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EXPERIMENTS
AND
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CONSIDERATIONS
Touching
COLOURS.

First occasionally Written, among some other *Essays*, to a Friend; and now suffer'd to come abroad as

THE
BEGINNING
Of An
EXPERIMENTAL HISTORY
OF
COLOURS.

By the Honourable *ROBERT BOYLE*,
Fellow of the ROYAL SOCIETY.

Non fingendum, aut excogitandum, sed inveniendum, quid Natura faciat, aut ferat. Bacon.

LONDON,
Printed for *Henry Herringman* at the *Anchor* in the Lower-walk of the *New-Exchange*. MDC LXX.

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THE PREFACE.

Having in convenient places of the following Treatise, mention'd the Motives, that induc'd me to write it, and the Scope I propos'd to my self in it, I think it superfluous to entertain the Reader now with what he will meet with hereafter. And I should judge it needless, to trouble others, or my self, with any thing of Preface: were it not that I can scarce doubt but this Book will fall into the hands of some Readers, who being unacquainted with the difficulty of attempts of this nature, will think it strange that I should publish any thing about Colours, without a particular Theory of them. But I dare expect that Intelligent and Equitable Readers will consider on my behalf: That the professed Design of this Treatise is to deliver things rather Historical *than*

Dogmatical, *and consequently if I have added divers new* speculative *Considerations and hints, which perhaps may afford no despicable Assistance towards the framing of a solid and comprehensive Hypothesis, I have done at least as much as I promis'd, or as the nature of my Undertaking exacted. But another thing there is, which if it should be objected, I fear I should not be able so easily to answer it, and that is; That in the following Treatise (especially in the third part of it) the Experiments might have been better Marshal'd, and some of them deliver'd in fewer words. For I must confess that this Essay was written to a private Friend, and that too, by snatches, at several times, and places, and (after my manner) in loose sheets, of which I oftentimes had not all by me that I had already written, when I was writing more, so that it needs be no wonder if all the Experiments be not ranged to the best Advantage, and if some connexions and consecutions of them might easily have been mended. Especially since having carelesly laid by the loose Papers, for several years after they were written, when I came to put them together to dispatch them to the Press, I found some of those I reckon'd upon, to be very unseasonably wanting. And to make any great change in the order of the rest, was more than the Printers importunity, and that, of my own avo-*

cations

cations (and perhaps also considerabler sollicitations) would permit. But though some few preambles of the particular Experiments might have (perchance) been spared, or shortened, if I had had all my Papers under my View at once; Yet in the most of those Introductory passages, the Reader will (I hope) find hints, or Advertisements, as well as Transitions. If I sometimes seem to insist long upon the circumstances of a Tryal, I hope I shall be easily excused by those that both know, how nice divers experiments of Colours are, & consider, that I was not barely to relate *them, but so as to teach a young Gentleman to make them. And if I was not sollicitous, to make a nicer division of the whole Treatise, than into three parts, whereof the One contains some considerations about Colours in general. The Other exhibits a specimen of an Account of particular Colours, Exemplified in Whiteness and Blackness. And the Third, promiscuous Experiments about the remaining Colours (especially Red) in order to a Theory of them. If I say, I contented my self with this easie Division of my Discourse, it was perhaps because I did not think it so necessary to be curious about the Method or Contrivance of a Treatise, wherein I do not pretend to present my Reader with a compleat Fabrick, or so much as Model; but only to bring in Materials proper for the Building; And if I*

did not well know how Ingenious the Curiosity and Civility of Friends makes them, to perswade Men by specious allegations, to gratifie their desires; I should have been made to believe by persons very well qualify'd to judge of matters of this nature, that the following Experiments will not need the addition of accurate Method & speculative Notions to procure Acceptance for the Treatise that contains them: For it hath been represented, That in most of them, as the Novelty will make them surprizing, and the quickness of performance, keep them from being tedious; so the sensible changes, that are effected by them, are so manifest, so great, and so sudden, that scarce any will be displeased to see them, and those that are any thing Curious will scarce be able to see them, without finding themselves excited, to make Reflexions upon them. But though with me, who love to measure Physical things by their use, not their strangeness, *or* prettiness, *the partiality of others prevails not to make me over-value these, or look upon them in themselves as other than Trifles: Yet I confess, that even since I did divers years ago shew some of them to a Learned Company of* Virtuosi: *so many persons of differing Conditions, and even Sexes, have been Curious to see them, and pleas'd not to Dislike them, that I cannot Despair, but that by complying with those that urge the Publica-*

tion

tion of them. I may both gratifie and excite the Curious, and lay perhaps a Foundation, whereon either others or my self may in time superstruct a substantial Theory of Colours. And if Aristotle, *after his Master* Plato, *have rightly observ'd Admiration to be the* Parent of Philosophy, *the wonder, some of these Trifles have been wont to produce in all sorts of Beholders, and the access they have sometimes gain'd even to the Closets of Ladies, seem to promise, that since the subject is so pleasing, that the Speculation appears as Delightful as Difficult, such easie and recreative Experiments, which require but little time, or charge, or trouble in the making, and when made are sensible and surprizing enough, may contribute more than others, (far more important but as much more difficult) to recommend those parts of Learning (Chymistry and Corpuscular Philosophy) by which they have been produc'd, and to which they give Testimony even to such kind of persons, as value a pretty Trick more than a true Notion, and would scarce admit Philosophy, if it approached them in another Dress: without the strangeness or endearments of pleasantness to recommend it. I know that I do but ill consult my own Advantage in the consenting to the Publication of the following Treatise: For those things, which, whilst men knew not how they were perform'd,*

appeared so strange, will, when the way of making them, and the grounds on which I devis'd them, shall be Publick, quickly lose all that their being Rarities, *and their* being thought Mysteries, *contributed to recommend them. But 'tis fitter for Mountebanks than Naturalists to desire to have their discoveries rather admired than understood, and for my part I had much rather deserve the thanks of the Ingenious, than enjoy the applause of the Ignorant. And if I can so far contribute to the discovery of the nature of Colours, as to help the Curious to it, I shall have reach'd my End, and saved my self some Labour, which else I may chance be tempted to undergo in prosecuting that Subject, and adding to this Treatise, which I therefore call a* History, *because it chiefly contains matters of fact, and which History the Title declares me to look upon but as* Begun: *Because though that above a hundred, not to say a hundred and fifty Experiments, (some loose, and others interwoven amongst the discourses themselves) may suffice to give a* Beginning *to a History not hitherto, that I know, begun by any; yet the subject is so fruitful, and so worthy, that those that are Curious of these Matters will be far more wanting to themselves than I can suspect, if what I now publish prove any more than a* Beginning. *For, as I hope my Endeavours*

may

may afford them some assistance towards this work, so those Endeavours are much too Unfinished to give them any discouragement, as if there were little left for others to do towards the History of Colours.

For (first) I have been willing to leave unmention'd the most part *of those Phænomena of Colours, that Nature presents us of her own accord, (that is, without being guided or overruled by man) such as the different Colours that several sorts of Fruits pass through before they are perfectly ripe, and those that appear upon the fading of flowers and leaves, and the putrefaction (and its several degrees) of fruits, &c. together with a thousand other obvious instances of the changes of colours. Nor have I* much *medled with those familiar Phænomena wherein man is not an idle spectator; such as the Greenness produc'd by salt in Beef much powder'd, & the Redness produc'd in the shells of Lobsters upon the boyling of those fishes; For I was willing to leave the* gathering *of* Observations *to those that have not the opportunity to make* Experiments. *And for the same reasons, among others, I did purposely omit the Lucriferous practise of Trades-men about Colours; as the ways of making Pigments, of Bleanching wax, of dying Scarlet, &c. though to divers of them I be not a Stranger, and of some I have my self made Tryal.*

Next

Next; *I did purposely pass by divers Experiments of other Writers that I had made tryal of* (*and that not without registring some of their Events*) *unless I could some way or other improve them, because I wanted leisure to insert them, and had thoughts of prosecuting the work once begun of laying together those I had examin'd by themselves in case of my not being prevented by others diligence. So that there remains not a little, among the things that are already published, to imploy those that have a mind to exercise themselves in repeating and examining them. And I will not undertake, that* none *of the things deliver'd, even in this Treatise, though never so faithfully set down, may not prove to be thus far of this Sort, as to afford the Curious somewhat to add about them. For I remember that I have somewhere in the Book it self acknowledged, that having written it by snatches, partly in the Country and partly at unseasonable times of the year, when the want of fit Instruments, and of a competent variety of flowers, salts, Pigments, and other materials made me leave some of the following Experiments, (especially those about Emphatical Colours) far more unfinish'd than they should havee been, if it had been as easie for me to* supply *what was wanting to compleat them, as to* discern. *Thirdly, to avoid discouraging the young Gentleman I call* Pyrophilus, *whom*

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the leſs Familiar, and more Laborious operations of Chymiſtry would probably have frighted, I purpoſely declin'd in what I writ to him, the ſetting down any Number of ſuch Chymical Experiments, as, by being very elaborate or tedious, would either require much skill, or exerciſe his patience. And yet that this ſort of Experiments is exceedingly Numerous, and might more than a little enrich the Hiſtory of Colours, thoſe that are vers'd in Chymical proceſſes, will, I preſume, eaſily allow me.

And (laſtly) for as much as I have occaſion more than once in my ſeveral Writings to treat either purpoſely or incidentally of matters relating to Colours; I did not, perhaps, conceive my ſelf oblig'd, to deliver in one Treatiſe all *that I would ſay concerning that ſubject.*

But to conclude, by ſumming up what I would ſay concerning what I have *and what I* have not *done, in the following Papers; I ſhall not* (on the one ſide) *deny, that conſidering that I pretended not to write an accurate Treatiſe of Colours, but an Occaſional Eſſay to acquaint a private friend with what then occurred to me of the things I had thought or try'd concerning them; I might preſume I did enough for once, if I did clearly and faithfully ſet down, though not* all *the Experiments I could, yet at leaſt ſuch a*

variety

variety of them, that an attentive Reader that shall consider the Grounds on which they have been made, and the hints that are purposely (though dispersedly) couched in them, may easily compound *them, and otherwise* vary *them, so as very much to increase their Number. And yet* (on the other side) *I am so sensible both of how much I have, either out of necessity or choice, left undone, and of the fruitfulness of the subject I have begun to handle; that though I had performed far more than 'tis like many Readers will judge I have, I should yet be very free to let them apply to my Attempts that of* Seneca, *where having spoken of the Study of Natures Mysteries, and Particularly of the Cause of Earth-Quakes, he subjoins.* Nulla res consummata est dum incipit. Nec in hac tantum re omnium maxima ac involutissimâ, in quâ etiam cum multum actum erit, omnis ætas, quod agat inveniet; sed in omni alio Negotio, longè semper à perfecto fuere Principia.

L. Annæ. 1. Senecæ Natur. Quæst. l. 6. c. 5.

The

The Publiſher to the READER.

Friendly Reader,

HEre is preſented to thy view one of the Abſtruſeſt as well as the Gentileſt Subjects of Natural Philoſophy, the *Experimental Hiſtory of Colours*; which though the Noble Author be pleaſed to think but *Begun*, yet I muſt take leave to ſay, that I think it ſo well begun, that the work is more than half diſpatcht. Concerning which I cannot but give this Advertiſement to the Reader, that I have heard the Author expreſs himſelf, that it would not ſurpriſe him, if it ſhould happen to be objected, that ſome of theſe Experiments have been already publiſhed, partly by Chymiſts, and partly by two or three very freſh Writers upon other Subjects. And though the number of theſe Experiments be but very ſmall, and though they be none of the conſiderableſt, yet it may on this occaſion be further repreſented, that it is eaſie for our Author to name ſeveral men, (of whoſe number I can truly name my

ſel-

self) who remember either their having seen him make, or their having read, his Accounts of the Experiments delivered in the following Tract several years since, and long before the publication of the Books, wherein they are mentioned. Nay in divers passages (where he could do it without any great inconvenience) he hath struck out Experiments, which he had tryed many years ago, because he since found them divulged by persons from whom he had not the least hint of them; which yet is not touched, with design to reflect upon any Ingenious Man, as if he were a Plagiary: For, though our Generous Author were not reserved enough in shewing his Experiments to those that expressed a Curiosity to see them (amongst whom a very Learned Man hath been pleased publickly to acknowledge it several years ago*; yet the same thing may be well enough lighted on by persons that know nothing of one another

* *He that desires more instances of this kind and matter, that according to this doctrine may much help the Theory of colours, and particularly the force both of Sulphureous and volatile, as likewise of Alcalizate and Acid Salts, and in what particulars, Colours likely depend not in their causation from any Salt at all, may beg his information from M. Boyle, who hath some while since honoured me with the sight of his Papers concerning this subject, containing many excellent experiments, made by him for the Elucidation of this doctrine, &c. Dr. R. Sharrock in his ingenious and useful History of the Propagation and Improvement of Vegetables, published in the year 1660.*

another. And especially Chymical Laboratories may many times afford the same *Phænomenon* about Colours to several persons at the same or differing times. And as for the few *Phænomena* mention'd in the same Chymical Writers, as well as in the following Treatise, our Author hath given an account, why he did not decline rejecting them in the Anotations upon the 47. Experiment of the third part. Not here to mention, what he elsewhere saith, to shew what use may be Justifiably made of Experiments not of his own devising by a Writer of Natural History, if, what he employs of other mens, be well examined or verified by himself.

In the mean time, this Treatise is such, that there needs no other invitation to peruse it, but that 'tis composed by one of the deepest and most indefatigable Searchers of Nature, which, I think the World, as far as I know it, affords. For mine own part, I feel a secret Joy within me, to see such beginnings upon such *Themes*, it being demonstratively true, *Mota facilius Moveri*, which causeth me to entertain strong hopes, that this Illustrious *Virtuoso* and Restless Inquirer into Nature's Secrets will not stop here, but go on and prosper in the Disquisition of the other principal Colours, *Green*, *Red*, and *Yellow*. The Reasoning faculty set once

once a float, will be carried on, and that with ease, especially, when the productions thereof meet, as they do here, with so greedy an Entertainment at home and abroad. I am confident, that the *ROYAL SOCIETY*, lately constituted by his *MOST EXCELLENT MAJESTY for improving Natural knowledge*, will judge it their interest to exhort our Author to the prosecution of this Argument, considering, how much it is their design and business to accumulate a good stock of such accurate Observations and Experiments, as may afford them and their Off-spring genuine Matter to raise a Masculine Philosophy upon, whereby the Mind of Man may be enobled with the Knowledge of solid Truths, and the Life of Man benefited with ampler accommodations, than it hath been hitherto.

Our Great Author, one of the Pillars of that Illustrious Corporation, is constantly furnishing large *Symbola's* to this work, and is now fall'n, as you see, upon so comprehensive and important a Theme, as will, if insisted on and compleated, prove one of the considerablest pieces of that structure. To which, if he shall please to add his Treatise of *Heat* and *Flame*, as he is ready to publish his

Experi-

Experimental Accounts of *Cold*, I esteem, the World will be obliged to Him for having shewed them both the *Right* and *Left-Hand* of Nature, and the Operations thereof.

The considering Reader will by this very Treatise see abundant cause to sollicit the Author for more; sure I am, that of whatever of the Productions of his Ingeny comes into *Forreign parts* (where I am happy in the acquaintance of many intelligent friends) is highly valued; And to my knowledge, there are those among the French, that have lately begun to learn English, on purpose to enable themselves to read his Books, being impatient of their Traduction into Latin. If I durst say all, I know of the Elogies received by me from abroad concerning Him, I should perhaps make this Preamble too prolix, and certainly offend the modesty of our Author.

Wherefore I shall leave this, and conclude with desiring the Reader, that if he meet with other faults besides those, that the Errata take notice of (as I believe he may) he will please to consider both the weakness of the Authors eyes, for not reviewing, and the manifold Avo-

cations of the Publisher for not doing his part; who taketh his leave with inviting those, that have also considered this Nice subject experimentally, to follow the Example of our Noble Author, and impart such and the like performances to the now very inquisitive world. *Farewel.*

H. O.

THE

THE CONTENTS.

CHAP. I.

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Part the Second.

Of the Nature of Whiteness and Blackness.

CHAP. I.

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Errata:

Pag. 142. l. 20. These words, *And to manifest*, with the rest of what is by a mistake further printed in this fourth Experiment, belongeth, and is to be referred to the end of the second Experiment, p. 137.

THE *EXPERIMENTAL HISTORY OF COLOURS' BEGUN.*

THE FIRST PART.

CHAP. I.

1 I Have ſeen you ſo paſſionately addicted, *Pyrophilus*, to the delightful Art of Limning and Painting, that I cannot but think my ſelf obliged to acquaint you with ſome of thoſe things that have occurred to me concerning the changes of Colours. And I may expect that I ſhall as well ſerve the *Virtuoſi* in general, as gratifie you in particular, by furniſhing a perſon, who, I hope, will both improve my Communications, and communicate his Improvements, with ſuch Experiments and Obſervations as may both invite you to enquire ſeriouſly into the Nature of Colours, and aſſiſt you in the Inveſtigation of it. This being the principal ſcope of the following Tract, I ſhould do that which might prevent my own deſign,

if I ſhould here attempt to deliver you an accurate and particular Theory of Colours; for that were to preſent you with what I deſire to receive from you; and, as far as in me lay, to make that ſtudy needleſs, to which I would engage you.

2. Wherefore my preſent work ſhall be but to divert and recreate, as well as excite you by the delivery of matters of fact, ſuch as you may for the moſt part try with much *eaſe*, and poſſibly not without ſome *delight*: And leſt you ſhould expect any thing of Elaborate or Methodical in what you will meet with here, I muſt confeſs to you before-hand, that the ſeaſons I was wont to chuſe to deviſe and try Experiments about Colours, were thoſe daies, wherein having taken Phyſick, and finding my ſelf as unfit to ſpeculate, as unwilling to be altogether idle, I choſe this diverſion as a kind of Mean betwixt the one and the other. And I have the leſs ſcrupled to ſet down the following Experiments, as ſome of them came to my mind, and as the Notes wherein I had ſet down the reſt, occurr'd to my hands, that by declining a Methodical way of delivering them, I might leave you and my ſelf the greater liberty and convenience to add to them, and tranſpoſe them as ſhall appear expedient.

3. Yea,

3. Yea, that you may not think me too reſerv'd, or look upon an Enquiry made up of meer Narratives, as ſomewhat jejune, I am content to *premiſe* a few conſiderations, that now offer themſelves to my thoughts, which relate in a more general way, either to the nature of Colours, or to the ſtudy of it. And I ſhall *inſert* an *Eſſay*, as well Speculative as Hiſtorical, of the Nature of Whiteneſs and Blackneſs, that you may have a *Specimen* of the Hiſtory of Colours, I have ſometimes had thoughts of; and if you diſlike not the Method I have made uſe of, I hope, you, and ſome of the *Virtuoſi*, your friends, may be thereby invited to go thorow with *Red*, *Blew*, *Yellow*, and the reſt of the particular Colours, as I have done with *White* and *Black*, but with far more ſagacity and ſucceſs. And if I can invite ingenious men to undertake ſuch tasks, I doubt not but the Curious will quickly obtain a better Account of Colours, than as yet we have, ſince in our Method the Theorical part of the Enquiry being attended, and as it were interwoven with the Hiſtorical, whatever becomes of the diſputable Conjectures, the Philoſophy of Colours will be promoted by the indiſputable Experiments.

CHAP. II.

1. TO come then in the first place to our more general Considerations, I shall begin with saying something as to the Importance of examining the Colours of Bodies. For there are some, especially *Chymists*, who think, that a considerable diversity of Colours does constantly argue an equal diversity of Nature, in the Bodies wherein it is conspicuous; but I confess I am not altogether of their mind; for not to mention changeable Taffaties, the blew and golden necks of Pigeons, and divers Water-fowl, Rainbows Natural and Artificial, and other Bodies, whose Colours the Philosophers have been pleased to call not Real, but Apparent and Phantastical; not to insist on these, I say, (for fear of needlesly engaging in a Controversie) we see in Parrots, Goldfinches, and divers other Birds, not only that the contiguous feathers which are probably as near in properties as place, are some of them Red, and others White, some of them Blew, & others Yellow, *&c.* but that in the several parts of the self-same feather there may often be seen the greatest disparity of Colours; and so in the leaves of Tulips, July-flowers, and some other Vegetables the

the ſeveral leaves, and even the ſeveral parts of the ſame leaf, although no difference have been obſerv'd in their other properties, are frequently found painted with very different Colours. And ſuch a variety we have much more admired in that lovely plant which is commonly, and not unjuſtly call'd the *Marvail of Peru*; for of divers ſcores of fine Flowers, which in its ſeaſon that gaudy Plant does almoſt daily produce, I have ſcarce taken notice of any two that were dyed perfectly alike. But though *Pyro*: ſuch things as theſe, among others, keep me from daring to affirm, that the Diverſity and change of Colours does *alwaies* argue any great difference or alteration, betwixt, or in, the Bodies, wherein it is to be diſcerned; yet that *oftentimes* the Alteration of Colours does ſignifie conſiderable Alterations in the diſpoſition of parts of Bodies, may appear in the Extraction of Tinctures, and divers other Chymical Operations, wherein the change of Colours is the chief, and ſometimes the only thing, by which the Artiſt regulates his proceeding, and is taught to know when 'tis ſeaſonable for him to leave off. Inſtances of this ſort are more obvious in divers ſorts of fruits, as Cherries, Plums, *&c.* wherein, according as the Vegetable ſap is ſweetned, or otherwiſe

ripened, by passing from one degree to another of Maturation, the external part of the fruit passes likewise from one to another Colour. But one of the noblest Instances I have met with of this kind, is not so obvious; and that is the way of tempering Steel to make Gravers, Drills, Springs, and other Mechanical Instruments, which we have divers times both made Artificers practise in our presence, and tryed our selves, after the following manner. First, the slender Steel to be tempered is to be hardened by heating as much of it as is requisite among glowing Coals, till it be glowing hot, but it must not be quenched assoon as it is taken from the fire (for that would make it too brittle, and spoil it) but must be held over a bason of water, till it descend from a White heat to a Red one, which assoon as ever you perceive, you must immediately quench as much as you desire to harden in the cold water. The Steel thus hardened, will, if it be good, look somewhat White, and must be made bright at the end, that its change of Colours may be there conspicuous; and then holding it so in the flame of a Candle, that the bright end may be, for about half an inch, or more, out of the flame, that the smoak do not stain or sully the brightness of it, you shall after a

while

while see that clean end, which is almost contiguous to the flame, pass very nimbly from one Colour to another, as from a brighter Yellow, to a deeper and reddish Yellow, which Artificers call a *sanguine*, and from that to a fainter first, and then a deeper Blew. And to bring home this Experiment to our present purpose, it is found by daily Experience, that each of these succeeding Colours argue such a change made in the texture of the Steel, that if it be taken from the flame, and immediately quenched in the tallow (whereby it is settled in whatever temper it had before) when it is Yellow, it is of such a hardness as makes it fit for Gravers Drills, and such like Tools; but if it be kept a few minutes longer in the flame till it grow Blew, it becomes much softer, and unfit to make Gravers for Metals, but fit to make Springs for Watches, and such like Instruments, which are therefore commonly of that Colour; and if the Steel be kept in the flame, after that this deep Blew hath disclosed it self, it will grow so soft, as to need to be new hardened again, before it can be brought to a temper, fit for Drills or Penknives. And I confess *Pyro*. I have taken much pleasure to see the Colours run along from the parts of the Steel contiguous to the flame, to the end of the In-

ſtrument, and ſucceed one another ſo faſt, that if a man be not vigilant, to thruſt the Steel into the tallow at the very nick of time, at which it has attain'd its due Colour, he ſhall miſs of giving his tool the right temper. But becauſe the flame of a Candle is offenſive to my weak eyes, and becauſe it is apt to either black or ſully the contiguous part of the Steel which is held in it, and thereby hinder the change of Colours from being ſo long and clearly diſcern'd, I have ſometimes made this Experiment by laying the Steel to be tempered upon a heated bar of Iron, which we find alſo to be employ'd by ſome Artificers in the tempering of ſuch great Inſtruments, as are too big to be ſoon heated ſufficiently by the flame of a Candle. And you may eaſily ſatisfie your ſelf *Pyro.* of the differing hardneſs and toughneſs, which is aſcribed to Steel temper'd at different Colours, if you break but ſome ſlender wires of Steel ſo temper'd, and obſerve how they differ in brittleneſs, and if with a file you alſo make tryal of their various degrees of hardneſs.

2. But *Pyrophilus*, I muſt not at preſent any further proſecute the Conſideration of the importance of Experiments about Colours, not only becauſe you will in the following papers find ſome Inſtances, that would here be

be presented you out of their due place, of the use that may be made of such Experiments, in discovering in divers bodies, what kind the salt is, that is predominant in them; but also because a speculative Naturalist might justly enough alledge, that as Light is so pleasing an object, as to be well worth our looking on, though it discover'd to us nothing but its self; so modifi'd Light called Colour, were worth our contemplation, though by understanding its Nature we should be taught nothing else. And however, I need not make either you or my self excuses for entertaining you on the subject I am now about to treat of, since the pleasure *Pyro.* takes in mixing and laying on of Colours, will I presume keep him, and will (I am sure) keep me from thinking it troublesome to set down, especially after the tedious processes (about other matters) wherewith I fear I may have tyr'd him, some easie, and not unpleasant Experiments relating to that subject.

3. But, before we descend to the more particular considerations, we are to present you concerning Colours, I presume it will be seasonable to propose at the very entrance a Distinction; the ignorance or neglect of which, seems to me to have frequently enough occasioned either mistakes or confu-

sion

ſion in the Writings of divers Modern Philoſophers; for Colour may be conſidered, either as it is a quality reſiding in the body that is ſaid to be coloured, or to modifie the light after ſuch or ſuch a manner; or elſe as the Light it ſelf, which ſo modified, ſtrikes upon the organ of ſight, and ſo cauſes that Senſation which we call Colour; and that this latter may be look'd upon as the more proper, though not the uſual acception of the word Colour, will be made probable by divers paſſages in the enſuing part of our diſcourſe; and indeed it is the Light it ſelf, which after a certain manner, either mingled with ſhades, or ſome other waies troubled, ſtrikes our eyes, that does more immediately produce that motion in the organ, upon whoſe account men ſay they ſee ſuch or ſuch a Colour in the object; yet, becauſe there is in the body that is ſaid to be coloured, a certain diſpoſition of the ſuperficial particles, whereby it ſends the Light reflected, or refracted, to our eyes thus and thus altered, and not otherwiſe, it may alſo in ſome ſenſe be ſaid, that Colour depends upon the viſible body; and therefore we ſhall not be againſt that way of ſpeaking of Colours that is moſt us'd among the Modern Naturaliſts, provided we be allowed to have recourſe when occaſion ſhall require

require to the premis'd distinction, and to take the more immediate cause of Colour to be the modifi'd Light it self, as it affects the Sensory; though the disposition also of the colour'd body, as that modifies the Light, may be call'd by that name Metonimically (to borrow a School term) or Efficiently, that is in regard of its turning the Light, that rebounds from it, or passes thorow it, into this or that particular Colour.

4. I know not whether I may not on this occasion add, that Colour is so far from being an Inherent quality of the object in the sense that is wont to be declar'd by the Schools, or even in the sense of some Modern Atomists, that, if we consider the matter more attentively, we shall see cause to suspect, if not to conclude, that though Light do more immediately affect the organ of sight, than do the bodies that send it thither, yet Light it self produces the sensation of a Colour, but as it produces such a determinate kind of local motion in some part of the brain; which, though it happen most commonly from the motion whereinto the slender strings of the *Retina* are put, by the appulse of Light; yet if the like motion happen to be produc'd by any other cause, wherein the Light concurs not at all,

all, a man ſhall think he ſees the ſame Colour. For proof of this, I might put you in mind, that 'tis uſual for dreaming men to think they ſee the Images that appear to them in their ſleep, adorn'd ſome with this, and ſome with that lively Colour, whilſt yet, both the Curtains of their bed, and thoſe of their eyes are cloſe drawn. And I might adde the confidence with which diſtracted perſons do oftentimes, when they are awake, think, they ſee black fiends in places, where there is no black object in ſight without them. But I will rather obſerve, that not only when a man receives a great ſtroak upon his eye, or a very great one upon ſome other part of his head, he is wont to ſee, as it were, flaſhes of lightning, and little vivid, but vaniſhing flames, though perhaps his eyes be ſhut: But the like apparitions may happen, when the motion proceeds not from ſomething without, but from ſomething within the body, provided the unwonted fumes that wander up and down in the head, or the propagated concuſſion of any internal part in the body, do cauſe about the inward extremities of the Optick Nerve, ſuch a motion as is wont to be there produc'd, when the ſtroak of the Light upon the *Retina* makes us conclude, that we ſee either Light, or ſuch and ſuch a Colour:

Colour: This the most ingenious *Des Cartes* hath very well observ'd, but because he seems not to have exemplifi'd it by any unobvious or peculiar observation, I shall endeavour to illustrate this Doctrine by a few Instances.

