DYEING is the art of staining textile substances with permanent colours. To cover their surfaces with colouring matters removable by daily use would be to apply a pigment rather than to communicate a dye. Dye-stuffs can penetrate the minute pores of vegetable and animal fibres only when presented to them in a state of solution, and they can constitute fast colours only by passing afterwards into the state of insoluble compounds with the fibres themselves. Dyeing thus appears to be altogether a chemical process, and to require for its due explanation and practice an acquaintance with the properties of the elementary bodies, and the laws which regulate their combinations. It is true, nevertheless, that many operations of this, as of other chemical arts, have been practised from the most ancient times, long before any just views were entertained of the nature of the changes that took place. Mankind, equally in the rudest and most refined state, have always sought to gratify the love of distinction by staining their dress, sometimes even their skin, with gaudy colours. Moses speaks of raiment dyed blue, and purple, and scarlet, and of sheep-skins dyed red,—circumstances which indicate no small degree of tinctorial skill. He enjoins purple stuffs for the works of the tabernacle and the vestments of the high priest.

In the article CALICO PRINTING we have shown from Pliny that the ancient Egyptians cultivated that art with some degree of scientific precision: seeing that they knew the use of mordants, or of those substances which, though they may impart no colour themselves, yet enable white cloth to absorb colouring drugs. Tyre, however, was the nation of antiquity which made dyeing its chief occupation and the staple of its commerce. There is little doubt that purple, the sacred symbol of royal and sacerdotal dignity, was a colour discovered in that city, and that the discovery and use of the dye contributed to the opulence and grandeur of the place. Homer marks the value as well as antiquity of this dye, by describing his heroes as arrayed in purple robes. Purple habits are mentioned among the presents made to Gideon by the Israelites from the spoils of the kings of Midian. The juice employed for communicating this dye was obtained from two different kinds of shell-fish, described by Pliny under the names of *purpura* and *buccinum;* and was extracted from a small vessel, or sac, in their throats, to the amount of only one drop from each animal. A darker and inferior colour was also procured by crushing the whole substance of the buccinum. A certain quantity of the juice collected from a vast number of shells being treated with sea-salt, was allowed to ripen for three days; after which it was diluted with five times its bulk of water, kept at a moderate heat for six days more, occasionally skimmed to separate the animal membranes, and when thus clarified was applied directly as a dye to white wool, previously prepared for this purpose by the action of lime-water, or of a species of lichen called fucus. Two operations were requisite to communicate the finest Tyrian purple: the first consisted in plunging the wool into the juice of the purpura; the second, into that of the buccinum. Fifty drachms of wool required one hundred of the former liquor, and two hundred of the latter. Sometimes a preliminary tint was given with coccus, the kermes of the present day, and the cloth received merely a finish from the precious animal juice. The colours, though probably not nearly so brilliant as those producible by our cochineal, seem to have been very durable, for Plutarch says, in his 'Life of Alexander' (chap. 36), that the Greeks found in the treasury of the King of Persia a large quantity of purple cloth, which was as beautiful as at first, though it was 190 years old. The difficulty of collecting the purple juice, and the tedious complication of the dyeing process, made the purple wool of Tyre so expensive at Rome that in the time of Augustus a pound of it cost nearly 30*l.* of our money. Notwithstanding this enormous price, such was the wealth accumulated in that capital, that many of its leading citizens decorated themselves in purple attire, till the emperors arrogated to themselves the privilege of wearing purple, and prohibited its use to every other person. This prohibition so much discouraged the art of dyeing purple as eventually to occasion its extinction, first in the western and then in the eastern empire, where, however, it existed in certain imperial manufactories till the 11th century.

Dyeing was little cultivated in ancient Greece. The people of Athens wore, generally, woollen dresses of the natural colour. But the Romans must have bestowed some pains upon this art. In the games of the circus, parties were distinguished by colours. Four of these are described by Pliny,—the green, the orange, the gray, and the white. The following ingredients were used by their dyers: a crude native alum mixed with copperas, copperas itself, blue vitriol, alkanet, lichen rocellus or archil, broom, madder, woad, nut-galls, the seeds of pomegranate, and of an Egyptian acacia.

