On this head Dr. Bancroft remarks, that, as cochineal and the tin mordant cannot be advantageously employed to dye linen or cotton, it is necessary for these substances solely to rely on the aluminous mordant, and to select the red coloring matter from other dye stuffs, especially from madder, with which the yellow of weld, quercitron bark, or fustic, may be combined in such proportions as may be sufficient for the required color. M. Berthollet gives some processes for colors, which he regards as mixtures of red and yellow, though some of them may more properly be considered browns or greens. The various shades of morrone are given to cotton, by first galling, and then dipping it in a bath of acetate of iron, formed by the pyroligneous acid, and afterwards in a bath of weld and verdigris, after which it is dyed with fustic, sometimes with the addition of soda and alum. It is then completely washed, passed through a strong madder bath; then dipped in a weak solution of sulphate of copper; and, lastly, passed through a bath containing soap.

262. The shades cinnamon and mordore are thus given: the stuffs are first dyed with verdigris and weld, then dipped in a solution of sulphate or acetate of iron, out of which they are wrung and dried. After this they are galled, allowing three ounces of galls to each pound of stuff, again dryed, alumed, and passed through a madder bath. They are then washed and immersed in a warm soap lie, through which they are turned till the color is sufficiently bright.

263. The shades of color usually denominated gray, have already been treated of, and the processes for dyeing them need not here be repeated.

264. Several highly respectable writers who have done great justice to the subject of dyeing have connected with their treatises on it a brief view of the process of calico printing: we should have followed their example in the present instance, had we not considered the subject, in its present highly improved state, as meriting a distinct notice, which will be found in another part of our work. See PRINTING, CALICO.

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