5. And first, I remember, that having, through Gods goodness, been free for several years, from troublesom Coughs, being afterwards, by an accident, suddenly cast into a violent one, I did often, when I was awaked in the night by my distempers, observe, that upon coughing strongly, it would seem to me, that I saw very vivid, but immediately disappearing flames, which I took particular notice of, because of the conjecture I am now mentioning.

6. An excellent and very discreet person, very near ally'd both to you and me, was relating to me, that some time since, whilst she was talking with some other Ladies, upon a sudden, all the objects, she looked upon, appeared to her dyed with unusual Colours, some of one kind, and some of another, but all so bright and vivid, that she should have been as much delighted, as surpriz'd with them, but that finding the apparition to continue, she fear'd it portended some very great alteration as to her health: As indeed the day after she was assaulted with

with such violence by Hysterical and Hypocondrical Distempers, as both made her rave for some days, and gave her, during that time, a Bastard Palsey.

7. Being a while since in a Town, where the Plague had made great havock, and inquiring of an ingenious man, that was so bold, as without much scruple to visit those that were sick of it, about the odd symptomes of a Disease that had swept away so many there; he told me, among other things, that he was able to tell divers Patients, to whom he was called, before they took their beds, or had any evident symptomes of the Plague, that they were indeed infected, upon peculiar observations, that being asked, they would tell him that the neighbouring objects, and particularly his cloths, appear'd to them beautifi'd with most glorious Colours, like those of the Rainbow, oftentimes succeeding one another; and this he affirm'd to be one of the most usual, as well as the most early symptomes, by which this odd Pestilence disclos'd it self: And when I asked how long the Patients were wont to be thus affected, he answered, that it was most commonly for about a day; and when I further inquired whether or no Vomits, which in that Pestilence were usually given, did not remove this symptome

(For

(For ſome uſed the taking of a Vomit, when they came aſhore, to cure themſelves of the obſtinate and troubleſome giddineſs caus'd by the motion of the ſhip) reply'd, that generally, upon the evacuation made by the Vomit, that ſtrange apparition of Colours ceaſed, though the other ſymptoms were not ſo ſoon abated, yet he added (to take notice of that upon the by, becauſe the obſervation may perchance do good) that an excellent Phyſician, in whoſe company he was wont to viſit the ſick, did give to almoſt all thoſe to whom he was called, in the beginning before Nature was much weakned, a pretty odd Vomit conſiſting of eight or ten drams of Infuſion of *Crocus Metallorum*, and about half a dram, or much more, of White Vitriol, with ſuch ſucceſs, that ſcarce one of ten to whom it was ſeaſonably adminiſtred, miſcarried.

8. But to return to the conſideration of Colours: As an apparition of them may be produced by motions from within, without the aſſiſtance of an outward object, ſo I have obſerved, that 'tis ſometimes poſſible that the Colour that would otherwiſe be produced by an outward object, may be chang'd by ſome motion, or new texture already produced in the Senſory, as long as that unuſual motion, or new diſpoſition laſts;

lasts; for I have divers times try'd, that after I have through a Telescope look'd upon the Sun, though thorow a thick, red, or blew glass, to make its splendor supportable to the eye, the impression upon the *Retina*, would be not only so vivid, but so permanent, that if afterwards I turned my eye towards a flame, it would appear to me of a Colour very differing from its usual one. And if I did divers times successively shut and open the same eye, I should see the adventitious Colour (if I may so call it) changed or impaired by degrees, till at length (for this unusual motion of the eye would not presently cease) the flame would appear to me, of the same hew that it did to other beholders; a not unlike effect I found by looking upon the Moon, when she was near full, thorow an excellent Telescope, without colour'd Glass to screen my eye with; But that which I desire may be taken notice of, because we may elsewhere have occasion to reflect upon it, and because it seems not agreeable to what Anatomists and Optical Writers deliver, touching the relation of the two eyes to each other, is this circumstance, that though my right eye, with which I looked thorow the Telescope, were thus affected by the over-strong impression of the light, yet when the flame

of

of a Candle, or some other bright object appear'd to me of a very unusual Colour, whilst look'd upon with the Discompos'd Eye, or (though not so notably) with both eyes at once; yet if I shut that Eye, and look-ed upon the same object with the other, it would appear with no other than its usual Colour, though if I again opened, and made use of the Dazled eye, the vivid adventitious Colour would again appear. And on this occasion I must not pretermit an Observation which may perswade us, that an over-vehement stroak upon the Sensory, especially if it be naturally of a weak constitution, may make a more lasting impression than one would imagine, which impression may in some cases, as it were, mingle with, and vitiate the action of vivid objects for a long time after.

For I know a Lady of unquestionable Veracity, who having lately, by a desperate fall, receiv'd several hurts, and particularly a considerable one upon a part of her face near her Eye, had her sight so troubl'd and disorder'd, that, as she hath more than once related to me, not only when the next morning one of her servants came to her bed-side, to ask how she did, his cloaths appear'd adorn'd with such variety of dazling Colours, that she was fain presently to

command him to withdraw, but the Images in her Hangings, did, for many days after, appear to her, if the Room were not extraordinarily darken'd, embelliſh'd with ſeveral offenſively vivid Colours, which no body elſe could ſee in them; And when I enquired whether or no White Objects did not appear to her adorn'd with more luminous Colours than others, and whether ſhe ſaw not ſome which ſhe could not now well deſcribe to any, whoſe eyes had never been diſtempered, ſhe anſwer'd me, that ſometimes ſhe thought ſhe ſaw Colours ſo new and glorious, that they were of a peculiar kind, and ſuch as ſhe could not deſcribe by their likeneſs to any ſhe had beheld either before or ſince; and that White Objects did ſo much diſorder her ſight, that if ſeveral daies after her fall, ſhe look'd upon the inſide of a Book, ſhe fanci'd ſhe ſaw there Colours like thoſe of the Rain-bow, and even when ſhe thought her ſelf pretty well recover'd, and made bold to leave her Chamber, the coming into a place where the Walls and Ceeling were whited over, made thoſe Objects appear to her cloath'd with ſuch glorious and dazling Colours, as much offended her ſight, and made her repent her venturouſneſs; and ſhe added, that this Diſtemper of her Eyes laſted no leſs than

than five or six weeks, though, since that, she hath been able to read and write much without finding the least Inconvenience in doing so. I would gladly have known, whether if she had shut the Injur'd Eye, the *Phænomena* would have been the same, when she employ'd only the other, but I heard not of this accident early enough to satisfie that Enquiry.

9. Wherefore, I shall now add, that some years before, a person exceedingly eminent for his profound Skill in almost all kinds of Philological Learning, coming to advise with me about a Distemper in his Eyes, told me, among other Circumstances of it, that, having upon a time looked too fixedly upon the Sun, thorow a Telescope, without any coloured Glass, to take off from the dazling splendour of the Object, the excess of Light did so strongly affect his Eye, that ever since, when he turns it towards a Window, or any White Object, he fancies, he seeth a Globe of Light, of about the bigness the Sun then appeared of to him, to pass before his Eyes: And having inquir'd of him, how long he had been troubled with this Indisposition, he reply'd, that it was already nine or ten years, since the Accident that occasioned it, first befel him.

10. I could here subjoyn, *Pyrophilus*, some memorable Relations that I have met with in the Account given us by the experienc'd *Epiphanius Ferdinandus*, of the Symptomes he observ'd to be incident to those that are bitten with the Tarantula, by which (Relations) I could probably shew, that without any change in the Object, a change in the Instruments of Vision may for a great while make some Colours appear Charming, and make others Provoking, and both to a high degree, though neither of them produc'd any such Effects before. These things, I say, I could here subjoyn in confirmation of what I have been saying, to shew, that the Disposition of the Organ is of great Importance in the Dijudications we make of Colours, were it not that these strange Stories belonging more properly to another Discourse, I had rather, (contenting my self to have given you an Intimation of them here) that you should meet with them fully deliver'd there.

CHAP. III.

1. BUt, *Pyrophilus*, I would not by all that I have hitherto discours'd, be thought to have forgotten the Distinction (of

(of Colour) that I mentioned to you about the beginning of the third Section of the former Chapter; and therefore, after all I have said of Colour, as it is modifi'd Light, and immediately affects the Sensory, I shall now re-mind you, that I did not deny, but that Colour might in some sense be consider'd as a Quality residing in the body that is said to be Colour'd; and indeed the greatest part of the following Experiments refer to Colour principally under that Notion, for there is in the Bodies we call Colour'd, and chiefly in their Superficial parts, a certain disposition, whereby they do so trouble the Light that comes from them to our Eye, as that it there makes that distinct Impression, upon whose Account we say, that the Seen body is either White or Black, or Red or Yellow, or of any one determinate Colour. But because we shall (God permitting) by the Experiments that are to follow some Pages hence, more fully and particularly shew, that the Changes, and consequently in divers places the Production and the appearance of Colours depends upon the continuing or alter'd Texture of the Object, we shall in this place intimate (and that too but as by the way) two or three things about this Matter.

2. And first it is not without some Rea-

ſon; that I aſcribe Colour (in the ſenſe formerly explain'd) *chiefly* to the Superficial parts of Bodies; for not to queſtion how much Opacous Corpuſcles may abound even in thoſe Bodies we call Diaphanous, it ſeems plain that of Opacous Bodies we do indeed ſee little elſe than the Superficies; for if we found the beams of Light that rebound from the Object to the Eye, to pierce deep into the Colour'd body, we ſhould not judge it Opacous, but either Tranſlucid, or at leaſt Semi-diaphanous; and though the Schools ſeem to teach us that Colour is a Penetrative Quality, that reaches to the Innermoſt parts of the Object, as if a piece of Sealing-wax be broken into never ſo many pieces, the Internal fragments will be as Red as the External ſurface did appear, yet that is but a Particular Example that will not overthrow the Reaſon lately offer'd, eſpecially ſince I can alledge other Examples of a contrary Import, and two or three Negative Inſtances are ſufficient to overthrow the Generality of a Poſitive Rule, eſpecially if that be built but upon One or a Few Examples. Not (then) to mention Cherries, Plums, and I know not how many other Bodies, wherein the skin is of one Colour, and what it hides of another; I ſhall name a couple of Inſtances drawn from the Co-

lours

lours of Durable bodies that are thought far more Homogeneous, and have not parts that are either Organical, or of a Nature approaching thereunto.

3. To give you the first Instance, I shall need but to remind you of what I told you a little after the beginning of this Essay, touching the Blew and Red and Yellow, that may be produc'd upon a piece of temper'd Steel; for these Colours though they be very Vivid, yet if you break the Steel they adorn, they will appear to be but Superficial; not only the innermost parts of the Metal, but those that are within a hairs breadth of the Superficies, having not any of these Colours, but retaining that of the Steel it self. Besides that, we may as well confirm this Observation, as some other particulars we elsewhere deliver concerning Colours, by the following Experiment which we purposely made.

4. We took a good quantity of clean Lead, and melted it with a strong Fire, and then immediately pouring it out into a clean Vessel of a convenient shape and matter, (we us'd one of Iron, that the great and sudden Heat might not injure it) and then carefully and nimbly taking off the Scum that floated on the top, we perceiv'd, as we expected, the smooth and

glossie Surface of the melted matter, to be adorn'd with a very glorious Colour, which being as Transitory as Delightful, did almost immediately give place to another vivid Colour, and that was as quickly succeeded by a third, and this as it were chas'd away by a fourth, and so these wonderfully vivid Colours successively appear'd and vanish'd (yet the same now and then appearing the second time) till the Metal ceasing to be hot enough to afford any longer this pleasing Spectacle, the Colours that chanc'd to adorn the Surface, when the Lead thus began to cool, remain'd upon it; but were so Superficial, that how little soever we scrap'd off the Surface of the Lead, we did in such places scrape off all the Colour, and discover only that which is natural to the Metal it self; which receiving its adventitious Colours, only when the heat was very Intense, and in that part which was expos'd to the comparatively very cold Air, (which by other Experiments seems to abound with subtil Saline parts, perhaps not uncapable of working upon Lead so dispos'd:) These things I say, together with my observing that whatever parts of the so strongly melted Lead were expos'd a while to the Air, turn'd into a kind of Scum or Litharge, how

how bright and clean ſoever they appear'd before, ſuggeſted to me ſome Thoughts or Ravings, which I have not now time to acquaint you with. One that did not know me, *Pyrophilus*, would perchance think I endeavour'd to impoſe upon you by relating this Experiment, which I have ſeveral times try'd; but the Reaſon why the *Phænomena* mention'd have not been taken notice of, may be, that unleſs Lead be brought to a much higher degree of Fuſion or Fluidity than is uſual, or than is indeed requiſite to make it melt, the *Phænomena* I mention'd will ſcarce at all diſcloſe themſelves; And we have alſo obſerv'd that this ſucceſſive appearing and vaniſhing of vivid Colours, was wont to be impair'd or determin'd whilſt the Metal expos'd to the Air remain'd yet hotter than one would readily ſuſpect. And one thing I muſt further Note, of which I leave you to ſearch after the Reaſon, namely, that the ſame Colours did not always and regularly ſucceed one another, as is uſually in Steel, but in the diverſify'd Order mention'd in this following Note, which I was ſcarce able to write down, the ſucceſſion of the Colours was ſo very quick; whether that proceeded from the differing degrees of Heat in the Lead expos'd to the cool Air, or from ſome

other

other Reason, I leave you to examine.

[*Blew, Yellow, Purple, Blew; Green, Purple, Blew, Yellow, Red; Purple, Blew, Yellow and Blew, Yellow, Blew, Purple, Green mixt; Yellow, Red, Blew, Green, Yellow, Red, Purple, Green.*]

5. The *Atomists* of Old, and some Learned men of late, have attempted to explicate the variety of Colours in Opacous bodies from the various Figures of their Superficial parts; the attempt is Ingenious, and the Doctrine seems partly True, but I confess I think there are divers other things that must be taken in as concurrent to produce those differing forms of Asperity, whereon the Colours of Opacous bodies seem to depend. To declare this a little, we must assume, that the Surfaces of all such Bodies, how Smooth or polite soever they may appear to our Dull Sight and Touch, are exactly smooth only in a popular, or at most in a Physical sense, but not in a strict and rigid sense.

6. This, excellent *Microscopes* shew us in many Bodies, that seem Smooth to our naked Eyes; and this not only as to the little Hillocks or Protuberancies that swell above

above that which may be conceiv'd to be the Plain or Level of the consider'd Surface; for it is obvious enough to those that are any thing conversant with such Glasses: but as to numerous Depressions beneath that Level, of which sort of Cavities by the help of a *Microscope*, which the greatest Artificer that makes them, judges to be the greatest Magnifying Glass in *Europe*, except one that equals it, we have on the Surface of a thin piece of Cork that appear'd smooth to the Eye, observ'd about sixty in a Row, within the length of less than a 31. and 32. part of an Inch, (for the Glass takes in no longer a space at one view) and these Cavities (which made that little piece of Cork look almost like an empty Honey-comb) were not only very distinct, and figur'd like one another, but of a considerable bigness, and a scarce credible depth; insomuch that their distinct shadows as well as sides were plainly discern'd and easie to be reckon'd, and might have been well distinguish'd, though they had been ten times lesser than they were; which I thought it not amiss to mention to you *Pyrophilus* upon the by, that you may thence make some Estimate, what a strange Inequality, and what a multitude of little Shades, there may really be, in a

scarce

ſcarce ſenſible part of the Phyſical ſuperficies, though the naked Eye ſees no ſuch matter. And as Excellent *Microſcopes* ſhew us this Ruggedneſs in many Bodies that paſs for Smooth, ſo there are divers Experiments, though we muſt not now ſtay to urge them, which ſeem to perſwade us of the ſame thing as to the reſt of ſuch Bodies as we are now treating of; So, that there is no ſenſible part of an Opacous body, that may not be conceiv'd to be made up of a multitude of ſingly inſenſible Corpuſcles, but in the giving theſe Surfaces that diſpoſition, which makes them alter the Light that reflects thence to the Eye after the manner requiſite to make the Object appear Green, Blew, &c. the Figures of theſe Particles have *a great*, but not *the only* ſtroak. 'Tis true indeed that the protuberant Particles may be of very great variety of Figures, Sphærical, Elliptical, Conical, Cylindrical, Polyedrical, and ſome very irregular; and that according to the Nature of theſe, and the ſituation of the Lucid body, the Light muſt be variouſly affected, after one manner from Surfaces (I now ſpeak of Phyſical Surfaces) conſiſting of Sphærical, and in another from thoſe that are made up of Conical or Cylindrical Corpuſcles; ſome being

being fitted to reflect more of the incident Beams of Light, others less, and some towards one part, others towards another. But besides this difference of Shape, there may be divers other things that may eminently concur to vary the forms of Asperity that Colours so much depend on. For, willingly allowing the Figure of the Particles in the first place, I consider secondly, that the superficial Corpuscles, if I may so call them, may be bigger in one Body, and less in another, and consequently fitted to allay the Light falling on them with greater shades. Next, the protuberant Particles may be set more or less close together, that is, there may be a greater or a smaller number of them within the compass of one, than within the compass of another small part of the Surface of the same Extent; and how much these Qualities may serve to produce Colour may be somewhat guess'd at, by that which happens in the Agitation of Water; for if the Bubbles that are thereby made be Great, and but Few, the Water will scarce acquire a sensible Colour; but if it be reduc'd to a Froth, consisting of Bubbles, which being very Minute and Contiguous to each other, are a multitude of them crowded into a narrow Room, the Water (turned to Froth)

Froth) does then exhibit a very manifeſt White Colour, to which theſe laſt nam'd Conditions of the Bubbles do as well as their Convex figure contribute) and that for Reaſons to be mention'd anon. Beſides, it is not neceſſary that the Superficial particles that exhibit one Colour, ſhould be all of them Round, or all Conical, or all of any one Shape, but Corpuſcles of differing Figures may be mingled on the Surface of the Opacous Body, as when the Corpuſcles that make a Blew Colour, and thoſe that make a Yellow, come to be accurately and skilfully mix'd, they make up a Green, which though it ſeem one ſimple Colour, yet in this caſe appears to be made by Corpuſcles of very differing Kinds, duly commix'd. Moreover, the Figure and Bigneſs of the little Depreſſions, Cavities, Furrows or Pores intercepted betwixt theſe protuberant Corpuſcles, are as well to be conſider'd as the Sizes and Shapes of the Corpuſcles themſelves: For we may conceive the Phyſical ſuperficies of a Body, where (as we ſaid) its Colour does as it were reſide, to be cut Tranſverſly by a Mathematical plain, which you know is conceiv'd to be without any Depth or Thickneſs at all, and then as

See the Diſcourſe of the Nature of Whiteneſs and Blackneſs.

ſome

some parts of the Physical superficies will be Protuberant, or swell above this last plain, so others may be depress'd beneath it, as (to explain my self by a gross Comparison) in divers places of the Surface of the Earth, there are not only Neighbouring Hills, Trees, &c. that are rais'd above the Horizontal Level of the Valley, but Rivers, Wells, Pits and other Cavities that are depress'd beneath it; and that such Protuberant and Concave parts of a Surface may remit the Light so differingly, as much to vary a Colour, some examples and other things, that we shall hereafter have occasion to take notice of in this Tract, will sufficiently declare, till when it may suffice to put you in mind, that of two Flat-sides of the same piece of, for example, red Marble, the one being diligently Polished, and the other left to its former Roughness, the differing degrees or sorts of Asperity, for the side that is smooth to the Touch wants not its Roughness, will so diversifie the Light reflected from the several Plains to the Eye, that a Painter would employ two differing Colours to represent them.

7. And I hope, *Pyrophilus*, you will not think it strange or impertinent, that I employ in divers passages of these Papers, examples

examples drawn from Bodies and Shadows far more Grofs, than thofe minute Protuberances and fhady Pores on which in moft cafes the Colour of a Body as 'tis an Inherent Quality or Difpofition of its Surface, feems to depend. For fometimes I employ fuch Examples, rather to declare my Meaning, than prove my Conjecture; things, whom their Smallnefs makes Inſenſible, being better repreſented to the Imagination by fuch familiar Objects, as being like them enough in other reſpects, are of a Viſible bulk. And next, though the Beams of Light are fuch ſubtil Bodies; that in reſpect of them, even Surfaces that are ſenſibly Smooth, are not exactly ſo; but have their own degree of Roughneſs, conſiſting of little Protuberances and Depreſſions; and though conſequently ſuch Inequalities may ſuffice to give Bodies differing Colours, as we ſee in Marble that appears White or Black, or Red or Blew, even when the moſt carefully Poliſh'd; yet 'tis plain by the late Inſtance of Red Marble, and many others, that even bigger Protuberances and greater Shades may likewiſe ſo Diverſifie the Roughneſs of a Bodies Superficies, as manifeſtly to concur to the varying of its Colour, whereby ſuch Examples appear to be proper enough

to

to be employ'd in such a Subject as we have now in hand. And having hinted thus much on this Occasion, I now proceed.

8. The Situation also of the Superficial particles is considerable, which I distinguish into the Posture of the single Corpuscles, in respect of the Light, and of the Eye, and the Order of them in reference also to one another; for a Body may otherwise reflect the Light, when its Superficial particles are more erected upon the Plain that may be conceiv'd to pass along their Basis, and when the Points or Extreams of such Particles are Obverted to the Eye, than when those Particles are so Inclin'd, that their Sides are in great part Discernable, as the Colour of Plush or Velvet will appear Vary'd to you, if you carefully stroak part of it one way, and part of it another; the posture of the particular Thrids, in reference to the Light, or the Eye, becoming thereby different. And you may observe in a Field of ripe Corn blown upon by the Wind, that there will appear as it were Waves of a Colour (at least Gradually) differing from that of the rest of the Field, the Wind by Depressing some of the Ears, and not at the same time others, making the one Reflect more from

the Lateral and Strawy parts, than do the reſt. And ſo, when Dogs are ſo angry, as to Erect the Hairs upon their Necks, and upon ſome other parts of their Bodies, thoſe Parts ſeem to acquire a Colour vary'd from that which the ſame Hairs made, when in their uſual Poſture they did far more ſtoop. And that the Order wherein the Superficial Corpuſcles are Rang'd, is not to be neglected, we may gueſs by turning of Water into Froth, the beating of Glaſs, and the ſcraping of Horns, in which caſes the Corpuſcles that were before ſo marſhall'd as to be Perſpicuous, do by the troubling of that Order become Diſpos'd to terminate and reflect more Light, and thereby to appear Whitiſh. And there are other ways in which the Order of the Protuberant parts, in reference to the Eye, may much contribute to the appearing of a particular Colour; for I have often obſerv'd, that when Peaſe are planted, or ſet in Parallel Lines, and are Shot up about half a Foot above the ſurface of the Ground, by looking on the Field or Plot of Ground from that part towards which the Parallel Lines tended, the greater part of the Ground by far would appear of its own dirty Colour, but if I look'd upon it Tranſverſly, the Plot would

would appear very Green, the upper parts of the Peaſe hindering the intercepted parts of the Ground, which as I ſaid retain'd their wonted Colour, from being diſcover'd by the Eye. And I know not, *Pyrophilus*, whether I might not add, that even the Motion of the Small Parts of a Viſible Object may in ſome caſes contribute, though it be not ſo eaſie to ſay how, to the Producing or the Varying of a Colour; for I have ſeveral times made a Liquor, which when it has well ſetled in a cloſe Vial, is Tranſparent and Colourleſs, but as ſoon as the Glaſs is unſtopp'd, begins to fly away very plentifully in a White and Opacous Fume; and there are other Bodies, whoſe Fumes, when they fill a Receiver, would make one ſuſpect it contains Milk, and yet when theſe Fumes ſettle into a Liquor, that Liquor is not White, but Tranſparent; and ſuch White Fumes I have ſeen afforded by unſtopping a Liquor I know, which yet is it ſelf Diaphanous and Red; Nor are theſe the only Inſtances of this Kind, that our Trials can ſupply us with. And if the Superficial Corpuſcles be of the Groſſer ſort, and be ſo Framed, that their differing Sides or Faces may exhibit differing Colours, then the Motion or Reſt of thoſe Corpuſcles may be

considerable, as to the Colour of the Superficies they compose, upon this account, that sometimes more, sometimes fewer of the Sides dispos'd to exhibit such a Colour may by this means become or continue more Obverted to the Eye than the rest, and compose a Physical Surface, that will be more or less sensibly interrupted; As, to explain my meaning, by proposing a gross Example, I remember, that in some sorts of Leavy Plants thick set by one another, the two sides of whose Leaves were of somewhat differing Colours, there would be a notable Disparity as to Colour, if you look'd upon them both when the Leaves being at Rest had their upper and commonly expos'd sides Obverted to the Eye, and when a breath of Wind passing thorow them, made great Numbers of the usually Hidden sides of the Leaves become conspicuous. And though the Little Bodies, we were lately speaking of, may Singly and Apart seem almost Colourless, yet when Many of them are plac'd by one another, so near, that the Eye does not easily discern an Interruption, within a sensible space, they may exhibit a Colour; as we see, that though a Slendereſt Thrid of Dy'd Silk do's, whilst look'd on Single, seem almost quite Devoyd of Redness, (for Instance)

ſtance) yet when numbers of theſe Thrids are brought together into one Skein, their Colour becomes notorious.

9. But the ſame Occaſion that invited me to ſay what I have mention'd concerning the Leaves of Trees, invites me alſo to give you ſome account of what happens in Changeable Taffities, where we ſee differing Colours, as it were, Emerge and Vaniſh upon the Ruffling of the ſame piece of Silk: As I have divers times with Pleaſure obſerv'd, by the help of ſuch a *Microſcope*, as, though it do not very much Magnifie the Object, has in recompence this great Conveniency, that you may eaſily as faſt as you pleaſe, remove it from one part to another of a Large Object, of which the Glaſs taking a great part at once, you may thereby preſently Survey the Whole. Now by the help of ſuch a *Microſcope* I could eaſily (as I began to ſay) diſcern, that in a piece of Changeable Taffity (that appear'd, for Inſtance, ſometimes Red, and ſometimes Green) the Stuff was compos'd of Red thrids and Green, paſſing under and over each other, and croſſing one another in almoſt innumerable points; and if I look'd through the Glaſs upon any conſiderable portion of the Stuff, that (for example ſake) to the

naked Eye appear'd to be Red, I could plainly see, that in that Position, the Red thrids were Conspicuous, and reflected a vivid Light; and though I could also perceive, that there were Green ones, yet by reason of their disadvantagious Position in the *Physical Surface* of the Taffity, they were in part hid by the more Protuberant Thrids of the other Colour; and for the same cause, the Reflection from as much of the Green as was discover'd, was comparatively but Dim and Faint. And if, on the contrary, I look'd through the *Microscope* upon any part that appear'd Green, I could plainly see that the red thrids were less fully expos'd to the Eye, and obscur'd by the Green ones, which therefore made up the Predominant Colour. And by observing the Texture of the Silken Stuff, I could easily so expose the Thrids either of the one Colour or of the other to my Eye, as at pleasure to exhibit an apparition of Red or Green, or make those Colours succeed one another: So that, when I observ'd their Succession by the help of the Glass, I could mark how the Predominant Colour did as it were start out, when the Thrids that exhibited it came to be advantagiously plac'd; And by making little Folds in the Stuff after a certain manner,

the

the Sides that met and terminated in those Folds, would appear to the naked Eye, one of them Red, and the other Green. When Thrids of more than two differing Colours chance to be Interwoven, the resulting changeableness of the Taffity may be also somewhat different. But I chuse to give an Instance in the Stuff I have been speaking of, because the mixture being more Simple, the way whereby the Changeableness is produc'd, may be the more easily apprehended: and though Reason alone might readily enough lead a considering Man to guess at the Explication, in case he knew how changeable Taffities are made: yet I thought it not impertinent to mention it, because both Scholars and Gentlemen are wont to look upon the Inquiry into Manufactures, as a *Mechanick* employment, and consequently below them; and because also with such a *Microscope* as I have been mentioning, the discovery is as well pleasant as satisfactory, and may afford Hints of the Solution of other *Phænomena* of Colours. And it were not amiss, that some diligent enquiry were made, whether the *Microscope* would give us an account of the Variableness of Colour, that is so Conspicuous and so Delightful in Mother of Pearl, in Opals, and some

other resembling Bodies: For though I remember I did formerly attempt something of that Kind (fruitlesly enough) upon Mother of Pearl, yet not having then the advantage of my best *Microscope*, nor some Conveniences that might have been wish'd, I leave it to you, who have better Eyes, to try what you can do further; since 'twill be *Some* discovery to find, that, in this case the best Eyes and *Microscopes* themselves can make *None*.