The moderns have obtained from the New World several dye-drugs unknown to the ancients, such as cochineal, quercitron, Brazil wood, logwood, annatto, &c.; and they have discovered the art of using indigo as a dye, which the Romans knew only as a pigment. But the vast superiority of our dyes over those of former times must be ascribed principally to the employment of pure alum and solution of tin as mordants, either alone or mixed with other bases; substances which give to our common dye-stuffs remarkable depth, durability, and lustre. Another improvement in dyeing of more recent date is the application to textile substances of metallic compounds, such as Prussian blue, chrome yellow, manganese brown, &c.

Indigo, the innoxious and beautiful product of an interesting tribe of tropical plants, which is adapted to form the most useful and substantial of all dyes, was actually denounced as a dangerous drug, and forbidden to be used, by our parliament in the reign of Queen Elizabeth. An Act was passed authorising searchers to burn both it and logwood in every dye-house where they could be found. This Act remained in full force till the time of Charles II.; that is, for a great part of a century. The purpose of this statute was professedly to check the use of two dye-drugs supposed to be dangerous; but it is probable that the legislation was suggested by the growers or makers of certain English drugs, to favour their monopoly.

Mr. Delaval made many ingenious experiments to prove that the particles of dye-stuffs possess no power of reflecting light, and that, therefore, when viewed upon a dark ground, they all appear black, whatever colour they may exhibit when seen by light transmitted through them. He hence inferred that the difference of colour shown by dyed cloths is owing to the white light which is reflected from the textile fibres being decomposed in its passage through the superinduced colouring particles. We think it more than probable that this conclusion is in some respects incorrect, and that the aluminous, iron, and tin bases form combinations with dye-stuffs which are capable of reflecting light, independent of the reflection from the fibre itself. There can be no doubt, however, that this latter reflected light adds greatly to the brightness of the tints, and that the whiter the textile substance is, the better dye it will, generally speaking, receive. It is for this reason that scouring or bleaching of the stuffs is usually prescribed as a process preliminary to dyeing.

Bergman appears to have been the first who referred to chemical affinities the phenomena of dyeing. Having plunged wool and silk into two separate vessels, containing solution of indigo in sulphuric acid diluted with a great deal of water, he observed that the wool abstracted much of the colouring matter, and took a deep blue tint, but that the silk was hardly changed. He ascribed this difference to the greater affinity subsisting between the particles of sulphate of indigo and wool, than between these and silk; and he showed that the affinity of the wool is sufficiently energetic to render the solution colourless by attracting the whole of the indigo, while that of the silk can separate only a little of it. He thence concluded that dyes owed both their permanence and their depth to the intensity of that attractive force.

We have therefore to consider in dyeing the play of affinities between the liquid medium in which the dye is dissolved and the fibrous substance to be dyed. When wool is plunged in a solution containing cochineal, tartar, and salt of tin, it readily assumes a beautiful scarlet hue; but when cotton is subjected to the same bath it receives only a feeble pink tinge. Dufay took a piece of cloth woven of woollen warp and cotton weft, and having exposed it to the fulling-mill in order that both kinds of fibre might receive the same treatment, he then subjected it to the scarlet dye; he found that the woollen threads became of a vivid red, while the cotton continued white. By studying these differences of affinity, and by varying the preparations and processes, with the same or different dye-stuffs, we may obtain an indefinite variety of colours of variable solidity and depth of shade.

Dye-stuffs, whether of vegetable or animal origin, though susceptible of solution in water, and, in this state, of penetrating the pores of fibrous bodies, seldom possess alone the power of fixing their particles so durably as to be capable of resisting the action of water, light, and air. For this purpose they require to be aided by another class of bodies, already alluded to, which bodies may not possess any colour in themselves, but serve in this case merely as a bond of union between the dye and the substance to be dyed. These bodies were supposed, in the infancy of the art, to seize the fibres by an agency analogous to that of the teeth of animals, and were hence called *mordants,* from the Latin verb *mordere,* to bite. But the term derived from it has gained such a footing in the language of the dyer that all writers upon his art are compelled to adopt it.

Mordants may be regarded, in general, as not only fixing but also occasionally modifying the dye, by forming with the colouring particles an insoluble compound, which is deposited within the textile fibres.

