IX. Conſiderations relative to the Nature of Wool, Silk, and Cotton, as Objects of the Art of Dying; on the various Preparations, and Mordants, requiſite for theſe different Subſtances; and on the Nature and Properties of colouring Matter. Together with ſome Obſervations on the Theory of Dying in general, and particularly the Turkey Red; by Mr. THOMAS HENRY, F. R. S. and of the American Philoſophical Society.

From the MEMOIRS of the LITERARY and PHILOSOPHICAL SOCIETY of MANCHESTER.

PART I.

IN the following memoir, on a ſubject to which too little attention has been directed by Engliſh writers, my principal intention is to preſent, at

one view, the preparatory and other proceſſes for the dying of wool, ſilk, and cotton; and to endeavour to deduce a theory better ſuited to account for the reſults than has hitherto been advanced. In the execution of this undertaking, it will be neceſſary to repeat ſeveral things from Hellot, Macquer, and d'Apligny, who have written ſeparate treatiſes on the dying of theſe materials; and I am to confeſs great obligations to that very celebrated chemiſt M. Berthollet, whoſe reſearches are, every day, affording new and important information in the ſeveral departments of the hermetic art.

The art of dying, or of imparting to different materials, employed for the fabrication of garments and furniture, thoſe beautiful colours which are afforded by many articles of the vegetable, animal, and mineral kingdoms, appears to have been of high antiquity *. As moſt of theſe materials are, of themſelves, either of dark and diſagreeable colours, or elſe devoid of all colour, it is probable, that, even in the very earlieſt ages,

* Delaval on light and colours.

the

the love of ornament, which is natural to mankind, would induce them to ſtain their veſtments with various colouring ingredients, eſpecially with vegetable juices. But the art of imparting *permanent* dyes to cloth, and affixing to its fibres ſuch colouring materials as could not eaſily be waſhed out by water, or 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; this 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 in long proceſs of time.

It has been proved by our ingenious aſſociate Mr. Delaval, that the Egyptians were poſſeſſed of the art of dying, and even of that of printing on cloths. In a paſſage which he has quoted from Pliny, that author relates, that the Egyptians having beſmeared, or drawn on, white cloth, with various ſubſtances, which were in themſelves colourleſs, but capable of abſorbing colouring matter, threw it into a caldron of hot liquor,

tinged with dying materials, and that, though the parts, thus drawn upon, were not diſtinguiſhable before the cloth was immerſed in the colouring liquor, and though this liquor contained only one colour, it was ſurpriſing to ſee the cloth taken out ſtained with ſeveral different colours, according as the different parts of it had been impregnated with the various ſubſtances capable of receiving and altering the nature of the pigment.

This is ſo plain a deſcription of the art of what is now called callico-printing, that though it is my intention to refer thoſe gentlemen, who wiſh to be more intimately acquainted with the ancient hiſtory of dying, to that written by Mr. Delaval, and prefixed to his ingenious treatiſe on light and colours, yet I could not refrain from relating it on this occaſion.

Permit me alſo to mention another hiſtorical fact, from the ancient hiſtory of this art. The Phœnicians held a decided pre-eminence in the tinctorian art, for many ages; their purple and ſcarlet cloths were ſought after by every civilized 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 monopolizing the wearing of the beautiful cloths of Tyre, theſe misjudging 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. The enacting and enforcing of ſumptuary laws requires great judgement and delicacy, and much caution ſhould be uſed, leſt, in curbing exceſſive luxury, the arts, which are ſupported by its moderate indulgence, ſhould be deſtroyed: ſuch, however, was the fate of the Tyrian dyes. 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, ſickened, and expired, and, with the trade, the art likewiſe periſhed.

This example, of the interference of government ſo materially injuring, and even annihilating, an uſeful art, and the commerce depending on it, though carried to an exceſs never likely to be imitated

imitated in theſe days, ſhould make miniſters cautious that they do not form laws which may diſcourage or fetter our manufactures; for freedom is the very ſoul of trade, and in proportion as the one is invaded, the other will certainly decline.

In this nation, the art of dying had made no conſiderable progreſs till about the beginning of the laſt century *; before that period our cloths were ſent to Holland to be dreſſed and dyed. Probably, however, this was practiſed only in the caſe of particular colours; for it appears that the dyers of London received their charter of incorporation from Henry the Sixth. My friend Mr. Charles Taylor has put into my hands a ſmall tract, entituled, *A profitable Book, declaring Divers approved Remedies to take out Spots and Staines, in Silkes, Velvets, Linen, and Woollen Clothes; with divers Colours how to dye Velvets and Silkes, Linen and Woollen, Fuſtian and Threade. Alſo to dreſs Leather, and to colour Felles, &c. &c. very neceſſarie for all men, eſpecially for thoſe who hath or*

* Chambers's Cyclopædia, article Dying.