10. I confess, *Pyrophilus*, that a great part of what I have deliver'd, (or propos'd rather) concerning the differing forms of Asperity in Bodies, by which Differences the incident Light either comes to be Reflected with more or less of Shade, and with that Shade more or less Interrupted, or else happens to be also otherwise Modify'd or Troubl'd, is but Conjectural. But I am not sure, that if it were not for the dulness of our Senses, either these or some other Notions of Kin to them, might be better countenanc'd; for I am apt to suspect, that if we were sharp-sighted enough, or had such perfect *Microscopes*, as I fear are more to be wish'd than hop'd for, our promoted Sense might discern in the Physical Surfaces of Bodies, both a great many latent Ruggednesses, and the particular Sizes,

Sizes, Shapes, and Situations of the extreamly little Bodies that cause them, and perhaps might perceive among other Varieties that we now can but imagine, how those little Protuberances and Cavities do Interrupt and Dilate the Light, by mingling with it a multitude of little and singly undiscernable Shades, though some of them more, and some of them less Minute, some less, and some more Numerous, according to the Nature and Degree of the particular Colour we attribute to the Visible Object; as we see, that in the Moon we can with Excellent *Telescopes* discern many Hills and Vallies, and as it were Pits and other Parts, whereof some are more, and some less Vividly illustrated, and others have a fainter, others a deeper Shade, though the naked Eye can discern no such matter in that Planet. And with an Excellent *Microscope*, where the *Naked* Eye did see but a Green powder, the *Assisted* Eye as we noted above, could discern particular Granules, some of them of a Blew, and some of them of a Yellow colour, which Corpuscles we had beforehand caus'd to be exquisitely mix'd to compound the Green.

11. And, *Pyrophilus*, that you may not think me altogether extravagant in what I have

have said of the Possibility, (for I speak of no more) of discerning the differing forms of Asperity in the Surfaces of Bodies of several Colours, I'll here set down a Memorable particular that chanc'd to come to my Knowledge, since I writ a good part of this *Essay*; and it is this. Meeting casually the other Day with the deservedly Famous * Dr. *J. Finch*, Extraordinary *Anatomist* to that Great Patron of the *Virtuosi*, the now Great Duke of *Toscany*, and enquiring of this Ingenious Person, what might be the chief Rarity he had seen in his late return out of *Italy* into *England*, he told me, it was a Man at *Maestricht* in the Low-Countrys, who at certain times can discern and *distinguish Colours by the Touch* with his Fingers. You'l easily Conclude, that this is far more strange, than what I propos'd but as *not Impossible*; since the Sense of the *Retina* seeming to be much more Tender and quick than that of those Grosser Filaments, Nerves or Membranes of our Fingers, wherewith we use to handle Gross and Hard Bodies, it seems scarce credible, that any Accustomance, or Diet, or peculiarity of Constitution, should enable a Man to distinguish

* *Since for his eminent Qualities and Loyalty Grac'd by his Majesty with the Honour of Knighthood.*

ſtinguiſh with ſuch Groſs and Unſuitable Organs, ſuch Nice and Subtile Differences as thoſe of the forms of Aſperity, that belong to differing Colours, to receive whoſe Languid and Delicate Impreſſions by the Intervention of Light, Nature ſeems to have appointed and contexed into the *Retina* the tender and delicate Pith of the Optick Nerve. Wherefore I confeſs, I propos'd divers Scruples, and particularly whether the Doctor had taken care to bind a Napkin or Hankerchief over his Eyes ſo carefully, as to be ſure he could make no uſe of his Sight, though he had but counterfeited the want of it; to which I added divers other Queſtions, to ſatisfie my ſelf, whether there were any Likelihood of Colluſion or other Tricks. But I found that the Judicious Doctor having gone far out of his way, purpoſely to ſatisfie himſelf and his Learned Prince about this wonder, had been very Watchful and Circumſpect to keep *Himſelf* from being Impos'd upon. And that he might not through any miſtake in point of Memory miſ-inform *Me*, he did me the Favour at my Requeſt, to look out the Notes he had Written for his Own and his Princes Information, the ſum of which Memorials, as far as we ſhall mention them here, was this, That the Doctor having

having been inform'd at *Utretcht*, that there Lived one at some Miles distance from *Maestricht*, who could distinguish Colours by the Touch, when he came to the last nam'd Town, he sent a Messenger for him, and having Examin'd him, was told upon inquiry these Particulars:

That the Man's name was *John Vermaasen*, at that time about 33 Years of Age; that when he was but two years Old, he had the Small Pox, which rendred him absolutely Blind: That at this present he is an *Organist*, and serves that Office in a publick Quire.

That the Doctor discoursing with him over Night, the Blind man affirm'd, that he could distinguish Colours by the Touch, but that he could not do it, unless he were Fasting; Any quantity of Drink taking from him that Exquisiteness of Touch, which is requisite to so Nice a Sensation.

That hereupon the Doctor provided against the next Morning seven pieces of Ribbon, of these seven Colours, Black, White, Red, Blew, Green, Yellow, and Gray, but as for *mingled* Colours, this *Vermaasen* would not undertake to discern them, though if offer'd, he would tell that they were *Mix'd*.

That to discern the Colour of the Ribbon,

bon, he places it betwixt the Thumb and the Fore-finger, but his moſt exquiſite perception was in his Thumb, and much better in the right Thumb than in the left.

That after the Blind man had four or five times told the Doctor the ſeveral Colours, (though blinded with a Napkin for fear he might have ſome Sight) the Doctor found he was twice miſtaken, for he call'd the White Black, and the Red Blew, but ſtill, he, before his Errour, would lay them by in Pairs, ſaying, that though he could eaſily diſtinguiſh them from all others, yet thoſe two Pairs were not eaſily diſtinguiſh'd amongſt themſelves: whereupon the Doctor deſir'd to be told by him what kind of Diſcrimination he had of Colours by his Touch, to which he gave a reply, for whoſe ſake chiefly I inſert all this Narrative in this place, namely, That all the difference was more or leſs Aſperity, for ſays he, (I give you the Doctor's own words) Black feels as if you were feeling Needles points, or ſome harſh Sand, and Red feels very Smooth.

That the Doctor having deſir'd him to tell in Order the difference of Colours to his Touch, he did as follows;

Black and White are the moſt aſperous

or

or unequal of all Colours, and so like, that 'tis very hard to distinguish them, but Black is the most Rough of the two, Green is next in Asperity, Gray next to Green in Asperity, Yellow is the fifth in degree of Asperity, Red and Blew are so like, that they are as hard to distinguish as Black and White, but Red is somewhat more Asperous than Blew, so that Red has the sixth place, and Blew the seventh in Asperity.

12. To these Informations the Obliging Doctor was pleas'd to add the welcome present of three of those very pieces of Ribbon, whose Colours in his presence the Blind man had distinguished, pronouncing the one Gray, the other Red, and the third Green, which I keep by me as Rarities, and the rather, because he fear'd the rest were miscarry'd.

13. Before I saw the Notes that afforded me the precedent Narrative, I confess I suspected this man might have thus discriminated Colours, rather by the Smell than by the Touch; for some of the Ingredients imployed by Dyers to Colour things, have Scents, that are not so Languid, nor so near of Kin, but that I thought it not impossible that a very Critical Nose might distinguish them, and this I the rather suspected, because he requir'd, that the Ribbons,

bons; whose Colours he was to Name, should be offer'd him Fasting in the morning; for I have observ'd in Setting Dogs, that the feeding of them (especially with some sorts of Aliments) does very much impair the exquisite scent of their Noses. And though some of the foregoing particulars would have prevented that Conjecture, yet I confess to you (*Pyrophilus*) that I would gladly have had the Opportunity of Examining this Man my self, and of Questioning him about divers particulars which I do not find to have been yet thought upon. And though it be not incredible to me, that since the Liquors that Dyers employ to tinge, are qualified to do so by multitudes of little Corpuscles of the Pigment or Dying stuff, which are dissolved and extracted by the Liquor, and swim to and fro in it, those Corpuscles of Colour (as the *Atomists* call them) insinuating themselves into, and filling all the Pores of the Body to be Dyed, may Asperate its Superficies more or less according to the Bigness and Texture of the Corpuscles of the Pigment; yet I can scarce believe, that our Blind man could distinguish all the Colours he did, meerly by the Ribbons having more or less of Asperity, so that I cannot but think, notwithstanding this History, that the Blind man distin-

distinguish'd Colours not only by the *Degrees* of Asperity in the Bodies offer'd to him, but by *Forms* of it, though this (latter) would perhaps have been very difficult for him to make an Intelligible mention of, because those Minute disparities having not been taken notice of by men for want of touch as exquisite as our Blind Mans, are things he could not have Intelligibly expres's'd, which will easily seem probable, if you consider, that under the name of Sharp, and Sweet, and Sour, there are abundance of, as it were, immediate peculiar Relishes or Tasts in differing sorts of Wine, which though Critical and Experienc'd Palats can easily discern themselves, cannot make them be understood by others, such Minute differences not having hitherto any Distinct names assign'd them. And it seems that there was something in the Forms of Asperity that was requisite to the Distinction of Colours, besides the Degree of it, since he found it so difficult to distinguish Black and White from one another, though not from other Colours. For I might urge, that he seems not consonant to himself about the *Red*, which as you have seen in one place, he represents as somewhat more Asperous than the *Blew*; and in another, very Smooth: But because he speaks of this Smoothness in that place,

where

where he mentions the Roughneſs of *Black*, we may favourably preſume that he might mean but a *comparative Smoothneſs*; and therefore I ſhall not Inſiſt on this, but rather countenance my Conjecture by this, that he found it ſo Difficult, not only, to Diſcriminate Red and Blew; (though the firſt of our promiſcuous Experiments will inform you, that the Red reflects by great Odds more Light than the other) but alſo to diſtinguiſh Black and White from one another, though not from other Colours. And indeed, though in the Ribbons that were offer'd him, they might be almoſt equally Rough, yet in ſuch ſlender Corpuſcles as thoſe of Colour, there may eaſily enough be conceived, not only a greater Cloſeneſs of Parts, or elſe paucity of Protuberant Corpuſcles, and the little extant Particles may be otherwiſe Figur'd, and Rang'd in the White than in the Black, but the Cavities may be much Deeper in the one than the other.

14. And perhaps, (*Pyrophilus*) it may prove ſome *Illuſtration of what I mean*, and help you to conceive how *this may* be, if I Repreſent, that where the Particles are ſo exceeding Slender, we may allow the Parts expos'd to the Sight and Touch to be a little Convex in compariſon of the Erected

Particles of Black Bodies, as if there were Wyres I know not how many times ſlenderer than a Hair: whether you ſuppoſe them to be Figur'd like Needles, or Cylindrically, like the Hairs of a Bruſh, with Hemiſpherical (or at leaſt Convex) Tops, they will be ſo very Slender, and conſequently the Points both of the one ſort and the other ſo very Sharp, that even an exquiſite Touch will be able to diſtinguiſh no greater difference between them, than that which our Blind man allow'd, when comparing Black and White Bodies, he ſaid, that the latter was the leſs Rough of the two. Nor is every Kind of Roughneſs, though ſenſible enough, Inconſiſtent with Whiteneſs, there being Caſes, wherein the Phyſical Superficies of a Body is made by the ſame Operation both *Rough* and *White*; as when the Level Surface of clear Water being by agitation Aſperated with a multitude of Unequal Bubbles, do's thereby acquire a Whiteneſs; and as a Smooth piece of Glaſs, by being Scratch'd with a Diamond, do's in the Aſperated part of its Surface diſcloſe the ſame Colour. But more (perchance) of this elſewhere.

15. And erefore, we ſhall here paſs by the Queſtion, whether any thing might be

be consider'd about the Opacity of the Corpuscles of Black Pigments, and the *Comparative* Diaphanëity of those of many White Bodies, apply'd to our present Case; and proceed, to represent, That the newly mention'd Exiguity and Shape of the extant Particles being suppos'd, it will then be considerable what we lately but Hinted, (and therefore must now somewhat Explain) That the Depth of the little Cavities, intercepted between the extant Particles, without being so much greater in Black Bodies than in White ones, as to be perceptibly so to the Gross Organs of Touch, may be very much greater in reference to their Disposition of Reflecting the imaginary subtile beams of Light. For in Black Bodies, those Little intercepted Cavities, and other Depressions, may be so Figur'd, so Narrow and so Deep, that the incident Beams of Light, which the more extant Parts of the Physical Superficies are dispos'd to Reflect inwards, may be Detain'd there, and prove unable to Emerge; whilst in a White Body, the Slender Particles may not only by their Figure be fitted to Reflect the Light copiously outwards, but the intercepted Cavities being not Deep, nor perhaps very Narrow, the bottoms of them may be so constituted, as to

be fit to Reflect outwards much of the Light that falls even upon Them; as you may possibly better apprehend, when we shall come to treat of Whiteness, and Blackness. In the mean time it may suffice, that you take Notice with me, that the Blind mans Relations import no necessity of Concluding, that, though, because, according to the Judgment of his Touch, Black was the Roughest, as it is the Darkest of Colours, therefore White, which (according to us) is the Lightest, should be also the Smoothest: since I observe, that he makes Yellow to be two Degrees more Asperous than Blew, and as much less Asperous than Green; whereas indeed, Yellow do's not only appear to the Eye a Lighter Colour than Blew, but (by our first Experiment hereafter to be mention'd) it will appear, that Yellow reflected much more Light than Blew, and manifestly more than Green, (which we need not much wonder at, since in this Colour, and the two others (Blew and Yellow) 'tis not *only* the *Reflected Light* that is to be considered, since to produce both these, *Refraction* seems to Intervene, which by its Varieties may much alter the Case:) which both seems to strengthen the Conjecture I was formerly proposing, that there was something else in

in the *Kinds* of Asperity, as well as in the *Degrees* of it, which enabled our Blind man to Discriminate Colours, and do's at least shew, that we cannot in all Cases from the bare Difference in the Degrees of Asperity betwixt Colours, safely conclude, that the Rougher of any two always Reflects the least Light.

16. But this notwithstanding, (*Pyrophilus*) and whatever Curiosity I may have had to move some Questions to our Sagacious Blind man; yet thus much I think you will admit us to have gain'd by his Testimony, that since many Colours may be felt with the Circumstances above related, the Surfaces of such Coloured Bodies must certainly have differing *Degrees*, and in all probability have differing *Forms* or Kinds of Asperity belonging to them, which is all the Use that my present attempt obliges me to make of the History above deliver'd, that being sufficient to prove, *that* Colour do's much depend upon the Disposition of the Superficial parts of Bodies, and to shew in general, *wherein* 'tis probable that such a Disposition do's (principally at least) consist.

17. But to return to what I was saying before I began to make mention of our blind *Organist*, what we have deliver'd

touching the causes of the several Forms of Asperity that may Diversifie the Surfaces of Colour'd Bodies, may perchance somewhat assist us to make some Conjectures in the general, at several of the ways whereby 'tis possible for the Experiments hereafter to be mention'd, to produce the sudden changes of Colours that are wont to be Consequent upon them; for most of these *Phænomena* being produc'd by the Intervention of Liquors, and these for the most part abounding with very Minute, Active, and Variously Figur'd Saline Corpuscles, Liquors so Qualify'd may well enough very Nimbly alter the Texture of the Body they are employ'd to Work upon, and so may change the form of Asperity, and thereby make them Remit to the Eye the Light that falls on them, after another manner than they did before, and by that means Vary the Colour, so far forth as it depends upon the Texture or Disposition of the Seen Parts of the Object; which I say, *Pyrophilus*, that you may not think I would absolutely exclude all other ways of Modifying the Beams of Light between their Parting from the Lucid Body, and their Reception into the common Sensory.

18. Now there seem to me divers ways, by

by which we may conceive that Liquors may Nimbly alter the Colour of one another, and of other Bodies, upon which they Act; but my present haste will allow me to mention but some of them, without Insisting so much as upon those I shall name.

19. And first, the Minute Corpuscles that compose a Liquor may easily insinuate themselves into those Pores of Bodies, whereto their Size and Figure makes them Congruous, and these Pores they may either exactly fill, or but Inadequately, and in this latter Case they will for the most part alter the Number and Figure, and always the Bigness of the former Pores. And in what capacity soever these Corpuscles of a Liquor come to be Lodg'd or Harbour'd in the Pores that admit them, the Surface of the Body will for the most part have its Asperity alter'd, and the Incident Light that meets with a Grosser Liquor in the little Cavities that before contain'd nothing but Air, or some yet Subtiler Fluid, will have its Beams either Refracted, or Imbib'd, or else Reflected more or less Interruptedly, than they would be, if the Body had been Unmoistned, as we see, that even fair Water falling on White Paper, or Linnen, and divers other Bodies

apt to ſoak it in, will for ſome ſuch Reaſons as thoſe newly mention'd, immediately alter the Colour of them, and for the moſt part make it Sadder than that of the Unwetted Parts of the ſame Bodies. And ſo you may ſee, that when in the Summer the High-ways are Dry and Duſty, if there falls ſtore of Rain, they will quickly appear of a much Darker Colour than they did before; and if a Drop of Oyl be let fall upon a Sheet of White-Paper, that part of it, which by the Imbibition of the Liquor acquires a greater continuity, and ſome Tranſparency, will appear much Darker than the reſt, many of the Incident Beams of Light being now Tranſmitted, that otherwiſe would be Reflected towards the Beholders Eyes.

20. Secondly, A Liquor may alter the Colour of a Body by freeing it from thoſe things that hindred it from appearing in its Genuine Colour; and though this may be ſaid to be rather a Reſtauration of a Body to its own Colour, or a Retection of its native Colour, than a change, yet ſtill there Intervenes in it a change of the Colour which the Body appear'd to be of before this Operation. And ſuch a change a Liquor may work, either by Diſſolving, or Corroding, or by ſome ſuch way of carry-

carrying off that Matter, which either Veil'd or Disguis'd the Colour that afterwards appears. Thus we restore Old pieces of Dirty Gold to a clean and nitid Yellow, by putting them into the Fire, and into *Aqua-fortis*, which take off the adventitious Filth that made that pure Metal look of a Dirty Colour. And there is also, an easie way to restore Silver Coyns to their due Lustre, by fetching off that which Discolour'd them. And I know a *Chymical* Liquor, which I employ'd to restore pieces of Cloth spotted with Grease to their proper Colour, by Imbibing the Spotted part with this Liquor, which Incorporating with the Grease, and yet being of a very Volatile Nature, does easily carry it away with it self. And I have sometimes try'd, that by Rubbing upon a good Touch-stone a certain *Metalline* mixture so Compounded, that the Impression it left upon the Stone appear'd of a very differing Colour from that of Gold, yet a little of *Aqua-fortis* would in a Trice make the Golden Colour disclose it self, by Dissolving the other *Metalline* Corpuscles that conceal'd those of the Gold, which you know that *Menstruum* will leave Untouch'd.

21. Thirdly, A Liquor may alter the Colour

Colour of a Body by making a Comminution of its Parts, and that principally two ways; the first by Disjoining and dissipating those Clusters of Particles, if I may so call them, which stuck more Loosely together, being fastned only by some more easily Dissoluble Cement, which seems to be the Case of some of the following Experiments, where you'l find the Colour of many Corpuscles brought to cohere by having been Precipitated together, Destroy'd by the Affusion of very piercing and incisive Liquors. The other of the two ways I was speaking of, is, by Dividing the Grosser and more Solid Particles into Minute ones, which will be always Lesser, and for the most part otherwise Shap'd than the Entire Corpuscle so Divided, as it will happen in a piece of Wood reduc'd into Splinters or Chips, or as when a piece of Crystal heated red Hot and quench'd in Cold water is crack'd into a multitude of little Fragments, which though they fall not asunder, alter the Disposition of the Body of the Crystal, as to its manner of Reflecting the Light, as we shall have Occasion to shew hereafter.

22. There is a fourth way contrary to the third, whereby a Liquor may change the Colour of another Body, especially of another

another Fluid, and that is, by procuring the Coalition of several Particles that before lay too Scatter'd and Dispers'd to exhibit the Colour that afterwards appears. Thus sometimes when I have had a Solution of Gold so Dilated, that I doubted whether the Liquor had really Imbib'd any true Gold or no, by pouring in a little *Mercury*, I have been quickly able to satisfie my Self, that the Liquor contain'd Gold, that Metal after a little while Cloathing the Surface of the *Quick-silver*, with a Thin Film of its own Livery. And chiefly, though not only by this way of bringing the Minute parts of Bodies together in such Numbers as to make them become Notorious to the Eye, many of these Colours seem to be Generated which are produc'd by Precipitations, especially by such as are wont to be made with fair Water, as when Resinous Gumms dissolv'd in Spirit of Wine, are let fall again, if the Spirit be Copiously diluted with that weakning Liquor. And so out of the Rectify'd and Transparent Butter of *Antimony*, by the bare Mixture of fair Water, there will be plentifully Precipitated that Milk-white Substance, which by having its Looser Salts well wash'd off, is turn'd into that Medicine, which Vulgar *Chymists* are pleas'd to call *Mercurius Vitæ*.

23. A fifth way, by which a Liquor may change the Colour of a Body, is, by Diſlocating the Parts, and putting them out of their former Order into another, and perhaps alſo altering the Poſture of the ſingle Corpuſcles as well as their Order or Situation in reſpect of one another. What certain kinds of Commotion or Diſlocation of the Parts of a Body may do towards the Changing its Colour, is not only evident in the Mutations of Colour obſervable in *Quick-ſilver*, and ſome other Concretes long kept by *Chymiſts* in a Convenient Heat, though in cloſe Veſſels, but in the Obvious Degenerations of Colour, which every Body may take notice of in Bruis'd Cherries, and other Fruit, by comparing after a while the Colour of the Injur'd with that of the Sound part of the ſame Fruit. And that alſo ſuch Liquors, as we have been ſpeaking of, may greatly Diſcompoſe the Textures of many Bodies, and thereby alter the Diſpoſition of their Superficial parts, the great Commotion made in Metals, and ſeveral other Bodies by *Aqua-fortis*, Oyl of *Vitriol*, and other Saline *Menſtruums*, may eaſily perſwade us; and what ſuch Vary'd Situations of Parts may do towards the Diverſifying of the manner of their Reflecting the Light, may be

be Gues'd in some Measure by the Beating of Transparent Glass into a White Powder, but far better by the Experiments lately Pointed at, and hereafter Deliver'd, as the Producing and Destroying Colours by the means of subtil Saline Liquors, by whose Affusion the Parts of other Liquors are manifestly both Agitated, and likewise Dispos'd after another manner than they were before such Affusion. And in some *Chymical* Oyls, as particularly that of Lemmon Pills, by barely Shaking the Glass, that holds it, into Bubbles, that Transposition of the Parts which is consequent to the the Shaking, will shew you on the Surfaces of the Bubbles exceeding Orient and Lively Colours, which when the Bubbles relapse into the rest of the Oyl, do immediately Vanish.

24. I know not, *Pyrophilus*, whether I should mention as a Distinct way, because it is of a somewhat more General Nature, that Power, whereby a Liquor may alter the Colour of another Body, by putting the Parts of it into Motion; For though possibly the Motion so produc'd, does, as such, seldom suddenly change the Colour of the Body whose Parts are Agitated, yet this seems to be one of the most General, however not immediate Causes of the

the Quick change of Colours in Bodies. For the Parts being put into Motion by the adventitious Liquor, divers of them that were before United, may become thereby Disjoyn'd, and when that Motion ceases or decays, others of them may Stick together, and that in a new Order, by which means the Motion may sometimes produce Permanent Changes of Colours, as in the Experiment you will meet with hereafter, of presently turning a Snowy White Body into a Yellow, by the bare Affusion of fair Water, which probably so Dissolves the Saline Corpuscles that remain'd in the *Calx*, and sets them at Liberty to Act upon one another, and the Metal, far more Powerfully than the Water without the Assistance of such Saline Corpuscles could do. And though you rub Blew *Vitriol*, how Venereal and Unsophisticated soever it be, upon the Whetted Blade of a Knife, it will not impart to the Iron its Latent Colour; but if you moisten the *Vitriol* with your Spittle, or common Water, the Particles of the Liquor disjoyning those of the *Vitriol*, and thereby giving them the Various Agitation requisite to Fluid Bodies, the Metalline Corpuscles of the thus Dissolv'd *Vitriol* will lodge themselves in Throngs in the Small and Congruous Pores

Pores of the Iron they are Rubb'd on, and so give the Surface of it the Genuine Colour of the Copper.

25. There remains yet a way, *Pyrophilus*, to be mention'd, by which a Liquor may alter the Colour of another Body, and this seems the most important of all, because though it be nam'd but as One, yet it may indeed comprehend Many, and that is, by Associating the Saline Corpuscles, or any other sort of the more Rigid ones of the Liquor, with the Particles of the Body that it is employ'd to work upon. For these Adventitious Corpuscles Associating themselves with the Protuberant Particles of the Surface of a Colour'd Body, must necessarily alter their Bigness, and will most commonly alter their Shape. And how much the Colours of Bodies depend upon the Bulk and Figure of their Superficial Particles, you may Guess by this, that eminent ancient *Philosophers*, and divers *Moderns*, have thought that all Colours might in a general way be made out by these two; whose being Diversify'd, will in our Case be attended with these two Circumstances, the One, that the Protuberant Particles being Increas'd in Bulk, they will oftentimes be Vary'd as to the Closeness or Laxity of their

their Order, fewer of them being contain'd within the same Sensible (though Minute) space than before; or else by approaching to one another, they must Straiten the Pores, and it may be too, they will by their manner of Associating themselves with the Protuberant Particles, intercept new Pores. And this invites me to consider farther, that the Adventitious Corpuscles, I have been speaking of, may likewise produce a great Change as well in the little Cavities or Pores as in the Protuberances of a Colour'd Body; for besides what we have just now taken notice of, they may by Lodging themselves in those little Cavities, fill them up, and it may well happen, that they may not only fill the Pores they Insinuate themselves into, but likewise have their Upper parts extant above them; and partly by these new Protuberances, partly by Increasing the Bulk of the former, these Extraneous Corpuscles may much alter the Number and Bigness of the Surfaces Pores, changing the Old and Intercepting new ones. And then 'tis Odds, but the Order of the Little Extancies, and consequently that of the Little Depressions in point of Situation will be alter'd likewise: as if you dissolve *Quick-silver* in some kind of *Aqua-fortis*,

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the Saline Particles of the *Menstruum*, Associating themselves with the Mercurial Corpuscles, will make a Green Solution, which afterwards easily enough Degenerates. And Red Lead, or *Minium* being Dissolv'd in Spirit of Vinegar, yields not a Red, but a Clear Solution, the Redness of the Lead being by the Liquor Destroy'd. But a better Instance may be taken from Copper; for I have try'd, that if upon a Copper-plate you let some Drops of weak *Aqua-fortis* rest for a while, the Corpuscles of the *Menstruum* joining with those of the Metal, will produce a very sensible Asperity upon the Surface of the Plate, and will Concoagulate that way into very minute Grains of a Pale Blew *Vitriol*; whereas if upon another part of the same Plate you suffer a little strong Spirit of Urine to rest a competent time, you shall find the Asperated Surface adorn'd with a Deeper and Richer Blew. And the same *Aqua-fortis*, that will quickly change the Redness of Red Lead into a Darker Colour, will, being put upon Crude Lead, produce a Whitish Substance, as with Copper it did a Blewish. And as with Iron it will produce a Reddish, and on White Quills a Yellowish, so much may the Coalition of the Parts of the same

Liquor, with the differingly Figur'd Particles of Stable Bodies, divers ways Asperate the differingly Dispos'd Surfaces, and so Diversifie the Colour of those Bodies. And you'l easily believe, that in many changes of Colour, that happen upon the Dissolutions of Metals, and Precipitations made with Oyl of *Tartar*, and the like Fix'd Salts, there may Intervene a Coalition of Saline Corpuscles with the Particles of the Body dissolv'd or precipitated, if you examine how much the *Vitriol* of a Metal may be heavier than the Metalline part of it alone; upon the Score of the Saline parts Concoagulated therewith, and, that in several Precipitations the weight of the *Calx* does for the same Reason much exceed that of the Metal, when it was first put in to be Dissolv'd.

26. But, *Pyrophilus*, to consider these Matters more particularly would be to forget that I declar'd against Adventuring, at least for this time, at particular Theories of Colours, and that accordingly you may justly expect from me rather Experiments than Speculations; and therefore I shall Dismiss this Subject of the Forms of Superficial Asperity in Colour'd Bodies, as soon as I shall but have nam'd to you by way of Supplement to what we have hitherto

hitherto Discours'd in this Section, a Couple of Particulars, (which you'l easily grant me) The one, That there are divers other ways for the speedy Production even of True and Permanent Colours in Bodies, besides those Practicable by the help of Liquors; for proof of which Advertisement, though several Examples might be alleged, yet I shall need but Re-mind you of what I mention'd to you above, touching the change of Colours suddenly made on Temper'd Steel, and on Lead, by the Operation of Heat, without the Intervention of a Liquor. But the other particular I am to observe to you is of more importance to our present Subject, and it is, that though Nature and Art may in some cases so change the Asperity of the Superficial parts of a Body, as to change its Colour by either of the ways I have propos'd Single or Un-assisted: yet for the most part 'tis by two or three, or perhaps by more of the fore-mention'd ways Associated together, that the Effect is produc'd: and if you consider how Variously those several ways and some others Ally'd unto them, which I have left unmention'd, may be Compounded and Apply'd, you will not much wonder that such fruitful, whether Principles (or Manners of Diver-

sification) should be fitted to Change or Generate no small store of Differing Colours.