Such dyes as are capable of passing from the soluble into the insoluble state, and of thus becoming permanent, without the addition of a mordant, have been called substantive, and all the others have been called adjective colours. Indigo and tannin are perhaps the only dyes of organic origin to which the title substantive can be applied, and even they probably are so altered by atmospheric oxygen, in their fixation upon stuffs, as to form no exception to the true theory of mordants.

Mordants are of primary importance in dyeing; they enable us to vary the colours almost indefinitely with the same dye, to increase their lustre, and to give them a durability which they otherwise could not possess. A mordant is not always a simple agent; but in the mixture of which it consists various compounds may be formed, so that the substances may not act directly, but through a series of transformations. The China blue process [Calico Printing] affords a fine illustration of this truth. Sometimes the mordant is mixed with the colouring matters; sometimes it is applied by itself first of all to the stuff; and at others both these methods are conjoined. We may dye successively with liquors containing different substances, which will act differently according to the different mordants successively employed. One solution will give up its base to the stuff only when aided by heat; another acts better and more uniformly when cold, though this is a rarer case.

When a mordant consists of a changeable metallic oxide, as of iron or tin, unless great nicety be used in its application, either no effect or an injurious one may be produced upon the dye. All these circumstances prove how necessary it is for the dyer to be thoroughly versed in chemical science. Each of the great dye-works in Alsace, celebrated for the beauty and fixity of their colours, is superintended in the laboratory department by a gentleman who has studied chemistry for two or more sessions in the universities of Paris or some other eminent schools. The English cotton dyers, twenty or thirty years ago, were far inferior in skill to those of France; but they have recently made great advances. Now many of the Manchester houses have chemists (some of them men of great attainments), and no doubt in other towns also; and for smaller establishments there are professional consulting chemists.

The first principle of dyeing fast colours, we have seen, consists in causing the colouring matter to undergo such a change, when deposited upon the wool or other stuffs, as to become insoluble in the liquor of the dye-bath. The more powerfully it resists the action of other external agents, the more solid or durable is the dye. Generally speaking, a piece of well-dyed cloth should not be materially affected by hot water, by soap and water, by exposure to air and light, by dilute nitric acid, or even by very dilute aqueous chlorine.

In the following details concerning the art of dyeing we shall consider principally its application to wool and silk, having already treated, in the article Calico Printing, of what is peculiar to cotton and linen.

The operations to which wool and silk are subjected preparatory to being dyed are intended, 1, to separate certain foreign matters from the animal fibre; 2, to render it more apt to unite with such colouring particles as the dyer wishes to fix upon it, as also to take therefrom a more lively and agreeable tint, as well as to be less liable to soil in use. The matters foreign to the fibre are either such as are naturally associated with it during its production by the animal, such as have been added to it in the spinning and weaving operations, or such as have been accidentally applied.

Silk is scoured by means of boiling in soap and water, whereby it is freed from a varnish, improperly called gum. This consists of an azotised compound, which may be separated in a gelatinous form by cooling the hot water saturated with it. It constitutes about a fourth part of the weight of most raw silks, and contains a little colouring matter of an orange or yellow hue. When silk is required to be extremely white, either to be woven in that state, or to receive the brightest and purest dyes, it should be exposed to the action of humid sulphurous acid. For dark dyes, silk need not be scoured at all, in which case it preserves its whole weight. Wool is first washed in running water to separate its coarser impurities; it is then deprived of its *yolk* (a species of animal soap secreted from the skin of the sheep) either by the action of ammoniacal urine, by soap and water, or by a weak lye of carbonate of soda. Common wools lose in this way from 20 to 50 per cent. of their weight, and merino wools still more. They receive their final bleaching by the fumes of burning sulphur, or by aqueous sulphurous acid.