ſhall

ſhall have any Doings therein; with a perfect Table thereto, to find all Things ready, not the like reveled in England heretofore. Taken out of Dutche and Engliſhed by L. M. imprinted at London, by Thomas Parfoot, dwelling in the New Rents, 1596.

This little book, publiſhed at ſo early a period, contains many good proceſſes, and it is to be lamented that, during ſo long a lapſe of time, the Engliſh nation has not produced any work on this ſubject, that I know of, much ſuperior to it. The mode of computing the length of time, employed in many of the proceſſes contained in this publication, is curious. The immerſion of the ſubject in the dying liquor is, in general, ordered to be continued, not for ſo many minutes, but for five, ſix, or ſeven *pater-noſters* long.

The dying of woollen and ſilken goods has long ſince attained a conſiderable degree of excellence, while the manufactures of cotton, owing to the ſmall attraction of that ſubſtance for colouring matter, have been very deficient in this point. Till within theſe few years, the colours employed in the dying of fuſtians and cotton velvets were few; and, even at this day, many of them are fugitive.

fugitive. But it muſt be allowed that great improvements have been made within theſe few years; improvements principally owing to the ingenuity and public ſpirit of Mr. Wilſon, of this ſociety, who, by the application of chemical principles, and by a diligent inveſtigation of the nature of colouring ſubſtances, laid the foundation on which the preſent fabric is erected.

Much room is, however, ſtill left for the improvement of the art; and I am convinced that it is only by our practical dyers acquiring chemical knowledge, that it can ever be effected, to any great extent. While men do not underſtand the grounds on which they ſhould proceed, many errors muſt ariſe; many needleſs materials muſt be employed; and much expence, which might be ſpared, muſt be incurred. To promote this deſirable end, I ſhall, with the permiſſion of this ſociety, lay before them, not only ſuch information as I have extracted from the beſt writers on the ſubject, but ſuch facts as I have been able to collect, and obſervations which I have had opportunities of making, tending to form a juſt

theory

theory of dying, and eſpecially of thoſe proceſſes where mordants are employed.

The variety, which obtains in the facility with which animal and vegetable ſubſtances attract colouring matter, is a curious ſubject for inveſtigation. It is known that ſome colouring ingredients, which are moſt readily imbibed, and tenaciouſly held, by wool, have much leſs effect on ſilk, and are either wholly rejected, or very ſlightly attached to cotton or linen: different preparations and mordants, applied under different circumſtances, are requiſite for theſe ſeveral materials. M. du Fay's experiment, which he made before the Royal Academy of Sciences, has been ſo often related, that I ſhall not quote the particulars. Let us rather refer to the theories which have been advanced to account for theſe phenomena; enquire how far they appear to be founded on truth; and give the chemical analyſis of the various ſubſtances, which may perhaps ſerve to throw ſome new light on the ſubject.

Theſe phenomena have been variouſly explained: ſome have attributed the variety in the power of the ſeveral ſubſtances to retain the dying

ingredients applied to them, to the different ſtructure of their filaments; to the poroſity of wool, and to the impenetrability of cotton and linen *; at leaſt to the latter poſſeſſing pores of much inferior dimenſions; ſilk being ſuppoſed to hold a middle rank. Wool, ſay theſe theoriſts, is compoſed of numerous filaments, ſimilar to hairs, and, like them, conſiſting of tubes containing a medullary or oily matter. The ſides of theſe tubes are alſo perforated with an infinite number of ſmall orifices, communicating with the longitudinal canal. From this mechaniſm, it is excellently adapted for receiving extraneous bodies, which are not only capable of being applied to the ſuperficial pores of the filaments, but even of penetrating into the interior ſtructure of the tubes, when diveſted of the *medulla* they naturally contain.

Silk is deſcribed, by theſe writers, as a glutinous liquor, formed in, and excreted from, the body of the ſilk-worm; who ſpins it into a kind of thread, which hardens on expoſure to the air.

* D'Apligny; Art de la Teinture des fils, & étoffes de coton.

An operation which is facilitated by another ſubſtance, analogous to wax, which the worm alſo ſecretes, and with which the ſurface of the filament is varniſhed. This thread being formed by a continued ſeries of the dried glutinous particles, in the act of drying many pores muſt be formed on its ſurface. But theſe pores are ſuperficial; and the thread not containing a longitudinal canal, is therefore incapable of admitting any but minutely-divided particles, and thoſe in very limited quantities; and, as theſe particles cannot penetrate deeply into the ſubſtance of the ſilk, they require, for their confinement, ſome addition which ſhall more ſtrongly agglutinate them than is neceſſary in the dying of wool. Hence the difficulty of attaching permanent colours to ſilk; and hence the greater waſte of the dying materials; for as only the fineſt particles can be admitted into the pores, the remainder is loſt.