27. Hitherto, *Pyrophilus*, we have in discoursing of the Asperity of Bodies consider'd the little Protuberances of other Superficial particles which make up that Roughness, as if we took it for granted, that they must be perfectly Opacous and Impenetrable by the Beams of Light, and so, must contribute to the Variety of Colours as they terminate more or less Light, and reflect it to the Eye mix'd with more or less of thus or thus mingl'd Shades. But to deal Ingenuously with you, *Pyrophilus*, before I proceed any further, I must not conceal from you, that I have often thought it worth a Serious Enquiry, whether or no Particles of Matter, each of them singly Insensible, and therefore Small enough to be capable of being such Minute Particles, as the *Atomists* both of old and of late have (not absurdly) called *Corpuscula Coloris*, may not yet consist each of them of divers yet Minuter Particles, betwixt which we may conceive little Commissures where they adhere to one another, and, however, may not be Porous enough to be, at least in some degree, pervious to the unimaginably subtil Corpuscles that make up the beams of Light,

Light, and consequently to be in such a degree Diaphanous. For, *Pyrophilus*, that the proposed Enquiry may be of moment to him that searches after the Nature of Colour, you'l easily grant, if you consider, that whereas Perfectly Opacous bodies can but reflect the incident Beams of Light, those that are Diaphanous are qualified to refract them too, and that Refraction has such a stroak in the Production of Colours, as you cannot but have taken notice of, and perhaps admir'd in the Colours generated by the Trajection of Light through Drops of Water that exhibit a Rain bow, through Prismaticall Glasses, and through divers other Transparent bodies. But 'tis like, *Pyrophilus*, you'l more easily allow that about this matter 'tis rather Important to have a Certainty, than that 'tis Rational to entertain a Doubt; wherefore I must mention to you some of the Reasons that make me think it may need a further Enquiry; for I find that in a Darkned Room, where the Light is permitted to enter but at one hole, the little wandring Particles of Dust, that are commonly called Motes, and, unless in the Sun-beams, are not taken notice of by the unassisted Sight, I have, I say, often observ'd that these roving Corpuscles being look'd on by an Eye plac'd on one side of the

Beams that entered the Little hole, and by the Darkneſs having its Pupil much Enlarg'd, I could diſcern that theſe Motes as ſoon as they came within the compaſs of the Luminous, whether Cylinder or Inverted Cone, if I may ſo call it, that was made up by the unclouded Beams of the Sun, did in certain poſitions appear adorn'd with very vivid Colours, like thoſe of the Rain-bow, or rather like thoſe of very Minute, but ſparkling fragments of Diamonds; and as ſoon as the continuance of their Motion had brought them to an Inconvenient poſition in reference to the Light and the Eye, they were only viſible without Darting any lively Colours as before; which ſeems to argue that theſe little Motes, or minute Fragments of ſeveral ſorts of bodies reputed Opacous, and only crumbled as to their Exterior and Looſer parts into Duſt, did not barely reflect the Beams that fell upon them, but remit them to the Eye Refracted too. We may alſo obſerve, that ſeveral Bodies, (as well ſome of a Vegetable, as others of an Animal nature) which are wont to paſs for Opacous, appear in great part tranſparent, when they are reduc'd into thin parts, and held againſt a powerful Light. This I have not only taken notice of in pieces of Ivory reduc'd but into thick Leavs, as alſo in divers conſidera-

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ble Thick shells of Fishes, and in shaving of Wood, but I have also found that a piece of Deal, far thicker than one would easily imagine, being purposely interpos'd betwixt my Eye plac'd in a Room, and the clear Day-light, was not only somewhat Transparent, but (perhaps by reason of its Gummous nature) appear'd quite through of a lovely Red. And in the Darkned Room above mention'd, Bodies held against the hole at which the Light enter'd, appear'd far less Opacous than they would elsewhere have done, insomuch that I could easily and plainly see through the whole Thickness of my Hand, the Motions of a Body plac'd (at a very near distance indeed, but yet) beyond it. And even in Minerals, the Opacity is not always so great as many think, if the Body be made Thin; for White Marble though of a pretty Thickness, being within a Due distance plac'd betwixt the Eye and a Convenient Light, will suffer the Motions of ones Finger to be well discern'd through it, and so will pieces, Thick enough, of many common Flints. But above all, that Instance is remarkable, that is afforded us by *Muscovie* glass, (which some call *Selenites*, or the *Lapis Specularis*) for though plates of this Mineral, though but of a moderate Thickness, do often appear Opacous, yet

one of these be Dextrously split into the thinnest Leaves 'tis made up of, it will yield such a number of them, as scarce any thing but Experience, could have perswaded me; and these Leaves will afford the most Transparent sort of consistent Bodies, that, for ought I have observ'd, are yet known; and a single Leaf or Plate will be so far from being Opacous, that 'twill scarce be so much as Visible. And multitudes of Bodies there are, whose Fragments seem Opacous to the naked Eye, which yet, when I have included them in good *Microscopes*, appear'd Transparent; but, *Pyrophilus*, on the other side I am not yet sure that there are no Bodies, whose Minute Particles even in such a *Microscope* as that of mine, which I was lately mentioning, will not appear Diaphanous. For having consider'd *Mercury* Precipitated *per se*, the little Granules that made up the powder, look'd like little fragments of Coral beheld by the naked Eye at a Distance (for very Near at hand Coral will sometimes, especially if it be Good, shew some Transparency.) Filings likewise of Steel and Copper, though in an excellent *Microscope*, and a fair Day, they show'd like pretty Big Fragments of those Metals, and had considerable Brightness on some of their Surfaces, yet I was not satisfi'd, that I perceiv'd

ceiv'd any Reflection from the Inner parts of any of the Filings. Nay, having look'd in my beſt *Microſcope* upon the Red *Calx* of Lead, (commonly call'd *Minium*) neither I, nor any I ſhew'd it to, could diſcern it to be other than Opacous, though the Day were Clear, and the Object ſtrongly enlightned. And the deeply Red Colour of *Vitriol* appear'd in the ſame *Microſcope* (notwithſtanding the great Comminution effected by the Fire) but like Groſſy beaten Brick. So that, *Pyrophilus*, I ſhall willingly reſign you the care of making ſome further Enquiries into the Subject we have now been conſidering; for I confeſs, as I told you before, that I think that the Matter may need a further Scrutiny, nor would I be forward to Determine how far or in what caſes the Tranſparency or Semi-diaphaniety of the Superficial Corpuſcles of Bigger Bodies, may have an Intereſt in the Production of their Colours, eſpecially becauſe that even in divers White bodies, as Beaten Glaſs, Snow and Froth, where it ſeems manifeſt that the Superficial parts are ſingly Diaphanous, (being either Water, or Air, or Glaſs) we ſee not that ſuch Variety of Colours are produc'd as uſually are by the Refraction of Light even in thoſe Bodies, when by their Bigneſs, Shape, &c. they are conveniently

qualify'd

qualify'd to exhibit such various and lively Colours as those of the Rain-bow, and of Prismatical Glasses.

28. By what has been hitherto discours'd, *Eyraphilus*, we may be assisted to judge of that famous Controversie which was of Old disputed betwixt the *Epicureans* and other *Atomists* on the one side, and most other *Philosophers* on the other side. The former denying Bodies to be Coloured in the Dark, and the Latter making Colour to be an Inherent quality, as well as Figure, Hardness, Weight, or the like. For though this Controversie be Reviv'd, and hotly Agitated among the *Moderns*, yet I doubt whether it be in not great part a Nominal dispute; and therefore let us, according to the Doctrine formerly deliver'd, distinguish the Acceptions of the word Colour, and say, that if it be taken in the Stricter Sense, the *Epicureans* seem to be in the Right; for if Colour be indeed, though not according to them, but Light Modify'd, how can we conceive that it can Subsist in the Dark, that is, where it must be suppos'd there is no Light; but on the other side, if Colour be consider'd as a certain Constant Disposition of the Superficial parts of the Object to trouble the Light they Reflect after such and such a Determinate manner,

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this Constant, and if I may so speak, Modifying disposition persevering in the Object, whether it be Shin'd upon or no, there seems no just reason to deny, but that in this Sense, Bodies retain their Colour as well in the Night as Day; or, to speak a little otherwise, it may be said, that Bodies are Potentially Colour'd in the Dark, and Actually in the Light. But of this Matter discoursing more fully elsewhere, as 'tis a difficulty that concerns Qualities in general, I shall forbear to insist on it here.

CHAP. IV.

1. OF greater Moment in the Investigation of the Nature of Colours is the Controversie, Whether those of the Rain-bow, and those that are often seen in Clouds, before the Rising, or after the Setting of the Sun; and in a word, Whether those other Colours, that are wont to be call'd Emphatical, ought or ought not to be accounted True Colours. I need not tell you that the Negative is the Common Opinion, especially in the Schools, as may appear by that Vulgar distinction of Colours, whereby these under Consideration are term'd Apparent, by way of Opposition

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to those that in the other Member of the Distinction are call'd True or Genuine. This Question I say seems to me of Importance, upon this Account, that it being commonly Granted, (or however, easie enough to be provid) that Emphatical Colours are Light it self modify'd by Refractions chiefly, with a concurrence sometimes of Reflections, and perhaps some other Accidents depending on these two; if these Emphatical Colours be resolv'd to be Genuine, it will seem consequent, that Colours, or at least divers of them, are but Diversify'd Light, and not such Real and Inherent qualities as they are commonly thought to be.

2. Now since we are wont to esteem the Ecchoes and other Sounds of Bodies, to be True Sounds, all their Odours to be True Odours, and (to be short) since we judge other Sensible Qualities to be True ones, because they are the proper Objects of some or other of our Senses, I see not why Emphatical Colours, being the proper and peculiar Objects of the Organ of Sight, and capable to Affect it as Truly and as Powerfully as other Colours, should be reputed but Imaginary ones.

And if we have (which perchance you'l allow) formerly evinc'd Colour, (when

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the word is taken in its more Proper ſenſe) to be but Modify'd Light, there will be ſmall Reaſon to deny theſe to be true Colours, which more manifeſtly than others diſcloſe themſelves to be produc'd by Diverſifications of the Light.

3. There is indeed taken notice of a Difference betwixt theſe Apparent colours, and thoſe that are wont to be eſteem'd Genuine, as to the Duration, which has induc'd ſome Learned Men to call the former rather Evanid than Fantaſtical. But as the Ingenious *Gaſſendus* does ſomewhere Judiciouſly obſerve, if this way of Arguing were Good, the Greenneſs of a Leaf ought to paſs for Apparent, becauſe, ſoon Fading into a Yellow, it ſcarce laſts at all, in compariſon of the Greenneſs of an Emerauld. I ſhall add, that if the Sun-beams be in a convenient manner trajected through a Glaſs-priſm, and thrown upon ſome well-ſhaded Object within a Room, the Rainbow thereby painted on the Surface of the Body that Terminates the Beams, may oftentimes laſt longer than ſome Colours I have produc'd in certain Bodies, which would juſtly, and without ſcruple be accounted Genuine Colours, and yet ſuddenly Degenerate, and loſe their Nature.

4. A greater Diſparity betwixt Emphatical

phatical Colours, and others, may perhaps be taken from this, that Genuine Colours seem to be produc'd in Opacous Bodies by Reflection, but Apparent ones in Diaphanous Bodies, and principally by Refraction, I say Principally rather than Solely, because in some cases Reflection also may concur; but still this seems not to conclude these Latter Colours not to be True ones. Nor must what has been newly said of the Differences of True and Apparent Colours, be interpreted in too Unlimited a Sense, and therefore it may perhaps somewhat Assist you, both to Reflect upon the two fore-going Objections, and to judge of some other Passages which you'l meet with in this Tract; if I take this Occasion to observe to you, that if Water be Agitated into Froth, it exhibits you know a White Colour, which soon after it Loses upon the Resolution of the Bubbles into Air and Water; now in this case either the Whiteness of the Froth is a True Colour or not; if it be, then True Colours, supposing the Water pure and free from Mixtures of any thing Tenacious, may be as Short-liv'd as those of the Rain-bow; also the Matter, wherein the Whiteness did Reside, may in a few moments perfectly Lose all foot-steps or remains of it. And

Besides,

beſides; even Diaphanous Bodies may be capable of exhibiting True Colours by Reflection; for that Whiteneſs is ſo produc'd, we ſhall anon make it probable. But if on the other ſide it be ſaid, that the Whiteneſs of Froth is an Emphatical Colour, then it muſt no longer be ſaid, that Fantaſtical Colours require a certain Poſition of the Luminary and the Eye, and muſt be Vary'd or Deſtroy'd by the Change thereof, ſince Froth appears White, whether the Sun be Riſing or Setting, or in the Meridian, or any where between it and the Horizon, and from what (Neighbouring) place ſoever the Beholders Eye looks upon it. And ſince by making a Liquor Tenacious enough, yet without Deſtroying its Tranſparency, or Staining it with any Colour, you may give the little Films, whereof the Bubbles conſiſt, ſuch a Texture, as may make the Froth laſt very many Hours, if not ſome Days, or even Weeks, it will render it ſomewhat Improper to aſſign Duration for the diſtinguiſhing Character to diſcriminate Genuine from Fantaſtical Colours. For ſuch Froth may much outlaſt the Undoubtedly true Colours of ſome of Nature's Productions, as in that Gaudy Plant not undeſervedly call'd the Mervail of *Peru*, the Flowers do often Fade, the

ſame

same Day they are Blown; And I have often seen a *Virginian* Flower, which, usually Withers within the compass of a Day; and I am credibly Inform'd, that not far from hence a curious Herborist has a Plant, whose Flowers perish in about an Hour. But if the Whiteness of Water turn'd into Froth must therefore be reputed Emphatical, because it appears not that the Nature of the Body is Alter'd, but only that the Disposition of its Parts in reference to the Incident Light is Chang'd, why may not the Whiteness be accounted Emphatical too, which I shall shew anon to be Producible, barely by such another change in Black Horn? and yet this so easily acquir'd Whiteness seems to be as truly its Colour as the Blackness was before, and at least is more Permanent than the Greenness of Leaves, the Redness of Roses, and, in short, than the Genuine Colours of the most part of Nature's Productions. It may indeed be further Objected, that according as the Sun or other Luminous Body changes place, these Emphatical Colours alter or vanish. But not to repeat what I have just now said, I shall add, that if a piece of Cloath in a Drapers Shop (in such the Light being seldom Primary) be variously Folded, it will appear of differing

Colours,

Colours, as the Parts happen to be more Illuminated or more Shaded, and if you ſtretch it Flat, it will commonly exhibit ſome one Uniform Colour, and yet theſe are not wont to be reputed Emphatical, ſo that the Difference ſeems to be chiefly this, that in the Caſe of the Rain-bow, and the like, the Poſition of the Luminary Varies the Colour, and in the Cloath I have been mentioning, the Poſition of the Object does it. Nor am I forward to allow that in all Caſes the Apparition of Emphatical Colours requires a Determinate poſition of the Eye; for if Men will have the Whiteneſs of Froth Emphatical, you know what we have already Inferr'd from thence. Beſides, the Sun-beams trajected through a Triangular Glaſs, after the manner lately mention'd, will, upon the Body that Terminates them, Paint a Rain-bow, that may be ſeen whether the Eye be plac'd on the Right Hand of it or the Left, or Above or Beneath it, or Before or Behind it; and though there may appear ſome Little Variation in the Colours of the Rain-bow, beheld from Differing parts of the Room, yet ſuch a Diverſity may be alſo obſerv'd by an Attentive Eye in Real Colours, look'd upon under the like Circumſtances. Nor will it fol-

low, that becauſe there remains no Foot-ſteps of the Colour upon the Object, when the Priſm is Remov'd, that therefore the Colour was not Real, ſince the Light was truly Modify'd by the Refraction and Reflection it ſuffered in its Trajection through the Priſm; and the Object in our caſe ſerv'd for a Specular Body, to Reflect that Colour to the Eye. And that you may not be Startled, *Pyrophilus*, that I ſhould Venture to ſay, that a Rough and Colour'd Object may ſerve for a *Speculum* to Reflect the Artificial Rain-bow I have been mentioning, conſider what uſually happens in Darkned Rooms, where a Wall, or other Body conveniently Situated within, may ſo Reflect the Colours of Bodies, without the Room, that they may very clearly be Diſcern'd and Diſtinguiſh'd, and yet 'tis taken for granted, that the Colours ſeen in a Darkned Room, though they leave no Traces of themſelves upon the Wall or Body that Receives them, are the True Colours of the External Objects, together with which the Colours of the Images are Mov'd or do Reſt. And the Errour is not in the Eye, whoſe Office is only to perceive the Appearances of things, and which does Truly ſo, but in the Judging or Eſtimative faculty, which Miſtakingly

ly concludes that Colour to belong to the Wall, which does indeed belong to the Object, becauſe the Wall is that from whence the Beams of Light that carry the viſible *species*, do come in Straight Lines directly to the Eye; as for the ſame Reaſon we are wont at a certain Diſtance from Concave Sphærical Glaſſes, to perſwade our ſelves that we ſee the Image come forth to Meet us, and hang in the Air betwixt the Glaſs and Us, becauſe the Reflected Beams that Compoſe the Image croſs in that place, where the Image ſeems to be, and thence, and not from the Glaſs, do in Direct Lines take their Courſe to the Eye; and upon the like Cauſe it is, that divers Deceptions in Sounds and other Senſible Objects do depend, as we elſewhere declare.

5. I know not, whether I need add, that I have purpoſely Try'd, (as you'l find ſome Pages hence, and will perhaps think ſomewhat ſtrange) that Colours that are call'd Emphatical, becauſe not Inherent in the Bodies in which they Appear, may be Compounded with one another, as thoſe that are confeſſedly Genuine may. But when all this is ſaid, *Pyrophilus*, I muſt Advertiſe you, that it is but Problematically Spoken, and that though I think the Opi-

nion I have endeavour'd to fortifie Probable, yet a great part of our Discourse concerning Colours may be True, whether that Opinion be so or not.

CHAP. V.

1. THere are you know, *Pyrophilus*; besides those Obsolete Opinions about Colours which have been long since Rejected, very various Theories that have each of them, even at this day, Eminent Men for its Abetters; for the Peripatetick Schools, though they dispute amongst themselves divers particulars concerning Colours, yet in this they seem Unanimously enough to Agree, that Colours are Inherent and Real Qualities, which the Light doth but Disclose, and not concur to Produce. Besides there are *Moderns*, who with a slight Variation adopt the Opinion of *Plato*, and as he would have Colour to be nothing but a kind of Flame consisting of Minute Corpuscles as it were Darted by the Object against the Eye, to whose Pores their Littleness and Figure made them congruous; so these would have Colour to be an Internal Light of the more Lucid parts of the Object, Darkned and consequently Alter'd by the Various Mixtures of the less Luminous

nous parts. There are also others, who in imitation of some of the Ancient *Atomists*, make Colour not to be Lucid steam, but yet a Corporeal *Effluvium* issuing out of the Colour'd Body; but the Knowing'st of these have of late Reform'd their Hypothesis, by acknowledging and adding that some External Light is necessary to Excite, and as *they* speak, Sollicit these Corpuscles of Colour as *they* call them, and Bring them to the Eye. Another and more principal Opinion of the *Modern* Philosophers, to which this last nam'd may by a Favourable explication be reconcil'd, is that which derives Colours from the Mixture of Light and Darkness, or rather Light and Shadows. And as for the *Chymists* 'tis known, that the generality of them ascribes the Origine of Colours to the Sulphureous Principle in Bodies, though I find, as I elsewhere largely shew, that some of the Chiefest of them derive Colours rather from Salt than Sulphur, and others, from the third Hypostatical Principle, *Mercury*. And as for the *Cartesians* I need not tell you, that they, supposing the Sensation of Light to be produc'd by the Impulse made upon the Organs of Sight, by certain extremely Minute and Solid Globules, to which the Pores of the Air and other Diaphanous

phanous Bodies are pervious, endeavour to derive the Varieties of Colours from the Various Proportion of the Direct Progress or Motion of these Globules to their Circumvolution or Motion about their own Centre, by which Varying Proportion they are by this Hypothesis suppos'd qualify'd to strike the Optick Nerve after several Distinct manners, so to produce the perception of Differing Colours.

2. Besides these six principal Hypotheses, *Pyrophilus*, there may be some others, which though Less known, may perhaps as well as these deserve to be taken into consideration by you; but that I should copiously debate any of them at present, I presume you will not expect, if you consider the Scope of these Papers, and the Brevity I have design'd in them, and therefore I shall at this time only take notice to you in the general of two or three things that do more peculiarly concern the Treatise you have now in your hands.

3. And first, Though the Embracers of the several Hypotheses I have been naming to you, by undertaking each Sect of them to explicate Colours indefinitely, by the particular Hypotheses they maintain, seem to hold it forth as the only Needful Theory about that Subject; yet for my part I doubt whether

whether any one of all these Hypotheses have a right to be admitted Exclusively to all others; for I think it Probable, that Whiteness and Blackness may be explicated by Reflection alone without Refraction, as you'l find endeavour'd in the Discourse you'l meet with e're long of the Origine of Whiteness and Blackness; and on the other side, since I have not found that by any Mixture of White and True Black, (for there is a Blewish Black which many mistake for a Genuine) there can be a Blew, a Yellow, or a Red, to name no other Colours, produc'd; and since we do find that these Colours may be produc'd in the Glass-prism and other Transparent bodies, by the help of Refractions, it seems that Refraction is to be taken in into the Explication of some Colours, to whose Generation they seem to concur, either by making a further or other Commixture of Shades with the Refracted Light, or by some other way not now to be discours'd. And as it seems not improbable, that in case the Pores of the Air, and other Diaphanous bodies be every where almost fill'd with such *Globuli* as the *Cartesians* suppose, the Various kind of Motion of these *Globuli*, may in many cases have no small stroak in Varying our Perception of Colour, so

without the Supposition of these *Globuli*, which 'tis not so easie to evince, I think we may probably enough conceive in general, that the Eye may be Variously affected, not only by the Entire Beams of Light that fall upon it as they are such, but by the Order, and by the Degree of Swiftness, and in a word by the Manner according to which the Particles that compose each Particular Beam arrive at the Sensory, so that whatever be the Figure of the little Corpuscles, of which the Beams of Light consist, not only the Celerity or Slowness of their Revolution or Rotation in reference to their Progressive Motion, but their more absolute Celerity, their Direct or Undulating Motion, and other Accidents, which may attend their Appulse to the Eye, may fit them to make differing Impressions on it.

4. Secondly, For these and the like Considerations, *Pyrophilus*, I must desire that you would look upon this little Treatise, not as a Discourse written Principally to maintain any of the fore-mention'd Theories, Exclusively to all others, or substitute a New one of my own, but as the beginning of a History of Colours, upon which, when you and your Ingenious friends shall have Enrich'd it, a Solid Theory may be safely

safely built. But yet because this History is not meant barely for a Register of the things recorded in it, but for an *Apparatus* to a sound and comprehensitive Hypothesis, I thought fit, so to temper the whole Discourse, as to make it as conducible, as conveniently I can to that End, and therefore I have not scrupl'd to let you see that I was willing, as to save you the labour of Cultivating some Theories that I thought would never enable you to reach the Ends you aim at, so to contract your Enquiries into a Narrow compass; for both which purposes I thought it requisite to do these two things, the *One*, to set down some Experiments which by the help of the Reflections and Insinuations that attend them, may assist you to discover the Infirmness and Insufficiency both of the common Peripatetick Doctrine, and of the now more applauded Theory of the *Chymists* about Colour, because these two Doctrines having Possess'd themselves, the one of the most part of the Schools, and the other of the Esteem of the Generality of Physicians and other Learned Men, whose Professions and Ways of Study do not exact that they should Scrupulously examine the very First and Simplest Principles of Nature, I fear'd it would be to

little purpose, without doing something to discover the Insufficiency of these Hypotheses, that I should, (which was the *Other* thing I thought requisite for me to do) set down among my other Experiments those in the greatest Number, that may let you see, that, till I shall be Better Inform'd, I encline to take Colour to be a Modification of Light, and would invite you chiefly to Cultivate that Hypothesis, and Improve it to the making out of the Generation of Particular Colours, as I have Endeavour'd to apply it to the Explication of Whiteness and Blackness.

5. Thirdly, But, *Pyrophilus*, though this be at present the Hypothesis I prefer, yet I propose it but in a General Sense, teaching only that the Beams of Light, Modify'd by the Bodies whence they are sent (Reflected or Refracted) to the Eye, produce there that Kind of Sensation, Men commonly call Colour; But whether I think this Modification of the Light to be perform'd by Mixing it with Shades, or by Varying the Proportion of the Progress and Rotation of the *Cartesian Globuli Cœlestes*, or by some other way which I am not now to mention, I pretend not here to Declare. Much less do I pretend to Determine, or scarce so much as to Hope to know

know all that were requisite to be Known, to give You, or even my Self, a perfect account of the Theory of Vision and Colours; for in order to such an undertaking I would first Know what Light is, and if it be a Body (as a Body or the Motion of a Body it seems to be) what Kind of Corpuscles for Size and Shape it consists of, with what Swiftness they move Forwards, and Whirl about their own Centres. Then I would Know the Nature of Refraction, which I take to be one of the Abstrusest things (not to explicate Plausibly, but to explicate Satisfactorily) that I have met with in Physicks; I would further Know what Kind and what Degree of Commixture of Darkness or Shades is made by Refractions or Reflections, or both, in the Superficial particles of those Bodies, that being Shin'd upon, constantly exhibit the one, for Instance, a Blew, the other a Yellow, the third a Red Colour; I would further Know why this Contemperation of Light and Shade, that is made, for Example, by the Skin of a Ripe Cherry, should exhibit a Red, and not a Green, and the Leaf of the same Tree should exhibit a Green rather than a Red; and indeed, Lastly, why since the Light that is Modify'd into these Colours consists but of Corpuscles

puſcles moved againſt the *Retina* or Pith of the Optick Nerve, it ſhould there not barely give a Stroak, but produce a Colour, whereas a Needle wounding likewiſe the Eye, would not produce Colour, but Pain. Theſe, and perhaps other things I ſhould think requiſite to be Known, before I ſhould judge my Self to have fully Comprehended the True and Whole Nature of Colours; and therefore, though by making the Experiments and Reflections deliver'd in this Paper, I have endeavour'd ſomewhat to Leſſen my Ignorance in this Matter, and think it far more Deſireable to diſcover a Little, than to diſcover Nothing; yet I pretend but to make it Probable by the Experiments I mention, that ſome Colours may be Plauſibly enough Explicated in the General by the Doctrine here propos'd; For whenſoever I would Deſcend to the Minute and Accurate Explication of Particulars, I find my Self very Senſible of the great Obſcurity of things, without excepting thoſe which we never ſee but when they are Enlightned, and confeſs with *Scaliger*, *Latet natura hæc*, (ſays he, Speaking of that of Colour) *& ſicut aliarum rerum ſpecies in profundiſſima caligine inſcitiæ humanæ.*

Exercitat. 325. Parag. 4.

THE

THE EXPERIMENTAL HISTORY OF COLOURS.

PART II.

Of the Nature of Whiteneſs and Blackneſs.

CHAP. I.

1. THough after what I have acknowledged, *Pyrophilus*, of the Abſtruſe Nature of Colours in *particular*, you will eaſily believe, that I pretend not to give you a Satisfactory account of Whiteneſs and Blackneſs; Yet not wholly to fruſtrate your Expectation of my offering ſomething by way of Specimen towards the Explication of ſome Colours in particular,

cular, I shall make choice of These as the most Simple Ones (and by reason of their mutual Opposition the Least hardly explicable) about which to present you my Thoughts, upon condition you will take them at most to be my Conjectures, not my Opinions.

2. When I apply'd my Self to consider, how the cause of Whiteness might be explain'd by Intelligible and Mechanical Principles, I remembred not to have met with any thing among the Ancient *Corpuscularian* Philosophers, touching the Quality we call Whiteness, save that *Democritus* is by *Aristotle* said to have ascrib'd the Whiteness of Bodies to their Smoothness, and on the contrary their Blackness to their Asperity. But though about the Latter of those Qualities his Opinion be allowable, as we shall see anon, yet that he needs a Favourable Interpretation in what is Deliver'd concerning the First, (at least if his Doctrine be not Mis-represented in this point, as it has been in many others) we shall quickly have Occasion to manifest. But amongst the *Moderns*, the most Learned *Gassendus* in his Ingenious Epistle publish'd in the Year 1642. *De apparente Magnitudine*

Album quippe & nigrum, hoc quidem asperum esse dicit, hoc verò læve. de Sensu 3. & Sensil. 3.