Wools present remarkable differences in their aptitude of combining with dye-stuffs, depending upon the different structure of the imbrications of the filaments. The colouring particles seem to insinuate themselves at these pores with greater or less facility, and to be retained with greater or less force, according to the magnitude and form of the orifices. This difference in dyeing, therefore, is not due to the repulsive action of fatty matter, as has been commonly supposed, since it still exists in wool even when every particle of grease has been removed from it by alcohol and ether. A boiling in a solution of bran is often had recourse to, in order to make wool take the dye more readily and equally; but a hot lye containing one-half per cent. of crystallised carbonate of soda answers much better. When heated to the temperature of 140° or 150° Fahr., the wool should be immersed in that liquor, and turned about for half an hour. The wool receives a faint yellowish tint from this bath, but it speedily becomes white on exposure to air; or it may be whitened at once by passing it through tepid water containing a very small quantity of muriatic acid. The yellow colour is most probably occasioned by the reaction of the sulphur and iron contained in the wool.

According to the experiments of Thenard and Roard, alum combines with wool in the state of a salt, without separation of its acid constituent. Wool boiled with a solution of tartar decomposes a portion of it completely; some of the acid and a little of the tartar combine with the wool, while a neutral tartrate of potash remains in the bath. This fact is interesting in reference to the scarlet dye, showing the important part which tartaric acid here performs.

Tinctorial colours are either simple or compound. The simple are black, brown or dun, blue, yellow, and red; the compound are gray, purple, green, orange; and other numerous modifications, all producible by the mixture of simple colours. We shall treat here of only *black* and *brown*, in the present place.

1. *Black*.—If we apply to a white stuff blue, red, and yellow, in certain proportions, the resulting colour will be black. Proceeding on this principle, Castel asserted that 15 parts of blue, 5 of red, and 3 of yellow, will produce a perfect black; but in making this statement he was influenced rather by theoretical than practical considerations. In fact he has afforded us no means of procuring these simple colours in an absolute state. It is undoubtedly true, however, that red, yellow, and blue, employed in adequate quantities, will produce black: because they will together absorb, or obstruct the passage of all coloured light, or, in other words, cause its total privation, whence blackness must result. If we suppose a piece of cloth, to which these three colours have been communicated, but not in such proportions as to produce a pure black, we shall have a tint corresponding to the colour that is in excess; as, for example, a blue, violet, red, or greenish *black;* and with paler tints we shall have a bluish, violet, red, or greenish *gray*.

Gall-nuts, and a salt of iron, so generally employed for the black dye, give merely a violet or greenish-gray, and never a pure black. The pyrolignite of iron, which contains a brown empyreumatic matter, produces a brown inclining to greenish-yellow in light shades, and to chestnut-brown in dark hues. By galling cotton and silk, after a bath of pyrolignite of iron, and repeating the processes several times, a tolerably pure black may be procured. Galls, logwood, and a salt of iron (copperas) produce merely a very deep violet-blue; but if they be applied to wool in a hot bath, with frequent exposure to air, the logwood induces a brownness which is favourable to the formation of black.

The black dye for hats is communicated by logwood, copperas, and verdigris mixed in certain proportions in the same bath; from that mixture there results a vast quantity of an ochreous muddy precipitate, amounting to 25 per cent. of the copperas employed. This mud forms a deposit upon the hats which not only corrodes the fine beaver filaments, but causes both them and the felt to turn speedily of a rusty brown. A well-dyed black hat should retain its original tint as long as it lasts,—a condition seldom realised. Beaver hats, however, to which these remarks refer, have been almost superseded by those covered with silk plush, to which a different process of dyeing applies.

Since gall-nuts give a blue precipitate with the peroxide salts of iron, they are occasionally replaced by sumach, bablah, &c.; but account should be taken in this substitution of the proportions of red or yellow colouring matter in these substances, relatively to the tannin which alone forms the blue precipitate. When a black of the best possible shade is to be given, the wool should be first grounded with indigo, then passed through a bath of logwood, sumach, and protosulphate of iron (green copperas). Sumach and nut-galls may also be employed in the proportion of 6 to $2\frac{1}{2}$; or the sumach may be replaced by nut-galls, if they be equal to one-third of the sumach prescribed. A good black may be dyed upon an indigo ground with 100 lbs. of wool, by taking 200 lbs. of logwood, 60 lbs. of sumach, $2\frac{1}{2}$ lbs. of galls, and 20 lbs. of green copperas; and giving three heats of two hours each to the wool, with airings between. A good black, without an indigo blue ground, may be given to 100 lbs. of wool, by boiling it in a bath of 25 lbs. of alum and 674 of tartar; grounding it with weld and madder; then passing it through a bath of 200 lbs. of logwood, 60 of sumach, and $2\frac{1}{2}$ of galls; taking it out, adding to the bath 20 lbs. of copperas; lastly, giving it three heats of two hours each time.