Cotton is repreſented as a filamentous ſubſtance, envelloping the ſeed of the cotton plant. The filaments are ſaid to be tubular, and, like wool, to have exterior lateral pores, communicating with the longitudinal tubes. Theſe are much

ſmaller than thoſe of wool, and are filled with an unctuous matter, of which they muſt be deprived before they can be penetrated by the particles of the dying materials. This matter is difficult of ſolution, and hence, and from the minuteneſs of the tubes, ariſes the labour requiſite to complete the dying of cotton. That it really contains this unctuous ſubſtance is evident, they add, from the ſlow manner in which cotton imbibes water previous to its being prepared or ſcoured, and from its increaſed power of abſorption ſubſequent to that operation; by which alſo, though opaque before, it is rendered clear and tranſparent.

Linen, in the ſtate of flax, is probably alſo porous; but its pores being ſmaller than thoſe of the other ſubſtances, and being of a more compact texture, they admit with more difficulty the tinging particles, eſpecially thoſe of the good dye. The particles of the falſe dye, however, find pretty eaſy admittance. But, when the flax is ſpun, a number of accidental pores are formed in the thread, into which the particles of the greater or true dye may enter, and be better retained than in the flax; and for this reaſon the

twiſted

twiſted thread takes a better colour than either the flax, or *ſingle* thread.

If we allow the authenticity of the above facts, they will certainly account, in a ſatisfactory manner, for the different effects produced, by the ſame tinging materials, on ſubjects compoſed of wool, to thoſe produced on ſilk, cotton, or linen. If they be all porous, and the dimenſions of the pores of each be different, the ſubſtance which has the largeſt pores will be capable of receiving a much greater portion of tinging matter, than that which has the ſmalleſt. It may ſeem ſome confirmation of this theory that cloths, woven in various modes, are ſaid to receive colour more or leſs freely, according to their texture. But perhaps the various ſhades, obſervable in theſe caſes, may proceed from ſome circumſtances in the reflection and tranſmiſſion of the rays of light, ariſing from the alteration in the poſition of the reflecting and tranſmitting bodies.

To this theory it has been objected, and with much appearance of reaſon *, that the colouring

* Macquer, Dictionnaire de Chymie, edit. 2. vol. IV.

matter

matter is not merely inſinuated into the pores of the ſubſtance to be dyed, but becomes firmly attached to it; and that, the more numerous and large the pores are, the more of the colouring matter ſhould be abſorbed, and, as it were, hidden within them; whereas wool, which is ſuppoſed to contain pores more numerous and large than thoſe of ſilk, receives an equally brilliant crimſon from two parts of cochineal as is produced by five parts on ſilk; both ſubjects being prepared in the ſame manner, by aluming. And this, not becauſe the ſilk rejects any of the colouring particles of the cochineal, for the liquor is equally exhauſted of colour in one caſe as in the other, but it ſhould ſeem that ſilk can abſorb much more colouring matter, and yet is much leſs eaſily dyed, than wool. It is, therefore, more probable that dying is a mere application of colouring matter to the fibres of the materials to be dyed, aided by a chemical attraction between theſe ſubſtances; and that the entrance of the colour into the pores of the cloth, &c. is an ill-founded hypotheſis.

But is it not probable, admitting that a different mechaniſm may exiſt in the ſtructure of theſe ſubſtances, that there may alſo be a difference in the nature of their conſtituent or proximate principles; which may vary the force of their attraction for the tinging matter, or for thoſe ſubſtances which are uſed as baſes for that matter to adhere to, into the nature of which we ſhall hereafter examine. Neuman analyzed by fire, wool, ſilk, and cotton, and he found them to conſiſt of proximate principles differing in each from thoſe of the others *.

From one pound, avoirdupois, of wool, he obtained by diſtillation one ounce ſix drachms of volatile alkaline ſalt, ſeven ounces of urinous ſpirit, and two ounces and a half of empyreumatic oil; the *caput mortuum* weighed three ounces ſix drachms, of which two drachms were diſſipated by calcination.

Silk yielded, from a ſimilar weight, nine ounces of mixed matter, conſiſting of four ounces two drachms of urinous ſpirit, three ounces ſix

* Neuman's Chemiſtry by Lewis, vol. II.

drachms

drachms of volatile ſalt, and one ounce of empyreumatic oil. The reſiduum weighed ſeven ounces, loſt one ounce on calcination, and then afforded to water forty grains of fixed ſaline matter.