Magnitudine solis humilis & sublimis, reviving the *Atomical* Philosophy, has, though but Incidentally, deliver'd something towards the Explication of Whiteness upon Mechanical Principles: And because no Man that I know of, has done so before him, I shall, to be sure to do him Right, give you his Sense in his own Words: *Cogites velim* (says he) *lucem quidem in Diaphano nullius coloris videri, sed in Opaco tamen terminante Candicare, ac tantò magis, quantò densior sen collectior fuerit. Deinde aquam non esse quidem coloris ex se candidi & radium tamen ex eâ reflexum versus oculum candicare. Rursus cum plana aquæ Superficies non nisi ex una parte eam reflexionem faciat: si contigerit tamen illam in aliquot bullas intumescere, bullam unamquamque reflectionem facere, & candoris speciem creare certa Superficiei parte. Ad hæc Spumam ex aqua pura non alia ratione videri candescere & albescere quam quod sit congeries confertissima minutissimarum bullarum, quarum unaquæque suum radium reflectit, unde continens candor alborve apparet. Denique Nivem nihil aliud videri quam speciem purissimæ spumæ ex bullulis quam minutissimis & confertissimis cohærentis. Sed ridiculum me exhibeam, si tales meas nugas uberius proponem.* Epist. 2. pag. 45.

3. But

3. But though in this passage, that very Ingenious Person has Anticipated part of what I should say; Yet I presume you will for all that expect, that I should give you a fuller Account of that Notion of Whiteness, which I have the least Exceptions to, and of the Particulars whence I deduce it, which to do, I must mention to you the following Experiments and Observations.

Whiteness then consider'd as a Quality in the Object, seems chiefly to depend upon this, That the Superficies of the Body that is call'd White, is Asperated by almost innumerable Small Surfaces, which being of an almost Specular Nature, are also so Plac'd, that some Looking this way, and some that way, they yet Reflect the Rays of Light that fall on them, not towards one another, but outwards towards the Spectators Eye. In this Rude and General account of Whiteness, it seems that besides those Qualities, which are common to Bodies of other Colours, as for instance the Minuteness and Number of the Superficial parts, the two chief things attributed to Bodies as White are made to be: First, that its Little Protuberances and Superficial parts be of somewhat a Specular Nature, that they may as little Looking-glasses each of them Reflect the Beams it receives,

receives, (or the little Picture of the Sun made on it) without otherwise considerably Altering them; whereas in most other Colours, they are wont to be much Chang'd, by being also Refracted, or by being Return'd to the Eye, mixt with Shades or otherwise. And next, that its Superficial parts be so Situated, that they Retain not the Incident Rays of Light by Reflecting them Inwards, but send them almost all Back, so that the Outermost Corpuscles of a white Body, having their Various Little Surfaces of a Specular Nature, a Man can from no place Behold the Body, but that there will be among those Innumerable *Superficieculæ*, that look some one way, and some another, enough of them Obverted to his Eye, to afford like a broken Looking-glass, a confused Idæa, or Representation of Light, and make such an Impression on the Organ, as that for which Men are wont to call a Body White. But this Notion will perhaps be best Explain'd by the same Experiments and Observations, on which it is Built, and therefore I shall now advance to *Them*.

4. And in the first place I consider, that the Sun and other Powerfully Lucid Bodies, are not only wont to Offend, which we call to Dazle our Eyes, but that if any

Colour be to be Aſcrib'd to them as they are Lucid, it ſeems it ſhould be Whiteneſs: For the Sun at Noon-day, and in Clear weather, and when his Face is leſs Troubled, and as it were Stained by the Steams of Sublunary Bodies, and when his Beams have much leſs of the Atmoſphere to Traject in their Paſſage to our Eyes, appears of a Colour more approaching to White, than when nearer the Horizon, the Interpoſition of certain Sorts of Fumes and Vapours make him oftentimes appear either Red, or at leaſt more Yellow. And when the Sun Shines upon that Natural Looking-glaſs, a Smooth water, that part of it, which appears to this or that particular Beholder, the moſt Shin'd on, does to his Eye ſeem far Whiter than the reſt. And here I ſhall add, that I have ſometimes had the Opportunity to obſerve a thing, that may make to my preſent purpoſe, namely, that when the Sun was Veil'd over as it were, with a Thin White Cloud, and yet was too Bright to be Look'd upon Directly without Dazling, by caſting my Eyes upon a Smooth water, as we ſometimes do to obſerve Eclipſes without prejudice to our Eyes, the Sun then not far from the Meridian, appear'd to me not Red, but ſo White, that 'twas

not

not without some Wonder, that I made the Observation. Besides, though we in *English* are wont to say, a thing is Red hot, as an Expression of its being Superlatively *ignitum*, (if I may so Speak for want of a proper *English* word) yet in the Forges of Smiths, and the Furnaces of other Artificers, by that which they call a White heat, they mean a further Degree of *Ignition*, than by that which both they and we call a Red heat.

5. Secondly, I consider, that common Experience informs us, that as much Light Over-powers the Eye, so when the Ground is covered with Snow, (a Body extreamly White) those that have Weak Eyes are wont to complain of too much Light: And even those that have not, are generally Sensible of an Extraordinary measure of Light in the Air; and if they are fain to Look very long upon the Snow, find their Sight Offended by it. On which occasion we may call to mind what *Xenophon* relates, that his *Cyrus* marching his Army for divers days through Mountains covered with Snow, the Dazling splendor of its Whiteness prejudic'd the Sight of very many of his Souldiers, and Blinded some of them; and other Stories of that Nature may be met with in Writers of good

Note. And the like has been affirm'd to me by credible Persons of my own Acquaintance, and especially by one who though skill'd in Physick, and not Ancient, confess'd to me when I purposely ask'd him, that not only during his stay in *Muscovy*, he found his Eyes much Impair'd, by being reduc'd frequently to Travel in the Snow, but that the Weakness of his Eyes did not leave him when he left that Country, but has follow'd him into these Parts; and yet continues to Trouble him. And to this doth agree what I as well as others have observ'd, namely, that when I Travell'd by Night, when the Ground was all cover'd with Snow, though the Night otherwise would not have been Lightsom, yet I could very well see to Chuse my way. But much more Remarkable to my present purpose is that, which I have met with in *Olaus Magnus*, concerning the way of Travelling in Winter in the *Northern* Regions, where the Days of that Season are so very Short; for after other things not needful to be here Transcribed: *Iter*, says he, *Diurnum duo scilicet montana milliaria (quæ 12 Italica sunt) conficiunt. Nocte verò sub splendidissima Luna, duplatum iter consumunt aut triplatum. Neque id incommodè fit,*

Gent. Septen. Histor. lib. 4. cap. 13.

cum

cum nivium reverberatione lunaris ſplendor ſublimes & declives campos illuſtret, ac etiam montium præcipitia ac noxias feras à longè proſpiciant evitandas. Which Teſtimony I the leſs Scruple to allege, becauſe that it agrees very well with what has been Affirm'd to me by a Phyſician of *Moſco*, whom the Notion I have been Treating of concerning Whiteneſs invited me to ask whether he could not See much farther when he Travell'd by Night in *Ruſſia* than he could do in *England*, or elſewhere, when there was no Snow upon the Ground; For this Ingenious Perſon inform'd me, that he could See Things at a far greater Diſtance, and with more Clearneſs, when he Travell'd by Night on the *Ruſſian* Snow, though without the Aſſiſtance of Moonſhine, than we in theſe Parts would eaſily be perſwaded. Though it ſeems not unlikely to me, that the Intenſeneſs of the Cold may contribute ſomething to the conſiderableneſs of the Effect, by much Clearing the Air of Darkiſh Steams, which in theſe more Temperate Climates are wont to Thicken it in Snowy weather: For having purpoſely enquir'd of this Doctor, and conſulted that Ingenious Navigator Captain *James*'s Voyage hereafter to be further mention'd, I find both their Re-

lations agree in this, that in Dark Frosty Nights they could Discover more Stars, and See the rest Clearer than we in *England* are wont to do.

6. I know indeed that divers Learned Men think that Snow so strongly Affects our Eyes, not by a Borrow'd, but a Native Light; But I venture to give it as a Proof, that White Bodies reflect more Light than Others, because having once purposely plac'd a parcel of Snow in a Room carefully Darkned, that no Celestial Light might come to fall upon it; neither I, nor an Ingenious Person (skill'd in Opticks) whom I desir'd for a Witness, could find, that it had any other Light than what it receiv'd. And however, 'tis usual among those that Travel in Dark Nights, that the Guides wear something of White to be Discern'd by, there being scarce any Night so Dark, but that in the Free Air there remains some Light, though Broken and Debilitated perhaps by a thousand Reflections from the Opaceous Corpuscles that Swim in the Air, and send it to one another before it comes to arrive at the Eye.

7. Thirdly, And the better to shew that White Bodies reflect store of Light, in comparison of those that are otherwise Colour'd, I did in the Darkn'd Room, formerly

formerly mention'd, hold not far from the Hole, at which the Light was admitted, a Sheet only of White Paper, from whence casting the Sun-beams upon a White Wall, whereunto it was Obverted, it manifestly appear'd both to Me, and to the Person I took for a witness of the Experiment, that it Reflected a far greater Light, than any of the other Colours formerly mention'd, the Light so thrown upon the Wall notably Enlightning it, and by it a good part of the Room. And yet further to shew you, that White Bodies Reflect the Beams from them, and not Towards themselves, Let me add, that Ordinary Burning-glasses, such as are wont to be employ'd to light Tobacco, will not in a great while Burn, or so much as Discolour a Sheet of White Paper. Insomuch that even when I was a Boy, and Lov'd to make Tryals with Burning-glasses, I could not but wonder at this Odd *Phænomenon*, which set me very Early upon Guessing at the Nature of Whiteness, especially because I took notice, that the Image of the Sun upon a White Paper was not so well Defin'd (the Light seeming too Diffus'd) as upon Black, and because I try'd, that Blacking over the Paper with Ink, not only the Ink would be quickly Dry'd up, but the

Paper that I could not Burn before, would be quickly set on Fire. I have also try'd, that by exposing my Hand with a Thin Black Glove over it to the warm Sun, it was thereby very quickly and considerably more heated, than if I took off the Glove, and held my Hand naked, or put on it another Glove of Thin but White Leather. And having thus shewn you, *Pyrophilus*, that White Bodies Reflect the most Light of any, let us now proceed, to consider what is further to be taken notice of in them, in order to our present Enquiry.

8. And Fourthly, whereas among the Dispositions we attributed to White Bodies, we also intimated this, That such Bodies are apt, like *Speculums*, though but Imperfect ones, to Reflect the Light that falls on them Untroubled or Unstain'd, we shall besides other particulars to be met with in these Papers, offer you this in favour of the Conjecture; That in the Darkned Room several times mention'd in this Treatise, we try'd that the Sun-beams being cast from a Coloured Body upon a neighbouring White Wall, the Determinate Colour of the Body was from the Wall reflected to the Eye; whereas we could in divers cases manifestly alter the Colour arriving at the Eye, by Substituti[illegible]

at

at a convenient Distance, a (conveniently) Colour'd (and Glossy) Body instead of the White Wall. As by throwing the Beams from a Yellow Body upon a Blew, there would be Exhibited a kind of Green, as in the Experiments about Colours is more fully Declar'd.

9. I know not whether I should on this Occasion take notice, that when, as when looking upon the Calm and Smooth surface of a River betwixt my Eye, and the Sun, it appear'd to be a natural *Speculum*, wherein that Part which Reflected to my Eye the Entire and defin'd Image of the Sun, and the Beams less remote from those which exhibited That Image, appear'd indeed of a great and whitish Brightness, but the rest Comparatively Dark enough: if afterwards the Superficies chanc'd to be a little, but not much troubled, by a gentle breath of Wind, and thereby reduc'd into a Multitude of Small and Smooth *Speculums*, the surface of the River would suitably to the Doctrine lately deliver'd, at a Distance appear very much of Kin to White, though it would lose that Brightness or Whiteness upon the Return of the Surface to Calmness and an Uniform Level. And I have sometimes for Tryal sake brought in by a Lenticular Glass, the Image of a River, Shin'd upon by

by the Sun, into an Upper Room Darkn'd, and Distant about a Quarter of a Mile from the River, by which means the Numerous Declining Surfaces of the Water appear'd so Contracted, that upon the Body that receiv'd the Images, the whole River appear'd a very White Object at two or three paces distance. But if we drew Near it, this Whiteness appear'd to proceed from an Innumerable company of Lucid Reflections, from the several Gently wav'd Superficies of the Water, which look'd Near at hand like a Multitude of very Little, but Shining Scales of Fish, of which many did every moment Disappear, and as many were by the Sun, Wind and River generated anew. But though this Observation seem'd Sufficiently to discover, how the Appearing Whiteness in that case was Produc'd, yet in some other cases Water may have the Same, though not so Vivid a Colour upon other Accounts; for oftentimes it happens that the Smooth Surface of the Water does appear Bright or Whitish, by reason of the Reflection not immediately of the Images of the Sun, but of the Brightness of the Sky; and in such cases a Convenient Wind may where it passes along make the Surface look Black, by causing many such Furrows and Cavities, as may make the Inflected Superficies

ficies of the Water reflect the Brightneſs of the Sky rather Inward than Outward. And again, if the Wind encreaſe into a Storm, the Water may appear White, eſpecially near the Shore and the Ship, namely becauſe the Rude Agitation Breaks it into Fome or Froth. So much do Whiteneſs and Blackneſs depend upon the Diſpoſition of the Superficial parts of a Body to reflect the Beams of Light Inward or Outward. But that as White Bodies reflect the moſt Light of any, ſo their Superficial Particles are, in the Senſe newly Deliver'd, of a Specular Nature, I ſhall now further endeavour to ſhew both by the making of Specular bodies White, and the making of a White body Specular.

10. In the Fifth place then, I will inform You, that (not to repeat what *Gaſſendus* obſerves concerning Water) I have for Curioſity ſake Diſtill'd Quick-ſilver in a Cucurbit, fitted with a Capacious Glaſs-head, and obſerv'd that when the Operation was perform'd by the Degrees of Fire requiſite for my purpoſe, there would ſtick to the Inſide of the Alembick a multitude of Little round drops of *Mercury*. And as you know that *Mercury* is a Specular Body, ſo each of theſe Little drops was a ſmall round Looking-glaſs, and

and a Multitude of them lying Thick and near one another, they did both in my Judgment, and that of those I Invited to see it, make the Glass they were fastned to, appear manifestly a White Body. And yet as I said, this Whiteness depended upon the Minuteness and Nearness of the Little Mercurial *Globuli*, the Convexity of whose Surfaces fitted them to represent in a Narrow compass a Multitude of Little Lucid Images to differingly situated Beholders. And here let me observe a thing that seems much to countenance the Notion I have been recommending: namely, that whereas divers parts of the Sky, and especially the Milky way, do to the naked Eye appear White, (as the name it self imports) yet the Galaxie look'd upon through the Telescope, does not shew White, but appears to be made up of a Vast multitude of Little Stars; so that a multitude of Lucid Bodies, if they be so small that they cannot singly or apart be discern'd by the Eye, and if they be sufficiently Thick set by one another, may by their confus'd beams appear to the Eye one White Body. And why it is not possible, that the like may be done, when a Multitude of bright and little Corpuscles being crowded together, are made to send together Vivid beams to the Eye, though

though they Shine but as the Planets by a Borrow'd Light.

11. But to return to our Experiments. We may take notice, That the White of an Egg, though in part Transparent, yet by its power of Reflecting some Incident Rays of Light, is in some measure a Natural *Speculum*, being long agitated with a Whisk or Spoon, loses its Transparency, and becomes very White, by being turn'd into Froth, that is into an Aggregate of Numerous small Bubbles, whose Convex Superficies fits them to Reflect the Light every way Outwards. And 'tis worth Noting, that when Water, for instance, is Agitated into Froth, if the Bubbles be Great and Few, the Whiteness will be but Faint, because the number of *Specula* within a Narrow compass is but Small, and they are not Thick set enough to reflect so Many Little Images or Beams of the Lucid Body, as are requisite to produce a Vigorous Sensation of Whiteness: And partly lest it should be said, that the Whiteness of such Globulous particles proceeds from the Air Included in the Froth; (which to make good, it should be prov'd that the Air it self is White) and partly to illustrate the better the Notion we have propos'd of Whiteness, I shall add, that I purposely made this Experiment, I took a quantity of Fair

Fair water, and put to it in a clear Glass phial, a convenient quantity of Oyl or Spirit of Turpentine, because that Liquor will not incorporate with Water, and yet is almost as Clear and Colourless as it; these being Gently Shaken together, the Agitation breaks the Oyl (which as I said, is Indispos'd to Mix like Wine or Milk *per minima* with the Water) into a Multitude of Little Globes, which each of them Reflecting Outwards a Lucid Image, make the Imperfect Mixture of the two Liquors appear Whitish; but if by vehemently Shaking the Glass for a competent time you make a further Comminution of the Oyl into far more Numerous and Smaller *Globuli*, and thereby confound it also better with the Water, the Mixture will appear of a Much greater Whiteness, and almost like Milk; whereas if the Glass be a while let alone, the Colour will by degrees Impair, as the Oyly globes grow Fewer and Bigger, and at length will quite Vanish, leaving both the Liquors Distinct and Diaphanous as before. And such a Tryal hath not ill succeeded, when instead of the Colourless Oyl of Turpentine, I took a Yellow Mixture made of a good Proportion of Crude Turpentine dissolv'd in that Liquor; and (if I mis-remember not) it also succeeded better than one would

expect,

expect, when I employ'd an Oyl brought by Filings of Copper infused in it, to a deep Green. And this (by the way) may be the Reason, why often times when the Oyls of some Spices and of Anniseeds, &c. are Distilled in a Limbec with Water, the Water (as I have several times observ'd) comes over Whitish, and will perhaps continue so for a good while, because if the Fire be made too Strong, the Subtile Chymical Oyl is thereby much Agitated and Broken, and Blended with the Water in such Numerous and Minute Globules, as cannot easily in a short time Emerge to the Top of the Water, and whilst they remain in it, make it, for the Reason newly intimated, look Whitish; and perhaps upon the same Ground a cause may be rendred, why Hot water is observ'd to be usually more Opacous and Whitish, than the same Water Cold, the Agitation turning the more Spirituous, or otherwise Conveniently Dispos'd Particles of the Water into Vapours, thereby Producing in the Body of the Liquor a Multitude of Small Bubbles, which interrupt the Free passage, that the Beams of Light would else have Every way, and from the Innermost parts of the Water Reflect many of them Outwards. These and the like Examples, *Pyrophilus*, have

have induc'd me to Suſpect, that the Superficial Particles of White Bodies, may for the Moſt part be as well Convex as Smooth; I content my ſelf to ſay *ſuſpect* and *for the moſt part*, becauſe it ſeems not Eaſie to prove, that when Diaphanous bodies, as we ſhall ſee by and by, are reduc'd into White Powders, each Corpuſcle muſt needs be of a Convex Superficies, ſince perhaps it may ſuffice that Specular Surfaces look ſeveral ways. For (as we have ſeen) when a Diaphanous Body comes to be reduc'd to very Minute parts, it thereby requires a Multitude of Little Surfaces within a Narrow compaſs. And though each of theſe ſhould not be of a Figure Convenient to Reflect a Round Image of the Sun, yet even from ſuch an Inconveniently Figur'd body, there may be Reflected ſome (either Streight or Crooked) Phyſical Line of Light, which Line I call Phyſical, becauſe it has ſome Breadth in it, and in which Line in many caſes ſome Refraction of the Light falling upon the Body it depends on, may contribute to the Brightneſs; as if a Slender Wire, or Solid Cylinder of Glaſs be expos'd to the Light, you ſhall ſee in ſome part of it a vivid Line of Light, and if we were able to draw out and lay together a Multitude of theſe Little

Wires

Wires or Thrids of Glaſs, ſo Slender, that the Eye could not diſcern a Diſtance betwixt the Luminous Lines, there is little doubt (as far as I can gueſs by a Tryal purpoſely made with very Slender, but far leſs Slender Thrids of Glaſs, whoſe Aggregate was look'd upon one way White) but the whole Phyſical Superficies compos'd of them, would to the Eye appear White, and if ſo, it will not be always neceſſary that the Figure of thoſe Corpuſcles, that make a Body appear White, ſhould be *Globulous*. And as for Snow it ſelf, though the Learned *Gaſſendus* (as we have ſeen above) makes it to ſeem nothing elſe but a pure Frozen Froth, conſiſting of exceedingly Minute and Thick ſet Bubbles; yet I ſee no neceſſity of Admitting that, ſince not only by the Variouſly and Curiouſly Figur'd Snow, that I have divers times had the Opportunity with Pleaſure to obſerve, but alſo by the Common Snow, it rather doth appear both to the Naked Eye, and in a *Microſcope*, often, if not moſt commonly, to conſiſt principally of Little Slender Icicles of ſeveral Shapes; which afford ſuch Numerous Lines of Light, as we have been newly ſpeaking of.

12. Sixthly, If you take a Diaphanous body, as for inſtance a Piece of Glaſs, and

reduce it to Powder, the same Body, which when it was Entire, freely Transmitted the Beams of Light, acquiring by Contusion a multitude of Minute Surfaces, each of which is as it were a Little, but Imperfect *Speculum*, is qualify'd to Reflect in a Confus'd manner, so many either Beams, or Little and Singly Unobservable Images of the Lucid Body, that from a Diaphanous it Degenerates into a White Body. And I remember, I have for Trials sake taken Lumps of Rock Crystal, and Heating them Red hot in a Crucible, I found according to my Expectation, that being Quench'd in Fair water, even those that remain'd in seemingly entire Lumps, exchang'd their Transluceney for Whiteness, the Ignition and Extinction having as it were crack'd each Lump into a multitude of Minute Bodies, and thereby given it a great multitude of new Surfaces. And ev'n with Diaphanous Bodies, that are Colour'd, there may be this way a Greater Degree of Whiteness produc'd, than one would lightly think; as I remember, I have by Contusion obtain'd Whitish Powders of *Granates*, Glass of *Antimony*, and *Emralds* finely beaten; and you may more easily make the Experiment, by taking Good Venereal *Vitriol* of a Deep Blew, and

and comparing with some of the Entire Crystals purposely reserv'd, some of the Subtile Powder of the same Salt, which will Comparatively exhibit a very considerable degree of Whitishness.

13. Seventhly, And as by a Change of Position in the Parts, a Body that is not White, may be made White, so by a Slight change of the Texture of its Surface, a White Body may be Depriv'd of its Whiteness. For if (as I have try'd in Gold-smiths Shops) you take a piece of Silver that has been freshly Boyl'd, as the Artificers call it (which is done by, first Brushing, and then Decocting it with Salt and Tartar, and perhaps some other Ingredients) you shall find it to be of a Lovely White. But if you take a piece of Smooth Steel, and therewith Burnish a part of it, which may be presently done, you shall find that part will Lose its Whiteness, and turn a *Speculum*, looking almost every where Dark, as other Looking-glasses do; which may not a little confirm our Doctrine. For by this we may guess, what it is chiefly that made the Body White before, by considering that all that was done to deprive it of that Whiteness, was only to Depress the Little Protuberances that were before on the Surface of the Silver

into one Continu'd Superficies, and thereby effect this, that now the Image of the Lucid Body, and consequently a Kind of Whiteness shall appear to your Eye; but in some place of the greater Silver Looking-glass (whence the Beams reflected at an Angle Equal to that wherewith they fall on it, may reach your Eye) whilst the Asperity remain'd Undestroy'd, the Light falling on innumerable Little *Specula* Obverted some one way, and some another, did from all Sensibly Distinguishable parts of the Superficies reflect confus'd Beams or Representations of Light to the Beholders Eye, from whence soever he chance to Look upon it. And among the Experiments annex'd to this Discourse, you will find One, wherein by the Change of Texture in Bodies, Whiteness is in a Trice both Generated and Destroy'd.

CHAP. II.

1. WHat we have Discours'd of Whiteness, may somewhat Assist us to form a Notion of Blackness, those two Qualities being Contrary enough to Illustrate each other. Yet among the Ancient *Philosophers* I find less Assistance to

to form a Notion of Blackneſs than of Whiteneſs, only *Democritus* in the paſſage above Recited out of *Ariſtotle* has given a General Hint of the Cauſe of thiis Colour, by referring the Blackneſs of Bodies to their Aſperity. But this I call but a General Hint, becauſe thoſe Bodies that are Green, and Purple, and Blew, ſeem to be ſo as well as Black ones, upon the Account of their Superficial Aſperity. But among the *Moderns*, the formerly mention'd *Gaſſendus*, perhaps invited by this Hint of *Democritus*, has Incidentally in another Epiſtle given us, though a very Short, yet a ſomewhat Clearer account of the Nature of Blackneſs in theſe words: *Exiſtimare par eſt corpora ſuâpte Naturâ nigra conſtare ex particulis, quarum Superficieculæ ſcabræ ſint, nec facilè lucem extrorſum reflectant.* I wiſh this Ingenious Man had enlarg'd himſelf upon this Subject; For indeed it ſeems, that as that which makes a Body White, is chiefly ſuch a Diſpoſition of its Parts, that it Reflects (I mean without much Interruption) more of the Light that falls on it, than Bodies of any other Colour do, ſo that which makes a body black is principally a Peculiar kind of Texture, chiefly of its Superficial Particle, whereby it does as it were Dead the Light

that falls on it, so that very little is Reflected Outwards to the Eye.

2. And this Texture may be Explicated two, and perhaps more than two several ways, whereof the first is by Supposing in the Superficies of the Black Body a Particular kind of Asperity, whereby the Superficial Particles reflect but Few of the Incident Beams Outwards, and the rest Inwards towards the Body it self. As if for Instance, we should conceive the Surface of a Black Body to be Asperated by an almost Numberless throng of Little Cylinders, Pyramids, Cones, and other such Corpuscles, which by their being Thick Set and *Erected*, reflect the Beams of Light from one to another Inwards, and send them to and fro so often, that at length they are Lost, before they can come to Rebound out again to the Eye. And this is the first of the two mention'd ways of Explicating Blackness. The other way is by Supposing the Texture of Black Bodies to be such, that either by their Yielding to the Beams of Light, or upon some other Account, they do as it were Dead the Beams of Light, and keep them from being Reflected in any Plenty, or with any Considerable Vigour of Motion, Outwards. According to this Notion it may be said, that the

the Corpuſcles that make up the Beams of Light, whether they be Solary *Effluviums*, or Minute Particles of ſome Ætherial Subſtance, Thruſting on one another from the Lucid Body, do, falling on black bodies, meet with ſuch a Texture, that ſuch Bodies receive into themſelves, and Retain almoſt all the Motion communicated to them by the Corpuſcles that make up the Beams of Light, and conſequently Reflect but Few of them, or thoſe but Languidly, towards the Eye; it happening here almoſt in like manner as to a Ball, which thrown againſt a Stone or Floor, would Rebound a great way Upwards, but Rebounds very Little or not at all, when it is thrown againſt VVater, or Mud, or a Looſe Net, becauſe the Parts yield, and receive into themſelves the Motion, on whoſe Account the Ball ſhould be Reflected Outwards. But this laſt way of Explicating Blackneſs, I ſhall content my ſelf to have Propos'd, without either Adopting it, or abſolutely Rejecting it. For the Hardneſs of Touch-ſtones, Black Marble, and other Bodies, that being Black are Solid, ſeem to make it ſomewhat Improbable, that ſuch Bodies ſhould be of ſo Yielding a Texture, unleſs we ſhould ſay, that ſome Bodies may be more Diſpos'd to Yield to the Impulſes of

the Corpuſcles of Light by reaſon of a Peculiar Texture, than other Bodies, that in other Tryals appear to be Softer than they. But though the Former of theſe two Explications of blackneſs be that, by which we ſhall Endeavour to give an Account of it; yet as we ſaid, we ſhall not Abſolutely Reject this Latter, partly becauſe they both Agree in this, that Black Bodies Reflect but Little of the Light that falls on them, and partly becauſe it is not Impoſſible, that in ſome Caſes both the Diſpoſition of the Superficial particles, as to Figure and Poſition, and the Yielding of the Body, or ſome of its Parts, may jointly, though not in an Equal meaſure concur to the rendring of a Body Black. The Conſiderations that induc'd me to propoſe this Notion of Blackneſs, as I Explain'd it, are principally theſe:

3. Firſt, That as I lately ſaid, Whiteneſs and Blackneſs being generally reputed to be Contrary Qualities, Whiteneſs depending as I ſaid upon the Diſpoſition of the Parts of a Body to Reflect much Light, it ſeems likely, that Blackneſs may depend upon a Contrary Diſpoſition of the Black bodies Surface; but upon this I ſhall not Inſiſt.

4. Next then we ſee, that if a body of

One

One and the same Colour be plac'd, part in the Sun-beams, and part in the Shade, that part which is not Shin'd on will appear more of Kin to Blackness than the other, from which more Light Rebounds to the Eye; And Dark Colours seem the Blacker, the less Light they are Look'd upon in, and we think all Things Black in the Dark, when they send no Beams to make Impressions on our Organs of Sight, so that Shadows and Darkness are near of Kin, and Shadow we know is but a Privation of Light, and accordingly Blackness seems to proceed from the Paucity of Beams Reflected from the black body to the Eye; I say the Paucity of Beams, because those Bodies that we call black, as Marble, Jeat, &c. are Short of being perfectly so, else we should not see them at all. But though the Beams that fall on the Sides of those Erected Particles that we have been mentioning, do Few of them return Outwards, yet those that fall upon the Points of those Cylinders, Cones, or Pyramids, may thence Rebound to the Eye, though they make there but a Faint Impression, because they Arrive not there, but Mingl'd with a great Proportion of Little Shades. This may be Confirm'd by my having procur'd a Large piece of Black

Marble

Marble well Polish'd, and brought to the Form of a Large Sphærical and Concave *Speculum*; For on the Inside this Marble being well Polish'd, was a kind of Dark Looking-glass, wherein I could plainly see a Little Image of the Sun, when that Shin'd upon it. But this Image was very far from Offending and Dazling my Eyes, as it would have done from another *Speculum*; Nor, though the *Speculum* were large, could I in a long time, or in a Hot Sun set a piece of VVood on Fire, though a far less *Speculum* of the same Form, and of a more Reflecting Matter, would have made it Flame in a Trice.