The best French black, according to Hellot, may be given to wool by first dyeing it a dark blue in the indigo vat; then washing and fulling it; then, for every 50 lbs., putting into the copper 8 lbs. of bruised galls, and as much logwood tied up in a coarse canvas bag, and boiling them for twelve hours. One-third of the bath thus prepared is to be transferred into another copper with 1 lb. of verdigris, and the wool or stuff is to be worked in this solution without intermission for two hours: the bath being kept hot, but not boiling. After taking out the stuff, another third part of the first bath is to be added along with 4 lbs. of green copperas; the fire must be lowered while this salt is being dissolved, and the bath being refreshed with a little cold water, the stuff is to be worked through it for half an hour, and then aired. Lastly, the residuary third of the first bath is to be now introduced, taking care to squeeze the contents of the bag. From 8 to 10 lbs. of sumach are added; the liquor is just made to boil, then refreshed with some cold water; after which, a pound of green copperas being dissolved in it, the stuff is again passed through it for an hour. It is now taken out, aired, washed, then returned to the copper, and worked in the bath for another hour. It is next washed at the river and fulled. A finish is prescribed in the madder-bath.

The ordinary proportions used by the English black dyers for 100 lbs. of cloth, previously treated in the indigo vat, are about 5 lbs. of copperas, as much nut-galls bruised, and 30 lbs. of logwood. They first gall the cloth, and then pass it through the decoction of logwood in which the copperas has been dissolved A finish of weld is often given after fulling; but this is of doubtful utility, especially when a little soap has been used in the fulling-mill. Vitalis prefers the pyrolignite of iron to the sulphate for the black dye, and says it produces a softer and more velvety colour—an opinion which some English chemists dispute.

The black dye vat, as it gets exhausted, is employed to dye grays of various shades.

Silk is dyed black in two methods, according to the market for which it is made. When sold by weight, as was formerly the practice at Tours, and is now with silk thread in this country, it is an object with the dyer to load it with as much colouring or other matter as possible. Sugar is at present much employed to falsify the weight of English silk thread, as any person may discover by applying a hank of it to his tongue. We have seen thread more than doubled in weight by this fraudulent device. Such silk is called *English black* by the French, who are not suffered to practise this deception. When silk is sold by superficial measure, on the other hand, it becomes the dyer's object to give it a black colour with as little weight of materials as possible. Hence the distinction well known in the trade of heavy and light silks. In this, as in many similar examples of adulteration, a desire on the part of some dealers to undersell their neighbours probably produced the evil in the first instance; and then the others joined in the fraud for self-defence.

The 25 per cent. of weight which silk has lost in scouring may be in a great measure recovered by giving it a sufficient dose of galls. For this purpose a bath is made by boiling galls equal to two-thirds or three-fourths the weight of the silk for three or four hours in a sufficient quantity of water, and then letting the decoction settle for two hours. The silk must be steeped in this bath from twenty to thirty-six hours, and then washed in clear water. The first galling is, however, commonly given with a bath somewhat spent; and for heavy blacks generally upon unscoured silk. Several successive immersions in gall-baths, and of considerable duration, are usually given to silk, with intervening washings and wringings at the peg.

The silk dyers keep up from year to year a black vat, often of very complex composition. The essential constituents of the vat are sulphate of iron and gum; but many vegetable matters, as well as filings of iron, are usually added. This bath being heated short of boiling, and then allowed to settle for about an hour, the silks are worked in it with much manipulation, occasional wringing out, airing, and redipping. As the copperas and gum get exhausted, the bath must be replenished with these ingredients in due proportions. The addition of logwood and verdigris is very useful to the black silk dye, and is now generally made. A ground of walnut peels is a good and cheap preparation for this dye.