Cotton did not yield the ſame fœtid ſmell as wool when burned in the open air, nor any urinous ſalt or ſpirit in cloſe veſſels. A pound, avoirdupois, of cotton gave over, on diſtillation, ſeven ounces of an acidulous, fuliginous, oily ſpirit, and about ten drachms of an empyreumatic oil; the remaining coal was reduced, by calcination in a crucible, to eight ſcruples of white aſhes, which afforded a ſmall portion of fixed alkali. Monſieur Berthollet, a very ingenious French chemiſt, has lately analyzed theſe ſubſtances in a different manner *.

On diſtilling ſilk with nitrous acid, he obtained ſaccharine acid, and a greaſy matter, which, though it at firſt congealed on the ſurface of the liquor in the receiver, was afterwards diſſolved in it, by means of heat, even though diluted with

* Journal de Phyſique, vol. XXIX. Part II.

water

water, with which it paſſed through the filter. Wool alſo afforded the ſame greaſy matter, and acid of ſugar; the latter in much larger portion than any other ſubſtance which he treated in the ſame manner. But the oil of vegetable ſubſtances was entirely deſtroyed by this treatment, no greaſy matter being produced; on analyzing cotton, he procured ſaccharine acid, but no other product, and the quantity of that acid was far inferior to that yielded by animal ſubſtances *.

* M. Berthollet found the portion of ſaccharine acid, yielded by cotton, to be very ſmall indeed; nor did he find any other reſiduum in the retort, or any thing but the pure nitrous acid in the receiver. Almoſt the whole, therefore, of this vegetable matter ſeems to have been changed from a ſolid to an aërial form, and to have been diſſipated as gas; a ſtate to which the ſaccharine acid is alſo eaſily reducible. Thus, ſays he, probably are the moſt ſolid bodies convertible into elaſtic vapours; as, on the other hand, the moſt compact ſubſtances in nature may be formed by the union of different gaſes.

The ſaccharine acid was firſt diſcovered by Bergman in ſugar, but is obtainable from many other ſubſtances, both animal and vegetable, which contain its baſis, particularly from galls, which yield it in great abundance.

It ſhould appear then, that there is a conſiderable difference between the conſtituent parts of animal and vegetable ſubſtances. Animal ſubſtances contain much more oil than vegetable ones; and this oil is ſoluble in water, which the vegetable oil is not. The animal oil, on diſtillation, yields an alkaline, the vegetable, an acid, liquor. On the different properties of theſe oils, the diſtinction between the nature of animal and vegetable ſubſtances ſeems chiefly to depend. It is to be remarked, (in the analyſis of wool by M. Berthollet,) that though animal ſubſtances yielded much volatile alkali on diſtillation, no nitrous ammoniac was formed in his proceſs, which might have been expected, had the alkali been previouſly contained in the wool. This fact favours the opinion that the volatile alkali is formed during the proceſs of diſtillation. It is at leaſt probable that the alkali is ſo combined in animal bodies, as to require the aid of heat to free it from thoſe ſubſtances which neutralize or conceal it. Or, as we know that there is a ſtrong reſemblance between volatile alkali and the inflammable principle, may we not ſuppoſe that this

principle

principle may be forced, by heat, into combination with the animal acid, and the alkali be thus created *? Vegetables yield but little of this volatile alkali, but much acid liquor.

It may be added, that vegetable ſubſtances, whoſe oil is wholly deſtroyed by nitrous acid, and to whoſe texture the mineral acids in general are highly injurious, bear ſteeping in ſolutions of cauſtic alkali, of ſuch ſtrength as would prove totally deſtructive to wool.

How far theſe varieties, in the component parts of animal and vegetable ſubſtances, may influence their power of attracting colouring matter, I do not pretend to determine; but the propriety of a different previous treatment ſeems clearly deducible from them.

Wool has naturally ſo ſtrong an attraction for colouring matter as to need but little preparation,

* M. Berthollet has ſince proved the volatile alkali to be formed by the union of inflammable, with phlogiſticated, gas; and that it does not exiſt in animal ſubſtances, previous to their diſtillation or putrefaction. The effects therefore that have been aſcribed to the ſuppoſed volatile alkali of theſe ſubſtances, in the proceſſes of dying, muſt depend on ſome other cauſe.

previous to the more immediate proceſſes of dying; it is only neceſſary to ſcour from it a greaſy or fatty ſubſtance, called the *yolk*, which is contained in the fleece. For this purpoſe an alkaline liquor is neceſſary; but, as alkalies injure the texture of the wool, it is requiſite that a very dilute ſolution be employed; for, were the quantity of ſalt greater than is ſufficient for converting the yolk into a ſoap, it would attack the ſubſtance of the wool. Putrid urine, therefore, is generally uſed, as being cheap, and containing a volatile alkaline ſalt which, uniting with the greaſy matter, renders it ſoluble in water *.

* Hellot, Art de la Teinture des Laines, &c.

TO BE CONTINUED IN OUR NEXT.