5. And on this Occasion we may as well in Reference to something formerly deliver'd concerning VVhiteness, as in Reference to what has been newly said, Subjoyn what we further observ'd touching the Differing Reflections of Light from VVhite and Black Marble; namely, that having taken a pretty large Mortar of VVhite Marble, New, and Polish'd in the Inside, and Expos'd it to the Sun, we found that it Reflected a great deal of Glaring Light, but so Dispers'd, that we could not make the Reflected Beams concur in any such Conspicuous *Focus*, as that newly taken notice of in the Black Marble, though perhaps

perhaps there may enough of them be made to meet near the Bottom, to make some Kind of *Focus*, especially since by holding in the Night-time a Candle at a convenient Distance, we were able to procure a Concourse of some, though not many of the Reflected Beams, at about two Inches distant from the Bottom of the Mortar: But we found the heat even of the Sun-beams so Dispersedly Reflected to be very Languid, even in Comparison of the Black Marbles *Focus*. And the Little Picture of the Sun, that appear'd upon the White Marble as a *Speculum*, was but very Faint and exceeding ill Defin'd. Secondly, That taking two pieces of Plain and Polish'd Surfaces, and casting on them Successively the Beams of the same Candle, in such manner, as that the Neighbouring Superficies being Shaded by an Opacous and Perforated Body, the Incident Beams were permitted to pass but through a Round Hole of about Half an Inch Diameter, the Circle of Light that appear'd on the White Marble was in Comparison very Bright, but very ill Defin'd; whereas that on the Black Marble was far less Luminous, but much more precisely Defin'd.

6. Thirdly, When you Look upon a piece of Linnen that has Small Holes in it, those

those Holes appear very Black, and Men are often deceiv'd in taking Holes for Spots of Ink; And Painters to represent Holes, make use of Black, the Reason of which seems to be, that the Beams that fall on those Holes, fall into them so Deep, that none of them is reflected back to the Eye. And in narrow Wells part of the Mouth seems Black, because the Incident beams are reflected Downwards from one side to another, till they can no more rebound to the Eye.

We may consider too, that if Differing parts of the same piece of black Velvet be stroak'd Opposite ways, the piece of Velvet will appear of two Distinct kinds of Blackness, the one far Darker than the other; of which Disparity the Reason seems to be, that in the Less obscure part of the Velvet, the Little Silken Piles whereof 'tis made up, being Inclin'd, there is a Greater part of each of them Obverted to the Eye, whereas in the other part the Piles of Silk being more Erected, there are far Fewer beams Reflected Outwards from the Lateral parts of each Pile; so that most of those that Rebound to the Eye, come from the Tops of the Piles, which make but a Small part of the whole Superficies, that may be cover'd by the piece of Velvet.

Which

Which Explication I propose, not that I think the Blackness of the Velvet proceeds from the Cause assign'd, since each Single Pile of Silk is Black by reason of its Texture, in what Position soever you Look upon it; But that the Greater Blackness of one of these Tufts seems to proceed from the Greater Paucity of Beams Reflected from it, and that from the Fewness of those Parts of a Surface that Reflect Beams, and the Multitude of those Shaded Parts that Reflect none. And I remember, that I have oftentimes observ'd that the Position of Particular Bodies far greater than Piles of Silk in reference to the Eye, may notwithstanding their having each of them a Colour of its own, make one part of their Aggregate appear far Darker than the other; For I have near Great Towns often taken notice, that a Cart-load of Carrots pack'd up, appear'd of a much Darker Colour when Look'd upon, where the Points of the Carrots were Obverted to the Eye, than where the Sides of them were so.

7. Fourthly, In a Darkned Room, I purposely observ'd, that if the Sun-beams, which came in at the Hole were receiv'd upon White or any other Colour, and directed to a Convenient place of the Room, they

they would Manifestly, though not all Equally, Encrease the Light of that Part; whereas if we Substituted, either a piece of Black Cloth or Black Velvet, it would so Dead the Incident Beams, that the place (newly mention'd) whereto I Obverted the Black Body, would be Less Enlightned than it was before, when it received its Light but from the VVeak and Oblique Reflections of the Floor and VValls of a pretty Large Room, through which the Beams that came in at the Hole were Confusedly and Brokenly Dispers'd.

8. Fifthly, And to shew that the Beams that fall on Black Bodies, as they do not Rebound Outwards to the Eye, so they are Reflected towards the Body it self, as the Nature of those Erected Particles, to which we have imputed Blackness, requires, we will add an Experiment that will also confirm our Doctrine touching VVhiteness; Namely, that we took a Broad and Large Tile, and having VVhitened over one half of the Superficies of it, and Black'd the other, we expos'd it to the Summer Sun; And having let it lie there a convenient time (for the Difference is more Apparent, if it have not lain there too long) we found, as we expected, that whilst the VVhited part of the Tile remained Cool enough, the

Black'd

Black'd part of the same Tile was grown not only sensible, but very Hot, (sometimes to a strong Degree.) And to satisfie some of our Friends the more, we have sometimes left upon the Surface of the Tile, besides the VVhite and Black parts thereof, a part that Retain'd the native Red of the Tile it self, and Exposing them to the Sun, we observ'd this Last mention'd to have Contracted a Heat in comparison of the VVhite, but a Heat Inferiour to that of the Black, of which the Reason seems to be, that the Superficial Particles of Black Bodies, being, as we said, more Erected, than those of VVhite or Red ones, the Corpuscles of Light falling on their sides, being for the most part Reflected Inward from one Particle to another, and thereby engag'd as it were, and kept from Rebounding Upwards, they communicate their brisk Motion, wherewith they were impell'd against the Black Body, (upon whose account had they fallen upon a White Body, they would have been Reflected Outwards) to the Small parts of the Black Body, and thereby Produce in those small parts such an Agitation, as (when we feel it) we are wont to call Heat. I have been lately inform'd, that an Observation near of Kin to Ours, has been made by some Learned Men in *France* and *Italy*,

Italy, by long Expoſing to a very Hot Sun, two pieces of Marble, the one White, the other Black; but though the Obſervation be worthy of them, and may confirm the ſame Truth with our Experiment, yet beſides that our Tryal needs not the Summer, nor any Great Heat to ſucceed, It ſeems to have this Advantage above the other, that whereas bodies more Solid, and of a Cloſer Texture, though they uſe to be more Slowly Heated, are wont to receive a Greater Degree of Heat from the Sun or Fire, than (*Cæteris paribus*) Bodies of a Slighter Texture; I have found by the Information of Stone-cutters, and by other ways of Enquiry, that black Marble is much Solider and Harder than White, ſo that poſſibly the Difference betwixt the Degrees of Heat they receive from the Sun-beams will by many be aſcrib'd to the Difference of their Texture, rather than to that of their Colour, though I think our Experiment will make it Probable enough that the greater part of that Difference may well be aſcrib'd to that Diſpoſition of Parts, which makes the one Reflect the Sun-beams Inward, and the other Outwards. And with this Doctrine accords very well, that Rooms hung with black, are not only Darker than elſe they would be, but are wont

wont to be Warmer too; Insomuch that I have known a great Lady, whose Constitution was somewhat tender, complain that she was wont to catch Cold, when she went out into the Air, after having made any long Visits to Persons, whose Rooms were hung with Black. And this is not the only Lady I have heard complain of the Warmth of such Rooms; which though perhaps it may be partly imputed to the *Effluvia* of those Materials wherewith the Hangings were Dy'd, yet probably the Warmth of such Rooms depends chiefly upon the same Cause that the Darkness does; As (not to repeat what I formerly Noted touching my Gloves) to satisfie some Curious Persons of that Sex, I have convinc'd them, by Tryals, that of two Pieces of Silken Stuff given me by themselves, and expos'd in their Presence, to the same Window, Shin'd on by the Sun, the White was *considerably* Heated, when the Black was not so much as *Sensibly* so.

9. Sixthly, I remember, that Acquainting one Day a *Virtuoso* of Unsuspected Credit, that had visited hot Countries, with part of what I have here Deliver'd concerning Blackness, he Related to me by way of Confirmation of it, a very notable

Experiment which he had both seen others make, and made himself in a Warm Climate; namely, that having carefully Black'd over Eggs, and Expos'd them to the Hot Sun, they were thereby in no very long time well Roasted, to which Effect I conceive the Heat of the Climate must have Concurr'd with the Disposition of the Black Surface to Reflect the Sun-beams Inward; for I remember, that having made that among other Tryals in *England*, though in Summer-time, the Eggs I Expos'd, acquir'd indeed a considerable Degree of Heat, but yet not so Intense a One, as prov'd sufficient to Roast them.

10. Seventhly, and Lastly, Our Conjectures at the Nature of Blackness may be somewhat Confirm'd by the (formerly mention'd) Observation of the Blind *Dutch-man*, that discerns Colours with his Fingers; for he says, that he Feels a greater Roughness upon the Surfaces of Black Bodies, than upon those of Red, or Yellow, or Green. And I remember, that the Diligent *Bartholinus* says, that a blind Earl of *Mansfield* could Distinguish White from black only by the Touch, which would sufficiently Argue a great Disparity in the Asperities, or other Super-

Hist. Anatom. Cent. 3. Hist. 44.

Superficial Textures of bodies of those two Colours, if the Learn'd Relater had Affirm'd the Matter upon his own Knowledge.

11. These, *Pyrophilus*, are the chief things that Occur to me at present, about the Nature of Whiteness and Blackness, which if they have rendred it so much as Probable, that in *Most*, or at least *Many* Cases, the Causes of these Qualities may be such as I have Adventured to deliver, it is as much as I pretend to; for till I have Opportunity to Examine the Matter by some further Tryals, I am not sure, but that in some White and Black bodies, there may Concur to the Colour some peculiar Texture or Disposition of the body, whereby the Motion of the Small Corpuscles that make up the incident beams of Light, may be differingly Modify'd, before they reach the Eye, especially in this, that White bodies do not only Copiously Reflect those Incident Corpuscles Outwards, but Reflect them briskly, and do not otherwise Alter them in the manner of their Motion. Nor shall I now stay to Enquire, whether some of those other ways (as a Disposition to Alter the Velocity, the Rotation, or the Order and Manner of Appulse to the Eye of the Reflected Cor-

puſcles that Compos'd the Incident Beams of Light) which we mention'd when we conſider'd the Production of Colours in General, may not in ſome Caſes be Applicable to thoſe of White and Black Bodies: For I am yet ſo much a *Seeker* in this Matter, and ſo little Wedded to the Opinions I have propos'd, that what I am to add, ſhall be but the Beginning of a Collection of Experiments and Obſervations towards the Hiſtory of Whiteneſs and Blackneſs, without at preſent interpoſing my Explications of them, that ſo, I may aſſiſt your Enquiries without much Foreſtalling or Biaſſing your Judgment.

EXPE-

EXPERIMENT IN CONSORT, Touching Whiteneſs & Blackneſs.

Experiment I.

HAving promis'd in the 114, and 115. Pages of the foregoing Diſcourſe of Whiteneſs and Blackneſs, to ſhew, that thoſe two Colours may by a change of Texture in Bodies, each of them apart Diaphanous and Colourleſs, be at pleaſure and in a trice as well Generated as Deſtroy'd, We ſhall begin with Experiments that may acquit us of that promiſe.

Take then what Quantity you pleaſe of Fair Water, and having Heated it, put into it as much good Common Sublimate, as it is able to Diſſolve, and (to be ſure of having

ving it well glutted:) continue putting in the Sublimate, till some of it lie Untouch'd in the bottom of the Liquor, Filter this Solution through Cap-paper, to have it clear and limpid, and into a spoonful or two thereof, (put into a clean Glass-Vessel,) shake about four or five drops (according as you took more or less of this Solution) of good limpid Spirits of Urine, and immediately the whole mixture will appear White like Milk, to which Mixture if you presently add a convenient proportion of Rectify'd *Aqua Fortis* (for the number of drops is hard to determine, because of the Differing strength of the Liquor, but easily found by trial) the Whiteness will presently disappear, and the whole mixture become Transparent; which you may, if you please, again reduce to a good degree of Whiteness (though inferior to the first) only by a more copious affusion of fresh Spirit of Urine. *N.* First, That it is not so necessary to employ either *Aqua Fortis* or Spirit of Urine about this Experiment, but that we have made it with other Liquors instead of these; of which perhaps more elsewhere. Secondly, That this Experiment, though not made with the same *Menstruums*, nor producing the same Colour, is yet much of Kin to that other to be mention'd

mention'd in this Tract among our other Experiments of Colours, about turning a Solution of Præcipitate into an Orange-colour, and the Chymical Reaſon being much alike in both, the annexing it to one of them may ſuffice for both.

EXPERIMENT II.

Make a ſtrong Infuſion of broken Galls in Fair Water, and having Filtred it into a clean Vial, add more of the ſame liquor to it, till you have made it ſomewhat Tranſparent, and ſufficiently diluted the Colour, for the credit of the Experiment, leſt otherwiſe the Darkneſs of the liquor might make it be objected, that 'twas already almoſt Ink; Into this Infuſion ſhake a convenient quantity of a clear, but very ſtrong Solution of Vitriol, and you ſhall immediately ſee the mixture turn black almoſt like Ink, and ſuch a way of producing Blackneſs is vulgar enough; but if preſently after you do upon this mixture drop a ſmall quantity of good Oyl of Vitriol, and, by ſhaking the Vial diſperſe it nimbly through the two other liquors, you ſhall (if you perform your part well, and have employ'd Oyl of Vitriol clear and ſtrong enough) ſee the darkneſs of the Liquor preſently begin

to be discuss'd, and grow pretty clear and Transparent, losing its Inky blackness, which you may again restore to it by the affusion of a small quantity of a very strong Solution of Salt of Tartar. And though neither of these Atramentous Liquors will seem other than very pale Ink, if you write with a clean Pen dipt in them, yet that is common to them with some sorts of Ink that prove very good when Dry, as I have also found, that when I made these carefully, what I wrote with either of them, especially with the former, would when throughly dry grow black enough not to appear bad Ink. This Experiment of taking away and restoring blackness from and to the Liquors, we have likewise tryed in Common Ink; but there it succeeds not so well, and but very slowly, by reason that the Gum wont to be employed in the making it, does by its Tenacity oppose the operations of the above mention'd Saline Liquors. But to consider Gum no more, what some kind of Præcipitation may have to do in the producing and destroying of Inks without it, I have elsewhere given you some occasion and assistance to enquire; But I must not now stay to do so my self, only I shall take notice to you, that though it be taken for granted that bodies will not be Præcipitated by Alcalizat Salts,

that

that have not first been dissolv'd in some Acid *Menstruums*, yet I have found upon tryals, which my conjectures lead me to make on purpose, That divers Vegetables *barely infus'd*, or, *but slightly decocted in common water*, would, upon the affusion of a Strong and Clear *Lixivium* of Potashes, and much more of some other Præcipitating Liquors that I sometimes employ, afford good store of a Crudled matter, such as I have had in the Præcipitations of Vegetable substances, by the intervention of Acid things, and that this matter was easily separable from the rest of the Liquor, being left behind by it in the Filtre; and in making the first Ink mention'd in this Experiment, I found that I could by Filtration separate pretty store of a very black pulverable substance, that remain'd in the Filtre, and when the Ink was made clear again by the Oyl of Vitriol, the affusion of dissolv'd *Sal Tartari* seem'd but to Præcipitate, and thereby to Unite and render Conspicuous the particles of the Black mixture that had before been dispers'd into very Minute and singly Invisible particles by the Incisive and resolving power of the highly Corrosive Oyl of Vitriol.

EXPERI-

EXPERIMENT III.

If pieces of White Harts-horn be with a competent degree of fire distill'd in a Glass-retort, they will, after the avolation of the Flegm, Spirit, Volatile Salt, and the looser and lighter parts of the Oleagenous substance, remain behind of a cole-black colour. And even Ivory it self being skilfully Burnt (how I am wont to do it, I have elsewhere set down) affords Painters one of the best and deepest Blacks they have; and yet in the Instance of distill'd Harts-horn, the operation being made in Glass-vessels carefully clos'd, it appears there is no Extraneous black substance that insinuates it self into White Harts-horn, and thereby makes it turn black; but that the Whiteness is destroy'd, and the Blackness generated, only by a Change of Texture, made in the burnt Body, by the recess of some parts and the Transposition of others. And though I remember not that in many Distillations of Harts-horn I ever found the *Cap. Mort.* to pass from Black to a true Whiteness, whilst it continu'd in clos'd Vessels, yet having taken out the Cole-black fragments, and Calcin'd them in open Vessels, I could in few hours quite destroy that blackness, & without

out ſenſibly changing their Bulk or Figure, reduce them to great Whiteneſs. So much do theſe two Colours depend upon the Diſpoſition of the little parts, that the bodies wherein they are to be met with do conſiſt of. And we find, that if White Wine Tartar, or even the white Cryſtals of ſuch Tartar be burnt without being truly Calcin'd, the *Cap. Mortuum* (as the Chymiſts call the more Fixt part) will be black. But if you further continue the Calcination till you have perfectly Incinerated the Tartar, and kept it long enough in a Strong Fire, the remaining *Calx* will be White. And ſo we ſee that not only other Vegetable ſubſtances, but even White Woods, as the Hazel, will yield a black Charcoal, and afterwards Whitiſh Aſhes; And ſo Animal ſubſtances naturally White, as Bones and Eggſhels, will grow black upon the being burnt, and white again when they are perfectly Calcin'd.

EXPERIMENT IV.

But yet I much Queſtion whether that Rule delivered by divers, as well Philoſophers as Chymiſts, *aduſta nigra, ſed peruſta alba*, will hold as Univerſally as is preſum'd, ſince I have ſeveral Examples to allege againſt

gainſt it: For I have found that by burning Alabaſter, ſo as both to make it appear to boyl almoſt like Milk, and to reduce it to a very fine Powder, it would not at all grow Black, but retain its Pure and Native Whiteneſs, and though by keeping it longer than is uſual in the fire, I produc'd but a faint Yellow, even in that part of the Powder that lay neareſt the top of the Crucible; yet having purpoſely enquired of an Experienc'd Stone-cutter, who is curious enough in trying Concluſions in his own Trade, he told me he had found that if Alabaſter or Plaiſter of *Paris* be very long kept in a ſtrong Fire, the whole heap of burnt Powder would exchange its Whiteneſs for a much deeper Colour than the Yellow I obſerv'd. Lead being Calcin'd with a ſtrong fire turns (after having perhaps run through divers others Colours) into *Minium*, whoſe Colour we know is a deep Red; and if you urge this *Minium*, as I have purpoſely done with a ſtrong fire, you may much eaſier find a Glaſſie and Brittle Body darker than *Minium*, than any white *Calx* or Glaſs. 'Tis known among Chymiſts that the white *Calx* of Antimony, by the further and more vehement operation of the fire may be melted into Glaſs, which we have obtain'd of a Red Colour, which is

far

far deeper than that of the *Calx* of burnt Antimony; and though common Glass of Antimony being usually Adulterated with *Borax*, have its Colour thereby diluted, oftentimes to a very pale Yellow, yet not only ours made more sincerely, was, as we said, of a Colour less remote from Black, than was the *Calx*; but we observ'd, that by Melting it once or twice more, and so exposing it to the further operation of the Fire, we had, as we expected, the Colour heightned. To which we shall add but this one Instance (which is worth the taking notice of in Reference to Colours:) That, if you take Blew, but Unsophisticated, Vitriol, and burn it very slowly, and with a Gentle degree of Heat, you may observe, that when it is burnt but a Little, and yet so far as that you may rub it to Powder betwixt your fingers, it will be of a White or Whitish Colour; But if you Prosecute the Calcination, this Body which by a light Adustion was made White, will pass through other Colours, as Gray, Yellowish, and Red; and if you further burn it with a Long and Vehement fire, by that time it comes to be *Perustum*, it will be of a dark Purple, nearer to Black, not only than the first *Calx*, but than the Vitriol before it at all felt the fire. I might add that *Crocus Martis*

Martis (*per se* as they call it) made by the lasting violence of the Reverberated flames is not so near a Kin to White, as the Iron or Steel that afforded it was before its Calcinations; but that I suppose, these Instances may suffice to satisfie you, that Minerals are to be excepted out of the forementioned Rule, which perhaps, though it seldom fail in substances belonging to the Vegetable or Animal Kingdom, may yet be Question'd even in some of these, if that be true, which the Judicious Traveller *Bellonius* affirms, that Charcoals made out of the Wood of *Oxycæder* are White; And I could not find, that though in Retorts Harts-horn and other White bodies will be Denigrated by Heat, yet Camphire would not at all lose its Whiteness, though I have purposely kept it in such a heat, as made it melt and boyl. And to manifest, *Pyrophilus*, that Galls are not so requisite as many suppose to the making Atramentous Liquors, we have sometimes made the following Experiment; We took dried Rose-leaves and Decocted them for a while in Fair Water, into two or three spoonfuls of this Decoction we shook a few drops of a strong and well filtrated Solution of Vitriol (which perhaps had it been Green would have done as well) and immediately the

mixture

mixture did turn black, and when into this mixture presently after it was made, we shook a just Proportion of *Aqua Fortis*, we turn'd it from a Black Ink to a deep Red one; which by the affusion of a little Spirit of Urine may be reduc'd immediately to an Opacous and blackish Colour. And in regard, *Pyrophilus*, that in the former Experiments, both the Infusion of Galls, and the Decoction of Roses, and the Solution of Copperis employ'd about them, are endow'd each of them with its own Colour, there may be a more noble Experiment of the sudden production of Blackness made by the way mention'd in the Second Section of the Second Part of our Essays; for though upon the Confusion of the two Liquors there mention'd, there do immediately emerge a very Black mixture, yet both the Infusion of *Orpiment* and the Solution of *Minium* were before their being joyn'd together, Limpid and Colourless.

EXPERIMENT V.

And now I speak of Camphire, it puts me in mind of adding this Experiment, That, though as I said in clos'd Glasses, I could not Denigrate it by Heat, but it would Sublime to the sides and top of the Glass,

as

as it was before, yet not only it will, being set on fire in the free Air, send forth a copious smoak, but having purposely upon some of it that was flaming, clapt a Large Glass, almost in the form of a Hive, (but more Slender only) with a Hole at the top, (which I caus'd to be made to try Experiments of Fire and Flame in) it continued so long burning, that it Lin'd all the Inside of the Glass with a Soot as black as Ink, and so Copious, that the closeness of the Vessel consider'd, almost all that part of the White Camphire that did take Fire, seem'd to have been chang'd into that deep black Substance.

EXPERIMENT VI.

And this also brings into my mind another Experiment that I made about the production of blackness, whereof, for Reasons too long to be here deduced, I expected and found a good Success, and it was this: I took Rectifi'd Oyl of Vitriol (that I might have the Liquor clean as well as strong) and by degrees mixt with it a convenient proportion of the Essential Oyl, as Chymists call it, of Wormwood, drawn over with store of Water in a Limbec, and warily Distilling the mixture in a Retort, there remain'd

a scarce credible quantity of dry Matter, Black as a Coal. And because the Oyl of Wormwood, though a Chymical Oyl drawn by a *Virtuoso*, seem'd to have somewhat in it of the colour of the Plant, I Substituted in its Room, the Pure and Subtile Essential Oyl of Winter-Savory, and mixing little by little this Liquor, with (if I mis-remember not) an Equal weight of the formerly mention'd Rectify'd Oyl of Vitriol, and distilling them as before in a Retort, besides what there pass'd over into the Receiver, even these two clear Liquors left me a considerable Proportion, (though not so great as the two former) of a Substance black as Pitch, which I yet keep by me as a Rarity.

EXPERIMENT VII.

A way of Whiting Wax cheaply and in Great Quantity may be a thing of good Oeconomical Use, and we have elsewhere set down the Practice of Trades-men that Blanch it; But here Treating of Whiteness only in Order to the Philosophy of Colours, I shall not Examine which of the Slow ways may be best Employ'd, to free Wax from the Yellow Melleous parts, but shall rather set down a Quick

way of making it White, though but in very Small Quantities. Take then a little Yellow Wax, ſcraped or thinly ſliced, and putting it into a Bolts-head or ſome other Convenient Glaſs, pour to it a pretty deal of Spirit of Wine, and placing the Veſſel in Warm Sand, Encreaſe the Heat by degrees, till the Spirit of Wine begin to Simper or to Boyl a little; and continuing that degree of Fire, if you have put Liquor enough, you will quickly have the Wax diſſolv'd, then taking it off the fire, you may either ſuffer it to Cool as haſtily as with Safety to the Glaſs you can, or Pour it whilſt 'tis yet Hot into a Filtre of Paper, and either in the Glaſs where it Cools, or in the Filtre, you will ſoon find the Wax and *Menſtruum* together reduc'd into a White Subſtance, almoſt like Butter, which by letting the Spirit Exhale will ſhrink into a much leſſer Bulk, but ſtill retaining its Whiteneſs. And that which is pretty in the working of this Magiſtery of Wax, is, that the Yellowneſs vaniſhes, neither appearing in the Spirit of Wine that paſſes Limpid through the Filtre, nor in the Butter of Wax, if I may ſo call it, that, as I ſaid, is White.

EXPERI-

EXPERIMENT VIII.

There is an Experiment, *Pyrophilus*, which though I do not so exactly remember, and though it be somewhat Nice to make, yet I am willing to Acquaint You with, because the thing Produc'd, though it be but a Curiosity, is wont not a little to please the Beholders, and it is a way of turning by the help of a Dry Substance, an almost Golden-colour'd Concrete, into a White one; the several Tryals are not at present so fresh in my Memory to enable me to tell you certainly, whether an Equal only or a Double weight of common Sublimate must be taken in reference to the Tinglass, but if I mistake not, there was in the Experiment that succeeded best, Two parts of the Former taken to One of the Latter. These Ingredients being finely Powdred and exactly mix'd, we Sublim'd together by degrees of fire (the due Gradation of which is in this Experiment a thing of main Importance) there ascended a matter of a very peculiar Texture; for it was for the most part made up of very Thin, Smooth, Soft and Slippery Plates, almost like the finest sort of the Scales of Fishes, but of so Lovely a White Inclining to

Pearl-Colour, and of so curious and shining a Gloss, that they appear'd in some respect little Inferiour to Orient Pearls, and in other Regards, they seem'd to Surpass them, and were Applauded for a sort of the Prettiest Trifles that we had ever prepar'd to Amuse the Eye. I will not undertake that that though you'l hardly miss changing the Colour of your shining Tin-glass, yet you will the first or perhaps the second time hit Right upon the way of making the Glistering Sublimate I have been mentioning.

EXPERIMENT IX.

When we Dissolve in *Aqua Fortis* a mixture of Gold and Silver melted into one Lump, it usually happens that the Powder of Gold that falls to the bottom, as not being Dissoluble by that *Menstruum*, will not have its own Yellow, but appear of a Black Colour, though neither the Gold, nor the Silver, nor the *Aqua Fortis* did before manifest any Blackness. And divers Alchymists, when they make Solutions of Minerals they would Examine, are very Glad, if they see a Black Powder Precipitated to the Bottom, taking it for a Hopeful Sign, that those Particles are of a Golden Nature,

ture, which appear in a Colour so ordinary to Gold parted from other Metals by *Aqua Fortis*, that it is a trouble to the Refiner to Reduce the Præcipitated *Calx* to its Native Colour. For though, (as we have try'd) that may be Quickly enough done by Fire, which will make this Gold look very Gloriously (as indeed 'tis at least one of the Best ways that is practis'd for the Refining of Gold,) yet it requires both Watchfulness and Skill, to give it such a Degree of Fire as will serve to Restore it to its Lustre, without giving it such a One, as may bring it to Fusion, to which the Minuteness of the *Corpuscles* it consists of makes the Powder very apt. And this brings into my Mind, that having taken a Flat and Bright piece of Gold, that was Refin'd by a Curious and Skilful Person on purpose to Try to what height of Purity Gold could be brought by Art, I found that this very piece, as Glorious as it look'd, being rubb'd a little upon a piece of fine clean Linnen, did sully it with a kind of Black; and the like I have observ'd in Refin'd Silver, which I therefore mention, because I formerly suspected that the Impurity of the Metal might have been the only Cause of what I have divers times observ'd in wearing Silver-hilted Swords, Namely, that

where they rubb'd upon my Cloths, if they were of a Light-Colour'd Cloth, the Affriction would quickly black them; and congruously hereunto I have found Pens blackt almost all over, when I had a while carry'd them about me in a Silver Ink-case. To which I shall only add, that whereas in these several Instances of Denigration, the Metals are worn off, or otherwise Reduc'd into very Minute Parts, that Circumstance may prove not Unworthy your Notice.