2. *Brown or dun colour.*—This dye is not so common in England as on the Continent, where the colouring matter is generally produced at a very cheap rate by steeping ripe walnuts with their peels in water for a year or two, till the vat acquires a deep brown colour and a fetid smell. This infusion affords very agreeable and permanent brown tints without any mordant; while it preserves the downy softness of the wool, and requires but a simple and economical process. In dyeing with this infusion, a quantity of it proportional to the shade required is to be put into the copper, diluted with water, and made to boil. The cloth or yarn needs merely to be moistened beforehand with tepid water, to be then plunged in the bath, and turned about till sufficiently dyed. Some dyers, however, give the stuff a preparatory mordant of alum, and leave it to drain for twenty-four hours before subjecting it to the bath of walnut-peels.

Sumach is usually employed in this country to dye fawns, and some browns; but more beautiful browns may be given to woollen stuffs by boiling them first with one-fourth their weight of alum and some tartar and copperas, washing, and afterwards dyeing them in a madder bath. The shade of colour depends upon the proportion which the copperas bears to the alum.

A good brown may also be obtained by mordanting every pound of the stuff with two ounces of alum and one ounce of common salt in a boiling bath; and then dyeing it in a bath of logwood to which some copperas has been added; or the stuff dyed red in the madder bath may be turned about in the black dye vat till the required shade be produced.

The finest browns are produced by boiling each pound of the wool with two ounces of alum, dyeing it in a cochineal bath, and then transferring it to a bath containing a little cochineal darkened with acetate of iron. Instead of cochineal, the archil or cudbear bath may be used, with a little sumach or galls. This forms a cheaper but a more fugitive colour.

A beautiful brown tint, on wool or silk, may be obtained by first giving a pale blue shade in the indigo vat, then mordanting with alum, washing and finishing in a madder bath till the proper brown be brought up. The Saxon blue vat may also be used. If the stuff be mordanted with alum and tartar, then boiled in a madder bath, afterwards in one of weld or fustic, to which more or less copperas has been added, we shall have a mordore, cinnamon, or chestnut brown. By the combination of olive shades with red, bronze tints may be produced. For 25 lbs. of stuff a bath containing 4 lbs. of fustic will suffice. Boil the wood two hours, then turn the stuff in the bath for an hour, take it out, and drain. Add to the bath 4 or 6 ounces of copperas and a pound of madder or sandal-wood; then work the stuff in it till the wished-for shade is attained.

Silk may receive a ground of annatto, and then be dyed in a bath of logwood or Brazil wood, whereby a fine brown tint is obtained. Catechu is used for giving a bronze and brown to cotton goods. [CALICO-PRINTING.] Blue colours are dyed with indigo, Prussian blue, and woad; yellows with fustic, Persian berries, quercitron, turmeric, and weld; reds with archil or cudbear, Brazil wood, cochineal, kermes, lac, logwood, madder, safflower, or carthamus. The purple, green, and orange dyes are produced by various applications of cochineal, indigo, quercitron bark, &c.

M. Roard, long the skilful director of the Gobelins' dye-works, has observed that copper boilers exercise a considerable influence upon delicate dyes. He found that ammonia causes a blue precipitate in the alum bath made in such boilers; while it causes merely a white precipitate in the same bath made in vessels of glass, porcelain, and tin. When wool is kept for some hours in boiling water contained in a copper vessel, it acquires a greenish-gray tint,—a result increased by the ordinary mixture of alum and tartar. If into this bath white wool be plunged, it receives a greenish-yellow, or sometimes an ochrey hue. These observations of M. Roard are of considerable importance, and should lead dyers to employ tin or at least brass boilers instead of copper ones for all vivid colours. Heating with steam, either by double vessels, by straight or spiral tubes, ought on all occasions to be preferred in the dye-house to naked fires, which seldom fail to carbonise some portions of the vegetable or animal matters, and thereby to degrade the colours. The top edge or surface of the boilers should be about 3½ feet above the floor; this being a height which the workmen find most convenient for their manipulations when they stand upon a step 8 or 10 inches high.

The stuffs mordanted with alum should not be transferred to the bath immediately, but be allowed to drain and air for twenty-four hours. The colours are thereby rendered more lively than when dyed soon after the aluming. As experience has proved that an old alum bath is better than one fresh made, it should not be thrown away, but be strengthened or refreshed by the requisite additions of alum and tartar. It is certain that wools boiled in alum the second time, are more beautiful than those boiled in it the first time.