EXPERIMENT X.

That a Solution of Silver does Dye hair of a black colour, is a Known Experiment, which some persons more curious than dextrous, have so Unluckily made upon themselves as to make their Friends very Merry. And I remember that the other day, I made my self some Sport by an Improvement of this Observa ion; for having dissolv'd some pure Silver in *Aqua Fortis*, & Evaporated the *Menstruum ad siccitatem*, as they speak, I caus'd a Quantity of fair Water to be pour'd upon the *Calx* two or three several times, and to be at each Evaporated, till the *Calx* was very Dry, and all the Greenish Blewness that is wont to appear in common Crystals of Silver,

was

was quite carry'd away. Then I made those I meant to Deceive, Moisten some part of their Skin with their own Spittle, and slightly Rub the moistned parts with a little of this Prepar'd Silver; Whereupon they Admir'd to see, that a Snow-white Body laid upon the White Skin should presently produce a deep blackness, as if the stains had been made with Ink, especially considering that this blackness could not, like that produced by ordinary Ink, be readily Wash'd off, but requir'd many Hours, and part of it some days to its Obliteration. And with the same White *Calx* and a little Fair Water we likewise Stain'd the White Hafts of Knives, with a lasting Black in those parts where the *Calx* was plentifully enough laid on; for where it was laid on but very thinly, the Stain was not quite of so deep a Colour.

EXPERIMENT XI.

The Cause of the Blackness of those many Nations, which by one common Name we are wont to call *Negroes*, has been long since Disputed of by Learned Men, who possibly had not done amiss, if they had also taken into Consideration, why some whole races of other Animals besides Men, as

Foxes and Hares, are Distinguish'd by a Blackness not familiar to the Generality of Animals of the same Species; The General Opinion (to be mention'd a little lower) has been rejected even by some of the Antient Geographers, and among the Moderns *Ortelius* and divers other Learned Men have Questioned it. But this is no place to mention what thoughts I have had to and fro about these Matters: Only as I shall freely Acknowledge, that to me the Enquiry seems more Abstruse than it does to many others, and that because consulting with Authors, and with Books of Voyages, and with Travellers, to satisfie my self in matters of Fact, I have met with some things among them, which seem not to agree very well with the Notions of the most Classick Authors concerning these things; for it being my Present Work to deliver rather matters Historical than Theorys, I shall Annex some few of my Collections, instead of a Solemn Disputation. It is commonly presum'd that the Heat of the Climates wherein they live, is the reason, why so many Inhabitants of the Scorching Regions of *Africa* are Black; and there is this familiar Observation to Countenance this Conjecture, That we plainly see that Mowers, Reapers, and other Countrey-

people,

people, who spend the most part of the Hot Summer days expos'd to the Sun, have the skin of their Hands and Faces, which are the parts immediately expos'd to the Sun and Air, made of a darker Colour than before, and consequently tending to Blackness; And contrariwise we observe that the *Danes* and some other people that Inhabit cold Climates, and even the *English* who feel not so Rigorous a cold, have usually Whiter faces than the *Spaniards*, *Portugals* and other European Inhabitants of Hotter Climates. But this Argument I take to be far more Specious than Convincing; for though the Heat of the Sun may Darken the Colour of the Skin, by that Operation, which we in *English* call Sunburning; yet Experience doth not Evince, that I remember, That that Heat alone can produce a discolouring that shall amount to a true Blackness, like that of *Negroes*, and we shall see by and by that even the Children of some *Negroes* not yet Ten days Old (perhaps not so much by three quarters of that time) will notwithstanding their Infancy be of the same Hue with their Parents. Besides, there is this strong Argument to be alledg'd against the Vulgar Opinion, that in divers places in *Asia* under the same Parallel, or even of the same

Degree

Degree of Latitude with the *African* Regions inhabited by Blacks, the People are at most but Tawny; And in *Africa* it self divers Nations in the Empire of *Ethiopia* are not *Negroes*, though Situated in the Torrid Zone, and as near the Æquinoctial, as other Nations that are so (as the Black Inhabitants of *Zeylan* and *Malabar* are not in our Globes plac'd so near the Line as *Amara* the Famousest place in *Ethiopia*.) Moreover, (that which is of no small Moment in our present Disquisition) I find not by the best Navigators and Travellers to the *West-Indies*, whose Books or themselves I have consulted on this Subject, that excepting perhaps one place or two of small extent, there are any Blacks Originally Natives of any part of *America* (for the Blacks now there have been by the *Europeans* long Transplanted thither) though the New World contain in it so great a Variety of Climates, and particularly reach quite Cross the Torrid Zone from one Tropick to another. And though it be true that the *Danes* be a Whiter People than the *Spaniards*, yet that may proceed rather from other causes (not here to be enquir'd into) than from the Coldness of the Climate, since not only the *Swedes*

Olearius Voyage de Mosco & de Perse. *liv.* 3.

Swedes and other Inhabitants of those Cold Countries, are not usually so White as the *Danes*, nor Whiter than other Nations in proportion to their Vicinity to the Pole. [And since the Writing of the former part of this Essay, having an opportunity on a Solemn occasion to take Notice of the Numerous Train of some Extraordinary Ambassadors sent from the *Russian* Emperor to a great Monarch, observ'd, that (though it were then Winter) the Colour of their Hair and Skin was far less Whitish than the *Danes* who Inhabit a milder Region is wont to be, but rather for the most part of a Darkish Brown; And the Physitian to the Ambassador with whom those *Russes* came, being ask'd by me whether in *Muscovy* it self the Generality of the People were more inclin'd to have Dark-colour'd Hair than Flaxen, he answer'd Affirmatively; but seem'd to suspect that the True and Ancient *Russians*, a Sept of whom he told me he had met with in one of the Provinces of that vast Empire, were rather White like the *Danes*, than any thing near so Brown as the present *Muscovites* whom he guesses to be descended of the *Tartars*, and to have inherited their colour from them.] But to Prosecute our former Discourse, I shall add for further Proof of the Conjecture I was

countenan-

countenancing that good Authors inform us that there are *Negroes* in *Africa* not far from the *Cape of good Hope*, and consequently beyond the Southern Tropick, and without the Torrid Zone, much about the same Northern Latitude (or very little more) wherein there are divers *American* Nations that are not *Negroes*, and wherein the Inhabitants of *Candia*, some parts of *Sicily*, and even of *Spain* are not so much as Tawny-Mores. But (which is a fresh and strong Argument against the common Opinion,) I find by our recent Relations of *Greenland*, (our Accounts whereof we owe to the Curiosity of that Royal *Virtuoso* the present King of *Denmark*,) that the Inhabitants are Olive-colour'd, or rather of a Darker Hue. But if the Case were the same with Men, and those other kinds of Animals I formerly nam'd, I should offer something as a considerable proof, That Cold may do much towards the making Men White or Black, and however I shall set down the Observation as I have met with it, as worthy to come into the History of whiteness and Blackness, and it is, that in some parts of *Russia* and of *Livonia* it is affirm'd by *Olaus Magnus* and others, that Hares and Foxes (some add Partridges) which before were Black, or Red, or Gray,

Gray, do in the depth of Winter become White by reason of the great Cold; (for that it should be, as some conceive, by looking upon the Snow, seems improbable upon divers accounts) And I remember that having purposely enquir'd of a *Virtuoso* who lately Travell'd through *Livonia* to *Mosco*, concerning the Truth of this Tradition, he both told me, he believ'd it, and added, that he saw divers of those lately nam'd Animals either in *Russia* or *Livonia* (for I do not very well remember whether of the two) which, though White when he saw them in Winter, they assur'd him had been black, or of other Colours before the Winter began, and would be so again when it was over. But for further satisfaction, I also consulted one that had for some years been an Eminent Physitian in *Russia*, who though he rejected some other Traditions that are generally enough believ'd concerning that Countrey, told me nevertheless, that he saw no cause to doubt of this Tradition of *Olaus Magnus* as to Foxes and Hares, not only because 'tis the common and uncontroul'd Assertion of the Natives; but also because he himself in the Winter could never that he remembred see Foxes and Hares of any other colour than White; And I my self having seen a small White Fox

Fox brought out of *Russia* into *England* wards the latter end of Winter, foretold those that shew'd him me, that he would change colour in Summer, and accordingly coming to look upon him again in *July*, I found that the Back and Sides, together with the upper part of the Head and Tail, were already grown of a dark colour, the lower part of the Head and Belly containing as yet a Whiteness. Let me add, that were it not for some scruple I have, I should think more than what *Olaus* relates, confirm'd by the Judicious *Olearius*, who was twice employ'd into those parts as a Publick Minister, who in his Account of *Muscovy*, has this Passage: *The Hares there are Gray; but in some Provinces they grow White in the Winter.* And within some few Lines after: *It is not very difficult to find the Cause of this Change, which certainly proceeds only from the Outward Cold, since I know that even in Summer, Hares will change Colour, if they be kept a competent time in a Cellar*; I say, were it not for some Scruple, because I take notice, that in the same Page the Author affirms, that the like change of Colour that happens to Hares in some Provinces of *Muscovy*, happens to them also in *Livonia*, & yet immediately subjoyns, that in *Curland* the Hares vary not their colour in Winter,

ter, though these two last named Countries be contiguous, (that is) sever'd only by the River of *Dugna*; For it is scarce conceivable how Cold alone should have, in Countries so near, so strangely differing an operation, though no less strange a thing is confess'd by many, that ascribe the Complexion of *Negroes* to the Heat of the Sun, when they would have the River of *Cenega*, so to bound the *Moors*, that though on the North-side they are but Tawny, on the other side they are Black.

There is another Opinion concerning the Complexion of *Negroes*, that is not only embrac'd by many of the more Vulgar Writers, but likewise by that ingenious Traveller Mr. *Sandys*, and by a late most learned Critick, besides other men of Note; and these would have the blackness of *Negroes* an effect of *Noah*'s Curse ratify'd by God's, upon *Cham*; But though I think that even a Naturalist may without disparagement believe all the Miracles attested by the Holy Scriptures, yet in this case to fly to a Supernatural Cause, will, I fear, look like Shifting off the Difficulty, instead of Resolving it; for we enquire not the First and Universal, but the Proper, Immediate, and Physical Cause of the Jetty Colour of *Negroes*; and not only we do not find expressed in the Scrip-

Scripture, that the Curſe meant by *Noah* to *Cham*, was the Blackneſs of his Poſterity, but we do find plainly enough there that the Curſe was quite another thing, namely, that he ſhould be a Servant of ſervants, that is by an Ebraiſm, a very Abject Servant to his Brethren, which accordingly did in part come to paſs, when the *Iſraelites* of the poſterity of *Sem*, ſubdued the *Canaanites*, that deſcended from *Cham*, and kept them in great Subjection. Nor is it evident that Blackneſs is a Curſe, for Navigators tell us of Black Nations, who think ſo much otherwiſe of their own condition, that they paint the Devil White. Nor is Blackneſs inconſiſtent with Beauty, which even to our European Eyes conſiſts not ſo much in colour, as an Advantageous Stature, a comely Symmetry of the parts of the Body, and good features in the Face. So that I ſee not why Blackneſs ſhould be thought ſuch a curſe to the *Negroes*, unleſs perhaps it be, that being wont to go Naked in thoſe Hot Climates, the colour of their Skin does probably, according to the Doctrine above deliver'd, make the Sun-beams more ſcorching to them, than they would prove to a people of a White complexion.

Greater probability there is, That the Principal cauſe (for I would not exclude all

all concurrent ones) of the Blackness of *Negroes* is some Peculiar and Seminal Impression, for not only we see that *Blackmore* boyes brought over into these Colder Climates lose not their Colour; But good Authors inform us, That the Off-spring of *Negroes* Transplanted out of *Africa*, above a hundred years ago, retain still the Complexion of their Progenitors, though possibly in Tract of time it will decay; As on the other side, the White people removing into very Hot Climates, have their Skins by the Heat of the Sun scorch'd into Dark Colours; yet neither they, nor their Children have been observ'd, even in the Countrys of *Negroes*, to descend to a Colour amounting to that of the Natives; whereas I remember I have Read in *Pisos* excellent account of *Brasil*, that betwixt the *Americans* and *Negroes* are generated a distinct sort of Men, which they call *Cabocles*, and betwixt *Portugals* and *Æthiopian* women, He tells us, he has sometimes seen Twins, whereof one had a White Skin, the other a Black; not to mention here some other instances, he gives, that the productions of the mixtures of differing people, that is (indeed,) the effects of Seminal Impressions which they

Piso Nat. & Med. Hist. *Brasil. lib.* 1. in fine.

consequently argue to have been their causes; and we shall not much scruple at this, if we consider, that even Organical parts may receive great Differences from such peculiar Impressions, upon what account soever they came to be setled in the first Individual persons, from whom they are Propagated to Posterity, as we see in the Blobber-Lips and Flat-Noses of most Nations of *Negroes*. And if we may credit what Learned men deliver concerning the Little Feet of the *Chineses*, the *Macrocephali* taken notice of by *Hippocrates*, will not be the only Instance we might apply to our present purpose. And on this occasion it will not perchance be Impertinent to add somthing of what I have observ'd in other Animals, as that there is a sort of Hens that want Rumps; And that (not to mention that in several places there is a sort of Crows or Daws that are not Cole-black as ours, but partly of a whitish colour) in spight of *Porphyries* examples of Inseparable Accidents, I have seen a perfectly White Raven, as to Bill as well as Feathers, which I attentively consider'd, for fear of being impos'd upon. And this recalls into my Memory, what a very Ingenious Physician has divers times related to me of a young Lady, to whom being call'd, he found that though

she

she much complain'd of want of Health, yet there appear'd so little cause either in her Body, or her Condition to Gues that She did any more than fancy her self Sick, that scrupling to give her Physick, he perswaded her Friends rather to divert her Mind by little Journeys of Pleasure; in one of which going to Visit St. *Winifreds* Well, this Lady, who was a *Catholick*, and devout in her Religion, and a pretty while in the Water to perform some Devotions, and had occasion to fix her Eyes very attentively upon the Red peble-stones, which in a scatter'd order made up a good part of those that appear'd through the water, and a while after growing Big, she was deliver'd of a Child, whose White Skin was Copiously speckl'd with spots of the Colour and Bigness of those Stones, and though now this Child have already liv'd several years, yet she still retains them. I have but two things to add concerning the Blackness of *Negroes*, the one is, that the Seat of that Colour seems to be but the thin *Epidermes*, or outward Skin; for I knew a young *Negroe*, who having been lightly Sick of the Small Pox or Measles, (for it was doubted which of the two was his Disease) I found by enquiry of a person that was concern'd for him, that in those places the little Tu-

mors had broke their passage through the Skin, when they were gone, they left Whitish specks behind them; and the lately commended *Piso* assures us, that having the opportunity in *Brasil* to Dissect many *Negroes*, he clearly found that their Blackness went no deeper than the very outward Skin, which *Cuticula* or *Epidermis* being remov'd, the undermost Skin or *Cutis* appear'd just as White as that of *Europæan* Bodies. And the like has been affirmed to me by a Physician of our own, whom, hearing he had Dissected a *Negroe* here in *England*, I consulted about this particular. The other thing to be here taken notice of concerning *Negroes* is, That having enquir'd of an Intelligent acquaintance of mine (who keeps in the *Indies* about 300 of them as well Women as Men to work in his Plantations,) whether their Children come Black into the world; he answer'd, That they did not, but were brought forth of almost the like Reddish Colour with our *European* Children; and having further enquir'd, how long it was before these Infants appear'd Black, he reply'd, that 'twas not wont to be many days. And agreeable to this account I find that, given us in a freshly publish'd French Book written by a *Jesuit*, that had good opportunity

tunity of knowing the Truth of what he Delivers; for being one of the Missionaries of his Order into the Southern *America* upon the Laudable Design of Converting Infidels to Christianity, he Baptiz'd several Infants, which when newly Born, were much of the same Colour with *European* Babes, but within about a Week began to appear of the Hue of their Parents. But more Pregnant is the Testimony of our Countrey-man *Andrew Battel*, who being sent Prisoner by the *Portugals* to *Angola*, liv'd there, and in the adjoyning Regions, partly as a Prisoner, partly as a Pilot, and partly as a Souldier, near 18 years, and he mentioning the *African* Kingdom of *Longo*, peopled with Blacks, has this passage: *The Children in this Countrey are Born White, and change their Colour in two days to a Perfect Black.* As for Example, *The* Portugals *which dwell in the Kingdom of* Longo *have sometimes Children by the* Negroe-*women, and many times the Fathers are deceived, thinking, when the Child is Born, that it is theirs, and within two days it proves the Son or Daughter of a* Negroe, *which the* Portugals *greatly grieve at*; And the same person has elsewhere a Relation, which, if he have made no use at all of the liberty

Purchas Pilgrim. Second part, Seventh Book. 3. Chap. Sect. 5.

liberty of a Traveller, is very well worth our Notice, since this, together with that we have formerly mention'd of Seminal Impressions, shews a possibility, that a Race of *Negroes* might be begun, though none of the Sons of *Adam* for many Precedent Generations were of that Complexion. For I see not why it should not be at least as possible, that White Parents may sometimes have Black Children, as that *African Negroes* should sometimes have lastingly White ones, especially since concurrent causes may easily more befriend the Productions of the Former kind, than under the scorching Heat of *Africa* those of the Latter. And I remember on the occasion of what he delivers, that of the White Raven formerly mention'd, the Possessor affirm'd to me, that in the Nest out of which he was taken White, they found with him but one other Young one, and that he was of as Jetty a Black as any common Raven. But let us hear our Author himself: *Here are* (says he, speaking of the formerly mention'd Regions) *Born in this Countrey White Children, which is very rare among them, for their Parents are* Negroes; *And when any of them are born, they are presented to the King, and are* Purchas. *called* Doudos; *These are as White as any White*

White Men. These are the Kings witches, and are brought up in Witchcraft, and always wait on the King: There is no man that dare meddle with these Dondos, *if they go to the Market they may take what they list, for all Men stand in awe of them. The King of* Longo *hath four of them.* And yet this Country in our Globes is placed almost in the midst of the Torrid Zone (four or five Degrees Southward of the Line.) And our Author elsewhere tells us of the Inhabitants, that they are so fond of their Blackness, that they will not suffer any that is not of that Colour (as the *Portugals* that come to Trade thither) to be so much as Bury'd in their Land, of which he annexes a particular example, that may be seen in his Voyage preserv'd by our Industrious Countryman Mr. *Purchas*. But it is high time for me to dismiss Observations, and go on with Experiments.

Purchas Ibid. in fin.

EXPERIMENT XII.

The way, *Pyrophilus*, of producing Whiteness by Chymical Præcipitations is very well worth our observing, for thereby Bodies of very Differing Colours as well as Natures, though dissolv'd in Several Li-

quors, are all brought into *Calces* or Powders that are White. Thus we find that not only Crabs-eyes, that are of themselves White, and Pearls that are almost so, but *Coral* and *Minium* that are Red, being dissolv'd in Spirit of Vinegar, may be uniformly Præcipitated by Oyl of *Tartar* into white Powders. Thus Silver and Tin separately dissolv'd in *Aqua Fortis*, will the one Præcipitate it self, and the other be Præcipitated by common Salt-water into a White *Calx*, and so will Crude Lead and Quicksilver first dissolv'd likewise in *Aqua Fortis*. The like *Calx* will be afforded as I have try'd by a Solution of that shining Mineral Tinglass dissolv'd in *Aqua Fortis*, and Præcipitated out of it; and divers of these *Calces* may be made at least as Fair and White, if not better Colour'd, if instead of Oyl of *Tartar* they were Præcipitated with Oyl of *Vitriol*, or with another Liquor I could Name. Nay, that Black Mineral *Antimony* it self, being reduc'd by and with the Salts that concur to the Composition of common Sublimate, into that clear though Unctuous Liquor that Chymists commonly call Rectifi'd Butter of *Antimony*, will by the bare affusion of store of Fair Water be struck down into that Snow-white Powder, which when the adhering Saltness is well wash'd off,

off, Chymists are pleas'd to call *Mercurius Vitæ*, though the like Powder may be made of *Antimony*, without the addition of any *Mercury* at all. And this Lacteſcence, if I may ſo call it, does alſo commonly enſue when Spirit of Wine, being Impregnated with thoſe parts of Gums or other Vegetable Concretions, that are ſuppos'd to abound with Sulphureous Corpuſcles, fair Water is ſuddenly pour'd upon the Tincture or Solution. And I remember that very lately I did, for Tryal ſake, on a Tincture of *Benjamin* drawn with Spirit of Wine, and brought to be as Red as Blood, pour ſome fair Water, which preſently mingling with the Liquor, immediately turn'd the whole Mixture White. But if ſuch Seeming Milks be ſuffer'd to ſtand unſtirr'd for a convenient while, they are wont to let fall to the bottom a Reſinous Subſtance, which the Spirit of Wine Diluted and Weakned by the Water pour'd into it, as unable to ſupport any longer. And ſomething of Kin to this change of Colour in Vegetables is that, which Chymiſts are wont to obſerve upon the pouring of Acid Spirits upon the Red Solution of *Sulphur*, diſſolv'd in an Infuſion of Pot-aſhes, or in ſome other ſharp *Lixivium*, the Præcipitated *Sulphur* before it ſubſides, immediately turning the Red Li-

quor

quor into a White one. And other Examples might be added of this way of producing whiteneſs in Bodies by Præcipitating them out of the Liquors wherein they have been Diſſolv'd; but I think it may be more uſeful to admoniſh you, *Pyrophilus*, that this obſervation admits of Reſtrictions, and is not ſo Univerſal, as by this time perhaps you have begun to think it; For though moſt Præcipitated Bodies are white, yet I know ſome that are not; For Gold diſſolv'd in *Aqua Regis*, whether you Præcipitate it with Oyl of *Tartar*, or with Spirit of *Sal Armoniack*, will not afford a White but a Yellow *Calx*. *Mercury* alſo though reduced into Sublimate, and Præcipitated with Liquors abounding with Volatile Salts, as the Spirits drawn from Urine, Harts-horn, and other Animal ſubſtances, yet will afford, as we Noted in our firſt Experiment about Whiteneſs and Blackneſs, a white Præcipitate, yet with the Solution of Pot-aſhes and other Lixiviate Salts, it will let fall an Orange-Tawny Powder. And ſo will Crude *Antimony*, if, being diſſolv'd in a ſtrong Lye, you pour (as far as I remember) any Acid Liquor upon the Solution newly Filtrated, whilſt it is yet Warm. And if upon the Filtrated Solution of *Vitriol*, you pour a Solution of

one

one of these fix'd Salts, there will subside a copious substance, very far from having any Whiteness, which the Chymists are pleas'd to call, how properly I have elsewhere examin'd, the *Sulphur of Vitriol.* So that most Dissolv'd Bodies being by Præcipitation brought to White Powders, and yet some affording Præcipitates of other Colours, the reason of both the Phænomena may deserve to be enquir'd into.

EXPERIMENT XIII.

Some Learned Modern Writers are of Opinion, that the Account upon which Whiteness and Blackness ought to be call'd, as they commonly are, the two Extreme Colours, is, That Blackness (by which I presume is meant the Bodies endow'd with it) receives no other Colours; but Whiteness very easily receives them all; whence some of them compare Whiteness to the *Aristotelian Materia prima*, that being capable of any sort of Forms, as they suppose White Bodies to be of every kind of Colour. But not to Dispute about Names or Expressions, the thing it self that is affirm'd as Matter of Fact, seems to be True enough in most Cases, not in all, or so,

See *Scaliger* Exercit. 325. Sect. 9.

as

as to hold Universally. For though it be a common observation among Dyers, That Clothes, which have once been throughly imbu'd with Black, cannot so well afterwards be Dy'd into Lighter Colours, the præexistent Dark Colour infecting the Ingredients, that carry the Lighter Colour to be introduc'd, and making it degenerate into some more sad one; Yet the Experiments lately mention'd may shew us, that where the change of colour in black bodies is attempted, not by mingling Bodies of Lighter Colours with them, but by Addition of such things as are proper to alter the Texture of those Corpuscles that contain the Black Colour, 'tis no such difficult matter, as the lately mention'd Learned Men imagine, to alter the Colour of Black Bodies. For we saw that Inks of several Kinds might in a trice be depriv'd of all their Blackness; and those made with Log-wood and Red-Roses might also be chang'd, the one into a Red, the other into a Reddish Liquor; and with Oyl of *Vitriol* I have sometimes turn'd Black pieces of Silk into a kind of Yellow, and though the Taffaty were thereby made Rotten, yet the spoiling of that does no way prejudice the Experiment, the change of Black Silk into Yellow, being never the less True, because

cauſe the Yellow Silk is the leſs good. And as for Whiteneſs, I think the general affirmation of its being ſo eaſily Deſtroy'd or tranſmuted by any other Colour, ought not to be receiv'd without ſome Cautions and Reſtrictions. For whereas, according to what I formerly Noted, Lead is by Calcination turn'd into that Red Powder we call *Minium*; And Tin by Calcination reduc'd to a White *Calx*, the Common Putty that is ſold and us'd ſo much in Shops, inſtead of being, as it is pretended and ought to be, only the *Calx* of Tin, is, by the Artificers that make it, to ſave the charge of Tin, made (as ſome of themſelves have confeſs'd, and as I long ſuſpected by the cheap rate it may be bought for) but of half Tin and half Lead, if not far more Lead than Tin, and yet the Putty in ſpite of ſo much Lead is a very White Powder, without diſcloſing any Mixture of *Minium*. And ſo if you take two parts of Copper, which is a High-colour'd Metal, to but one of Tin, you may by Fuſion bring them into one Maſs, wherein the Whiteneſs of the Tin is much more Conſpicuous and Predominant than the Reddiſhneſs of the Copper. And on this occaſion it may not be Impertinent to mention an Experiment, which I relate upon the Credit of a very Honeſt man, whom

whom I purposely enquir'd of about it, being my self not very fond of making Tryals with *Arsenick*; the Experiment is this, That if you Colliquate *Arsenick* and Copper in a due proportion, the *Arsenick* will Blanch the Copper both within and without, which is an Experiment well enough known; but when I enquir'd, whether or no this White mixture being skilfully kept a while upon the Cupel would not let go its *Arsenick*, which made Whiteness its prædominant Colour, and return to the Reddishness of Copper, I was assur'd of the Affirmative; so that among Mineral Bodies, some of those that are White, may be far more capable, than those I am reasoning with seem to have known, of Eclipsing others, and of making their Colour Prædominant in Mixtures. In further Confirmation of which may be added, that I remember that I also took a lump of Silver and Gold melted together, wherein by the Æstimate of a very Experienc'd Refiner, there might be about a fourth or third part of Gold, and yet the Yellow Colour of the Gold was so hid by the White of the Silver, that the whole Mass appear'd to be but Silver, and when it was rubb'd upon the Touchstone, an ordinary beholder could scarce have distinguish'd it from the Touch of common Silver;

Silver; though if I put a little *Aqua Fortis* upon any part of the white Surface it had given the Touch-ſtone, the Silver in the moiſtned part being immediately taken up and conceal'd by the Liquor, the Golden Particles would preſently diſcloſe that native Yellow, and look rather as if Gold, than if the above mention'd mixture, had been rubb'd upon the Stone.

EXPERIMENT XIV.

I took a piece of Black-horn, (poliſh'd as being part of a Comb) this with a piece of broken Glaſs I ſcrap'd into many thin and curdled flakes, ſome ſhorter and ſome longer, and having laid a pretty Quantity of theſe ſcrapings together, I found, as I look'd for, that the heap they compos'd was White, and though, if I laid it upon a clean piece of White-Paper, its Colour ſeem'd ſomewhat Eclips'd by the greater Whiteneſs of the Body it was compared with, looking ſomewhat like Linnen that had been ſulli'd by a little wearing, yet if I laid it upon a very Black Body, as upon a Beaver Hatt, it then appear'd to be of a good White; which Experiment, that you may in a trice make when you pleaſe, ſeems very much to Disfavour both their Doctrine that

that would have Colours to flow from the ſubſtantial Forms of Bodies, and that of the Chymiſts alſo, who aſcribe them to one or other of their three Hypoſtatical Principles; for though in our Caſe there was ſo great a Change made, that the ſame Body without being ſubſtantially either Increas'd or Leſſened, paſſes immediately from one extreme Colour to another (and that too from Black to White) yet this ſo great and ſudden change is effected by a ſlight Mechanical Tranſpoſition of parts, there being no Salt or *Sulphur* or *Mercury* that can be pretended to be Added or Taken away, nor yet any ſubſtantial Form that can reaſonably be ſuppos'd to be Generated and Deſtroy'd, the Effect proceeding only from a Local Motion of the parts which ſo vary'd their Poſition as to multiply their diſtinct Surfaces, and to Qualifie them to Reflect far more Light to the Eye, than they could before they were ſcrap'd off from the entire piece of Black horn.

EXPERIMENT XV.