The methods of dyeing black and brown sufficiently explain the general principles, and we therefore conclude with a few observations of a general nature.

Mr. Solly, in communications recently made to the Society of Arts, has drawn attention to several matters having an important relation to the improvement of the art of dyeing. We will merely advert to two of these subjects,—the desirability of studying the chemistry of agriculture in relation to the growth of dye-plants; and the saving of freight in importing only the essential parts of dye-drugs, instead of the whole bulk.

Mr. Solly, in relation to the first of these two subjects, the influence of soil and culture on the chemistry of dye-plants, said, "It was observed that some of the madder grown near Avignon was inferior in the richness and brilliancy of its colour to that produced in other districts. The proprietor being anxious to discover the cause, was led to institute a chemical examination of the soil of his own land, in comparison with that of some of the best madder farms. The result showed that his soil was deficient in lime, while all the others contained it. He was therefore induced to give his land a good dressing of lime; and the result fully justified this course, for in the next year the crop of madder was inferior to none."

The same authority, in relation to the bulkiness of dye-materials, said, "Dye-stuffs are for the most part bulky and heavy substances, the carriage of which for any distance, by land or even by water, makes a very serious addition to their cost; consequently every mode of increasing the proportion per cent. of colouring matter is worthy of consideration; and those modes of preparation are best which yield the largest quantity of colour, and the least quantity of useless fibrous matter. Owing to the judicious manner in which the Chinese safflower is collected, it contains far more of the fine red colouring matter, and is consequently worth four or five times as much in the market as the best Bengal safflower; in addition to which, for want of due care in the drying, the latter is sometimes so much injured during the sea voyage as to be deteriorated fifty per cent. The loss thus sustained is often set down to the nature of the drug, and not to the careless habits of those employed in collecting it. When we remember how many thousand tons of dye-woods are annually imported, and how many thousand tons of it are absolutely useless woody fibre, we cannot help coming to the conclusion that here chemical science might be applied with great advantage; and that if colonists could be taught how to extract and concentrate the true colouring principle of these woods, much unprofitable labour and expense might be spared. Nay, more, the concentrated dye-stuff might be profitably imported from places from which the cost of carriage would altogether prevent the importation of the dye-stuff in its raw state. This is a matter of great practical importance, and one which has not yet received that attention it deserves. There are no doubt difficulties in the way; but after the many triumphs which man has achieved, we surely need not be deterred by any ordinary difficulties."

To the above we may add a few valuable observations, made by Mr. Simmonds in his 'Commercial Products of the Vegetable Kingdom,' on the useful qualities of many simple and well-known plants, and other substances, as dye-materials. "The beauty of the dyes given by common materials, in the Highlands of Scotland, to some of the cloths which were exhibited [at the Great Exhibition of 1851], should lead our botanists and chemists to examine more closely than they have hitherto done, the dye-stuffs that might be extracted from British plants. Woad, and the dyers' yellow wood, are both well known. A piece of tweed, spun and woven in Ross-shire, was dyed brown and black by such cheap and common dyes as moss and alder-bark; and the colours were unexceptionable. Sutherlandshire tweeds and stockings, possessing a rich brown colour, were produced with no more valuable dye than soot; in another piece, beautifully dyed, the yellow was obtained from stony rag; brown from the crops of young heather; and purple from the same, but subjecting the yarns to a greater action of the dye than was necessary to produce brown. There is very little doubt but that beautiful and permanent dyes, from brown to a very rich purple, might be cheaply produced by scientific preparations of the common heather. The inhabitants of Skye exhibited cloth with a peculiarly rich dye, obtained from the Crobal moss."

It has been shown in former articles [BLEACHING; CALICO PRINTING] that the legislature has sought to throw a shield of protection around the women and children employed in bleach and print works; that this attempt succeeded so far as concerned print works; but that bleach works still remain exempt from the operation of the Factory Acts. We have now to add that dye works are in the same category as bleach works. In the years 1854-5-6-7, both classes of establishments were subject to many parliamentary discussions, and to inquiries by commissioners—ending by a postponement of all legislation thereon.