And now, *Pyrophilus*, it will not be improper for us to take ſome notice of an Opinion touching the cauſe of Blackneſs, which I judged it not ſo ſeaſonable to Queſtion, till I had

I had set down some of the Experiments, that might justifie my dissent from it. You know that of late divers Learned Men, having adopted the three Hypostatical Principles, besides other Notions of the Chymists, are very inclinable to reduce all Qualities of Bodies to one or other of those three Principles, and particularly assign for the cause of Blackness the Sootie steam of *adust* or *torrifi'd Sulphur*. But I hope that what we have deliver'd above to countenance the Opinion we have propos'd about the cause of Blackness, will so easily supply you with several Particulars that may be made use of against this Opinion, that I shall now represent to you but two things concerning it.

And First it seems that the favourers of the Chymical Theories might have pitcht upon some more proper term, to express the Efficient of Blackness than *Sulphur adust*; for we know that *common Sulphur*, not only when Melted, but even when Sublim'd, does not grow Black by suffering the Action of the fire, but continues and ascends Yellow, and rather more than less White, than it was before its being expos'd to the fire. And if it be set on fire, as when we make that acid Liquor, that Chymists call *Oleum Sulphuris per campanam*, it affords

very little Soot, and indeed the flame yields so little, that it will scarce in any Degree Black a Sheet of White Paper, held a pretty while over the flame and smoak of it, which is observed rather to Whiten than Infect linnen, and which does plainly make Red Roses grow very Pale, but not at all Black, as far as the Smoak is permitted to reach the leaves. And I can shew you of a sort of fixt Sulphur made by an Industrious Laborant of your acquaintance, who assur'd me that he was wont to keep it for divers weeks together night and day in a naked and violent fire, almost like that of the Glass-house, and when, to satisfie my Curiosity, I made him take out a lump of it, though it were glowing hot (and yet not melted,) it did not, when I had suffered it to cool, appear Black, the true Colour of it being a true Red. I know it may be said, that *Chymists* in the Opinion above recited mean the *Principle of Sulphur*, and not *common Sulphur* which receives its name, not from its being *all* perfectly of a Sulphureous Nature, but for that *plenty* and *Predominancy* of the Sulphureous Principle in it. But allowing this, 'tis easie to reply, that still according to this very Reason, torrifi'd Sulphur should afford more Blackness, than most other concretes, wherein

wherein that Principle is confeſs'd to be far leſs copious. Alſo when I have expos'd Camphire to the fire in Cloſe Veſſels, as Inflameable, and conſequently (according to the Chymiſts) as Sulphureous a Body as it is, I could not by ſuch a Degree of Heat as brought it to Fuſion, and made it Boyl in the glaſs, impreſs any thing of Blackneſs, or of any other Colour, than its own pure White, upon this Vegetable Concrete. But what ſhall we ſay to Spirit of Wine, which being made by a Chymical Analyſis of the Liquor that affords it, and being totally Inflameable, ſeems to have a full right to the title they give it of *Sulphur Vegetabile*, & yet this fluid Sulphur not only contracts not any degree of Blackneſs by being often ſo heated, as to be made to Boyl, but when it burns away with an Actual flame, I have not found that it would diſcolour a piece of White Paper held over it, with any diſcernable Soot. Tin alſo, that wants not, according to the Chymiſts, a *Sulphur Jovialé*, when throughly burned by the fire into a *Calx*, is not Black, but eminently White. And I lately noted to you out of *Bellonius*, that the Charcoals of Oxy-cedar are not of the former of theſe two colours, but of the latter. And the Smoke of our Tinby coals here in *England*, has been

usually observ'd, rather to Blanch linnen than to Black it. To all which other Particulars of the like nature might be added, but I rather chuse to put you in mind of the third Experiment, about making Black Liquors, or Ink, of Bodies that were none of them Black before. For how can it be said, that when those Liquors are put together actually Cold, and continue so after their mixture, there intervenes any new *Adustion of Sulphur* to produce the emergent Blackness (and the same question will be appliable to the Blackness produc'd upon the blade of a Knife, that has cut Lemmons and some kind of Sowr apples, if the juice (though both Actually and Potentially Cold) be not quickly wip'd off) And when by the instilling either of a few drops of Oyl of Vitriol as in the second Experiment, or of a little of the Liquor mention'd in the Passage pointed at in the fourth Experiment (where I teach at once to Destroy one black Ink, and make another) the Blackness produc'd by those Experiments is presently destroy'd; if the Colour proceeded only from the plenty of Sulphurous parts, torrify'd in the Black Bodies, I demand, what becomes of them, when the Colour so suddenly dis-appears? For it cannot Reasonably be said, that all those that

ſuffic'd to make ſo great a quantity of Black Matter, ſhould reſort to ſo very ſmall a proportion of the Clarifying Liquor, (if I may ſo call it) as to be diluted by it, without at all denigrating it. And if it be ſaid that the Inſtill'd liquor diſpers'd thoſe black Corpuſcles, I demand, how that Diſperſion comes to deſtroy their Blackneſs, but by making ſuch a Local Motion of their parts, as deſtroys their former Texture? which may be a Matter of ſuch moment in caſes like ours, that I remember that I have in few hours, without addition, from Soot it ſelf, attain'd pretty ſtore of Cryſtalline Salt, and good ſtore of Tranſparent Liquor, and (which I have on another occaſion noted as remarkable) this ſo Black ſubſtance had its Colour ſo alter'd, by the change of Texture it receiv'd from the fire, wherewith it was diſtill'd, that it did for a great while afford ſuch plenty of very white Exhalations, that the Receiver, though large, ſeem'd to be almoſt filled with Milk.

Secondly, But were it granted, as it is in ſome caſes not improbable, that divers Bodies may receive a Blackneſs from a Sootie Exhalation, occaſion'd by the Aduſtion of their Sulphur, which (for the Reaſons lately mention'd I ſhould rather call their Oyly parts;) yet ſtill this account

is applicable but to some Particular Bodies, and will afford us no General Theory of Blackness. For if, for example, White Harts-horn, being, in Vessels well luted to each other, expos'd to the fire, be said to turn Black by the Infection of its own Smoke, I think I may justly demand, what it is that makes the Smoke or Soot it self Black, since no such Colour, but its contrary, appear'd before in the Harts-horn? And with the same Reason, when we are told, that torrify'd Sulphur makes Bodies Black, I desire to be told also, why Torrefaction makes Sulphur it self Black? nor will there be any Satisfactory Reason assign'd of these Quæries, without taking in those fertil as well as intelligible Mechanical Principles of the Position and Texture of the Minute parts of the body in reference to the Light and the Eye; and these applicable Principles may serve the turn in many cases, where the Aduſtion of Sulphur cannot be pretended; as in the appearing Blackness of an Open Window, lookt upon at a somewhat remote distance from the house, as also in the Blackness Men think they see in the Holes that happen to be in White Linnen, or Paper of the like Colour; and in the Increasing Blackness immediately Produc'd barely by so rubbing Velver,

whose

whoſe Piles were Inclin'd before, as to reduce them to a more Erected poſture; in which and in many other caſes formerly alledg'd, there appears nothing requiſite to the Production of the Blackneſs, but the hindring of the incident Beams of Light from rebounding plentifully enough to the Eye. To be ſhort, thoſe I reaſon with, do concerning Blackneſs, what the Chymiſts are wont alſo to do concerning other Qualities, namely to content themſelves to tell us, in what Ingredient of a Mixt Body, the Quality enquir'd after, does reſide, inſtead of explicating the Nature of it, which (to borrow a compariſon from their own Laboratories) is much as if in an enquiry after the cauſe of Salivation, they ſhould think it enough to tell us, that the ſeveral Kinds of Præcipitates of Gold and *Mercury*, as likewiſe of Quick-ſilver and Silver (for I know that make and uſe of ſuch Præcipitates alſo) do Salivate upon the account of the *Mercury*, which though Diſguis'd abounds in them, whereas the Difficulty is as much to know upon what account *Mercury* it ſelf, rather than other Bodies, has that power of working by Salivation. Which I ſay not, as though it were not *ſomething* (and too often the moſt we can arrive at) to diſcover in which of the

Ingredients of a Compounded Body, the Quality, whose Nature is sought, resides; but because, though this Discovery it self may pass for *something*, and is oftentimes more than what is taught us about the same subjects in the Schools, yet we ought not to think it *enough*, when more Clear and Particular accounts are to be had.

THE

THE Experimental History OF COLOURS Begun.

The Third PART.

Containing

Promiſcuous Experiments About COLOURS.

EXPERIMENT I.

BEcauſe that, according to the Conjectures I have above propos'd, one of the moſt General Cauſes of the Diverſity of Colours in Opacous Bodies, is, that ſome reflect the Light mingled with more, others with leſs of Shade (either

as

as to Quantity, or as to Interruption) I hold it not unfit to mention in the first place, the Experiments that I thought upon to Examine this Conjecture. And though coming to transcribe them out of some Physiological *Adversaria* I had written in loose Papers, I cannot find one of the chief Records I had of my Tryals of this Nature, yet the Papers that scap'd miscarrying, will, I presume, suffice to manifest the main thing for which I now alledge them; I find then among my *Adversaria*, the following Narrative.

October the 11. About ten in the Morning in Sun-shiny Weather, (but not without fleeting Clouds) we took several sorts of Paper Stain'd, some of one Colour, and some of another; and in a Darken'd Room whose Window look'd Southward, we cast the Beams that came in at a hole about three Inches and a half in a Diameter, upon a White wall that was plac'd on one side, about five foot distance from them.

The White gave much the Brightest Reflection.

The Green, Red, and Blew being Compar'd together, the Red gave much the strongest Reflection, and manifestly enough also threw its *Colour* upon the Wall; The Green and Blew were scarce Discernable by

by their Colours, and seem'd to reflect an almost Equal Light.

The Yellow Compar'd with the two last nam'd, Reflected somewhat more Light.

The Red and Purple being Compar'd together, the former manifestly Reflected a good deal more Light.

The Blew and Purple Compar'd together, the former seem'd to Reflect a little more Light, though the Purple Colour were more manifestly seen.

A Sheet of very well sleek'd Marbl'd Paper being Apply'd as the others, did not cast any of its Distinct Colours upon the Wall; nor throw its Light upon it with an equal Diffusion; but threw the Beams Unstain'd and Bright to this and that part of the Wall, as if it's Polish had given it the Nature of a specular Body. But comparing it with a sheet of White Paper, we found the Reflection of the latter to be much Stronger, it diffusing almost as much Light to a *good Extent* as the Marble Paper did to *one part* of the Wall.

The Green and Purple left us somewhat in suspence which Reflected the most Light; only the Purple seem'd to have some little Advantage over the Green, which was Dark in its kind.

Thus much I find in our above menti-

on'd

on'd *Collections*, among which there are also some Notes concerning the Production of *Compounded Colours, by Reflection* from Bodies differingly Colour'd. And these Notes we intended should supply us with what we should mention as our second Experiment: but having lost the Paper that contain'd the Particulars, and remembring only in General, that if the Objects which Reflected the Light were not Strongly Colour'd and somewhat Glossie, the Reflected Beams would not manifestly make a Compounded Colour upon the Wall, and even then but very faintly; we shall now say no more of that Matter, only reserving our selves to mention hereafter the Composition of a Green, which we still retain in Memory.

EXPERIMENT II.

We may add, *Pyrophilus*, on this Occasion, that though a Darken'd Room be Generally thought requisite to make the Colour of a Body appear by Reflection from another Body, that is not one of those that are commonly agreed upon to be Specular (as Polish'd Metal, Quick-silver, Glass, Water, &c.) Yet I have often observ'd that when I wore Doublets Lin'd with some silken

ken Stuff that was very Gloſſie and Vividly Colour'd, eſpecially Red, I could in an Inlightned Room plainly enough Diſcern the Colour upon the pure White Linnen that came out at my Sleeve and reach'd to my Cuffs; as if that Fine White Body were more Specular, than Colour'd and Unpoliſh'd Bodies are thought Capable of being.

EXPERIMENT III.

Whilſt we were making the newly mention'd Experiments, we thought fit to try alſo what compoſition of Colours might be made by Altering the Light in its Paſſage to the Eye by the Interpoſition not of Perfectly Diaphanous Bodies (that having been already try'd by others as well as by us (as we ſhall ſoon have occaſion to take notice) but of Semi-opacous Bodies, and thoſe ſuch as look'd upon in an ordinary Light, and not held betwixt it and the Eye, are not wont to be Diſcriminated from the reſt of Opacous Bodies; of this Tryal, our mention'd *Adverſaria* preſent us the following Account.

Holding theſe Sheets, ſometimes one, ſometimes the other of them, before the Hole betwixt the Sun and the Eye, with the

the Colour'd sides obverted to the Sun; we found them *single* to be somewhat Transparent, and appear of the same Colour as before, only a little alter'd by the great Light they were plac'd in; but laying *two* of them one over another, and applying them so to the Hole, the Colours were compounded as follows.

The Blew and Yellow scarce exhibited any thing but a Darker Yellow, which we ascrib'd to the Coarseness of the Blew Paper, and its Darkness in its Kind. For applying the Blew parts of the Marbl'd Paper with the Yellow Paper after the same manner, they exhibited a good Green.

The Yellow and Red look'd upon together gave us but a Dark Red, somewhat (and but a little) inclining to an Orange Colour.

The Purple and Red look'd on together appear'd more Scarlet.

The Purple and Yellow made an Orange.

The Green and Red made a Dark Orange Tawny.

The Green and Purple made the Purple appear more Dirty.

The Blew and Purple made the Purple more Lovely, and far more Deep.

The Red parts of the Marbl'd Paper look'd upon with the Yellow appear'd of a Red

Red far more like Scarlet than without it.

But the Fineneſs or Coarſeneſs of the Papers, their being carefully or ſlightly Colour'd, and divers other Circumſtances, may ſo vary the Events of ſuch Experiments as theſe, that if, *Pyrophilus*, you would Build much on them, you muſt carefully Repeat them.

EXPERIMENT IV.

The Triangular Priſmatical Glaſs being the Inſtrument upon whoſe Effects we may the moſt Commodiouſly ſpeculate the Nature of Emphatical Colours, (and perhaps that of Others too;) we thought it might be uſeful to obſerve the ſeveral Reflections and Refractions which the Incident Beams of Light ſuffer in Rebounding from it, and Paſſing through it. And this we thought might be beſt done, not (as is uſual,) in an ordinary enlightn'd Room, where (by reaſon of the Difficulty of doing otherwiſe) ev'n the curious have left Particulars Unheeded, which may in a convenient place be eaſily taken notice of; but in a darken'd Room, where by placing the Glaſs in a convenient Poſture, the Various Reflections and Refractions may be diſtinctly obſerv'd; and where it may appear *what* Beams are Unting'd,

ting'd, and *which* they are, that upon the Bodies that terminate them, do paint either the Primary or Secondary Iris. In pursuance of this we did in the above mention'd Darken'd Room, make observation of no less than four Reflections, and three Refractions that were afforded us by the same Prism, and thought that notwithstanding what was taught us by the Rules of Catoptricks and Dioptricks, it would not be amiss to find also, by hiding sometimes one part of the Prism, and sometimes another, and observing where the Light or Colour Vanish'd thereupon, by which Reflection and by which Refraction each of the several places whereon the Light rebounding from, or passing through, the Prism appear'd either Sincere or Tincted, was produc'd. But because it would be Tedious and not so Intelligible to deliver this in Words, I have thought fit to Refer you to the Annexed Scheme, where the Newly mention'd particulars may be at one View taken Notice of.

EXPERIMENT V.

I know not whether you will think it Inconsiderable to annex to this Experiment, That we observ'd in a Room not Darken'd,

Darken'd, that the Prismatical Iris (if I may so call it) might be Reflected without losing any of its several *Colours* (for we now consider not their *Order*) not only from a plain Looking-glass and from the calm surface of Fair Water, but also from a Concave Looking-glass; and that Refraction did as little Destroy those Colours as Reflection. For by the help of a large (double Convex) Burning glass through which we Refracted the Suns Beams, we found that one part of the Iris might be made to appear either beyond, or on this side of the other Parts of the same Iris; but yet the same Vivid Colours would appear in the Displac'd part (if I may so term it) as in the other. To which I shall add, that having, by hiding the side of the Prism, obverted to the Sun with an Opacous Body, wherein only one small hole was left for the Light to pass through, reduc'd the Prismatical Iris (cast upon White Paper) into a very narrow compass, and look'd upon it through a Microscope; the Colours appear'd the same as to kind that they did to the naked Eye.

EXPERIMENT VI.

It may afford matter of Speculation to the Inquisitive, such as you, *Pyrophilus*, that as the Colours of outward Objects brought into a darken'd Room, do so much depend for their Visibility upon the Dimness of the Light they are there beheld by; that the ordinary Light of the day being freely let in upon them, they immediately disappear: so our Tryals have inform'd us, that as to the Prismatical Iris painted on the Floor by the Beams of the Sun Trajected through a Triangular-glass; though the Colours of it appear very Vivid even at Noon-day, and in Sun-shiny Weather, yet by a more Powerful Light they may be made to disappear. For having sometimes, (in prosecution of some Conjectures of mine not now to be Insisted on,) taken a large Metalline Concave *Speculum*, and with it cast the converging Beams of the Sun upon a Prismatical Iris which I had caus'd to be projected upon the Floor, I found that the over-powerful Light made the Colours of the Iris disappear. And if I so Reflected the Light as that it crossed but the middle of the Iris, in that part only the Colours vanish'd or were made Invisible; those parts

parts of the Iris that were on the right and left hand of the Reflected Light (which seem'd to divide them, and cut the Iris asunder) continuing to exhibit the same Colours as before. But upon this we must not now stay to Speculate.

EXPERIMENT VII.

I have sometimes thought it worth while to take notice, whether or no the Colours of Opacous Bodies might not appear to the Eye somewhat Diversify'd, not only by the Disposition of the Superficial parts of the Bodies themselves, and by the Position of the Eye in Reference to the Object and the Light, (for these things are Notorious enough;) but according also to the Nature of the Lucid Body that shines upon them. And I remember that in Prosecution of this Curiosity, I observ'd a manifest Difference in some Kinds of Colour'd Bodies look'd on by Day-light, and afterwards by the Light of the Moon; either directly falling on them, or Reflected upon them from a Concave Looking-glass. But not finding at present in my Collections about Colours any thing set down of this Kind, I shall, till I have opportunity to repeat them, content my self to add what I find Register'd con-

cerning Colours look'd on by Candle-light, in regard that not only the Experiment is more easie to be repeated, but the Objects being the same sorts of Colour'd Paper lastly mention'd, the Collation of the two Experiments may help to make the Conjectures they will suggest somewhat the less uncertain.

Within a few days of the time above mention'd, divers Sheets of Colour'd Paper that had been look'd upon before in the Sunshine, were look'd upon at night by the light of a pretty big Candle, (snuff'd) and the Changes that were observ'd were these.

The Yellow seem'd much fainter than in the Day, and inclinable to a pale Straw-Colour.

The Red seem'd little Chang'd; but seem'd to Reflect Light more strongly than any other Colour (for White was none of them.)

A fair Deep Green look'd upon by it self, seem'd to be a Dark Blew: But being look'd upon together with a Dark Blew, appear'd Greenish; and beheld together with a yellow, appear'd more Blew than at first.

The Blew look'd more like a Deep Purple or Murray than it had done in the Day-light.

The Purple ſeem'd very little alter'd.

The Red look'd upon with the Yellow, made the Yellow look almoſt like Brown Cap-paper.

N. The Caution Subjoyned to the third Experiment, is alſo Applicable to this.

EXPERIMENT VIII.

But here I muſt not omit to ſubjoyn, that to ſatisfie our Selves, whether or no the Light of a Candle were not made unſincere, and as it were Ting'd with a Yellow Colour by the Admixtion of the Corpuſcles it aſſumes from its Fuel; we did not content our ſelves with what appears to the Naked Eye, but taking a pretty thick Rod or Cylinder (for thin Pieces would not ſerve the turn) of deep Blew Glaſs, and looking upon the Candles flame at a Convenient diſtance through it, we perceiv'd as we expected, the Flame to look Green; which as we often note, is the Colour wont to emerge from the Compoſition of Opacous Bodies, which were apart one of them Blew, and the other Yellow. And this perchance may be the main Reaſon of that which ſome obſerve, that a ſheet of very White Paper being look'd upon by Candle light, 'tis not eaſie at firſt to diſcern it from

a light Yellow or Lemon Colour; White Bodies (as we have elſewhere obſerv'd) having more than thoſe that are otherwiſe Colour'd, of a Specular Nature; in regard that though they exhibit not (unleſs they be Poliſh'd) the ſhape of the Luminary that ſhines on them, yet they Reflect its Light more Sincere and Untroubl'd, by either Shades or Refractions, than Bodies of other Colours (as Blew, or Green, or Yellow, or the like.)

EXPERIMENT IX.

We took a Leaf of ſuch Foliated Gold as Apothecaries are wont to Gild their Pills with; and with the Edge of a Knife, (lightly moyſten'd by drawing it over the ſurface of the Tongue, and afterwards) laid upon the edge of the Gold Leaf, we ſo faſten'd it to the Knife, that being held againſt the Light, it continu'd extended like a little Flag. This Leaf being held very near the Eye, and obverted to the Light, appear'd ſo full of Pores, that it ſeem'd to have ſuch a kind of Tranſparency as that of a Sive, or a piece of Cyprus, or a Love-Hood; but the Light that paſs'd by theſe Pores was in its Paſſages ſo Temper'd with Shadow, and Modify'd, that the Eye diſcern'd

cern'd no more a Golden Colour, but a Greeniſh Blew. And for others ſatiſfaction, we did in the Night look upon a Candle through ſuch a Leaf of Gold; and by trying the Effect of ſeveral Proportions of Diſtance betwixt the Leaf, the Eye and the Light, we quickly hit upon ſuch a Poſition for the Leaf of Gold, as that the flame, look'd on through it, appear'd of a Greeniſh Blew, as we have ſeen in the Day time. The like Experiment try'd with a Leaf of Silver ſucceeded not well.

EXPERIMENT X.

We have ſometimes found in the Shops of our Druggiſts, a certain Wood, which is there call'd *Lignum Nephriticum*, becauſe the Inhabitants of the Country where it grows, are wont to uſe the Infuſion of it made in fair Water againſt the Stone of the Kidneys; and indeed an Eminent Phyſician of our Acquaintance, who has very Particularly enquir'd into that Diſeaſe, aſſures me, that he has found ſuch an Infuſion one of the moſt effectual Remedies, which he has ever tried againſt that formidable Diſeaſe. The ancienteſt Account I have met with of this Simple, is given us by the Experienc'd *Monardes* in theſe Words.

Nobis, says he, *Nova Hispania mittit quoddam ligni genus crassum & enode, cujus usus jam diu receptus fuit in his Regionibus ad Renum vitia & Urinæ difficultates ac arenulas pellendas. Fit autem hac ratione, Lignum assulatim & minutim concisum in limpidissima aqua fontana maceratur, inque ea relinquitur, donec aqua à bibentibus absumpta sit, dimidia hora post injectum lignum aqua cæruleum colorem contrahit, qui sensim intenditur pro temporis diuturnitate, tametsi lignum candidum sit.* This Wood, *Pyrophilus*, may afford us an Experiment, which besides the singularity of it, may give no small assistance to an attentive Considerer towards the detection of the Nature of Colours. The Experiment as we made it is this. Take *Lignum Nephriticum*, and with a Knife cut it into thin Slices, put about a handful of these Slices into two, three, or four pound of the purest Spring-water, let them infuse there a night, but if you be in hast, a much shorter time may suffice; *decant* this Impregnated Water into a clear Glass Vial, and if you hold it directly between the Light and your Eye, you shall see it wholly Tincted (excepting the very top of the Liquor, wherein you will sometimes discern a Sky-colour'd Circle) with an

Nicolaus Monardes lib. *simplic. ex India allator.* cap. 27.

an almoſt Golden Colour, unleſs your Infuſion have been made too Strong of the Wood, for in that caſe it will againſt the Light appear ſomewhat Dark and Reddiſh, and requires to be diluted by the addition of a convenient quantity of fair Water. But if you hold this Vial from the Light, ſo that your Eye be plac'd betwixt the Window and the Vial, the Liquor will appear of a deep and lovely Cœruleous Colour, of which alſo the drops, if any be lying on the out-ſide of the Glaſs, will ſeem to be very perfectly; And thus far we have try'd the Experiment, and found it to ſucced even by the Light of Candles of the larger ſize. If you ſo hold the Vial over againſt your Eyes, that it may have a Window on one ſide of it, and a Dark part of the Room both before it and on the other ſide, you ſhall ſee the Liquor partly of a Blewiſh and partly of a Golden Colour. If turning your back to the Window, you pour out ſome of the Liquor towards the Light and towards your Eyes, it will ſeem at the coming out of the Glaſs to be perfectly Cœruleous, but when it is fallen down a little way, the drops may ſeem Particolour'd, according as the Beams of Light do more or leſs fully Penetrate and Illuſtrate them. If you take a Baſon about

half

half full of Water, and having plac'd it so in the Sun-beams Shining into a Room, that one part of the Water may be freely Illustrated by the Beams of Light, and the other part of it Darkned by the shadow of the Brim of the Bason; if then I say you drop of our Tincture, made somewhat strong, both into the Shaded and Illuminated parts of the Water, you may by looking upon it from several places, and by a little Agitation of the Water, observe divers pleasing Phænomena which were tedious to particularize. If you pour a little of this Tincture upon a sheet of White Paper, so as the Liquor may remain of some depth upon it, you may perceive the Neighbouring drops to be partly of one Colour, and partly of the other, according to the position of your Eye in reference to the Light when it looks upon them, but if you pour off all the Liquor, the Paper will seem Dy'd of an almost Yellow Colour. And if a sheet of Paper with some of this Liquor in it be plac'd in a window where the Sun-beams may shine freely on it, then if you turn your back to the Sun and take a Pen or some such slender Body, and hold it over-thwart betwixt the Sun and the Liquor, you may perceive that the Shadow projected by the Pen upon the Liquor, will not all of it be a vulgar

and

and Dark, but in part a curiouſly Colour'd ſhadow, that edge of it, which is next the Body that makes it, being almoſt of a lively Golden Colour, and the remoter verge of a Cœruleous one.

Theſe and other Phænomena, which I have obſerv'd in this delightful Experiment, divers of my friends have look'd upon not without ſome wonder, and I remember an excellent Oculiſt finding by accident in a friends Chamber a fine Vial full of this Liquor, which I had given that friend, and having never heard any thing of the Experiment, nor having any Body near him that could tell him what this ſtrange Liquor might be, was a great while apprehenſive, as he preſently after told me, that ſome ſtrange new diſtemper was invading his Eyes. And I confeſs that the unuſualneſs of the Phænomena made me very ſollicitous to find out the Cauſe of this Experiment, and though I am far from pretending to have found it, yet my enquiries have, I ſuppoſe, enabled me to give ſuch hints, as may lead your greater ſagacity to the diſcovery of the Cauſe of this wonder. And firſt finding that this Tincture, if it were too copious in the water, Kept the Colours from being ſo lively, and their Change from being ſo diſcernable, and finding

finding alſo that the Impregnating Virtue of this Wood did by its being frequently Infus'd in New Water by Degrees Decay, I Conjectur'd that the Tincture afforded by the Wood muſt proceed from ſome Subtiler parts of it drawn forth by the Water, which ſwimming to and fro in it did ſo Modifie the Light, as to exhibit ſuch and ſuch Colours; and becauſe theſe Subtile parts were ſo eaſily Soluble even in Cold water, I concluded that they muſt abound with Salts, and perhaps contain much of the Eſſential Salt, as the *Chymiſts* call it, of the Wood. And to try whether theſe Subtile parts were Volatile enough to be Diſtill'd, without the Diſſolution of their Texture, I carefully Diſtill'd ſome of the Tincted Liquor in very low Veſſels, and the gentle heat of a Lamp Furnace; but found all that came over to be as Limpid and Colourleſs as Rock-water, and the Liquor remaining in the Veſſel to be ſo deeply Cœruleous, that it requir'd to be oppos'd to a very ſtrong Light to appear of any other colour. I took likewiſe a Vial with Spirit of Wine, and a little Salt of Harts-horn, and found that there was a certain proportion to be met with betwixt the Liquor and the Salt, which made the Mixture fit to exhibit ſome little Variety

of

of Colours not Obſervable in Ordinary Liquors, as it was variouſly directed in reference to the Light and the Eye; but this Change of Colour was very far ſhort from that which we had admir'd in our Tincture. But however, I ſuſpected that the Tinging Particles did abound with ſuch Salts, whoſe Texture, and the Colour ſpringing from it, would probably be alter'd by piercing Acid Salts, which would in likelihood either make ſome Diſſipation of their Parts, or Aſſociate themſelves to the like Bodies, and either way alter the Colour exhibited by them; whereupon pouring into a ſmall Vial full of Impregnated Water, a very little Spirit of Vinegar, I found that according to my Expectation, the Cœruleous Colour immediately vaniſh'd, but was deceiv'd in the Expectation I had, that the Golden Colour would do ſo too; for, which way ſoever I turned the Vial, either to or from the Light, I found the Liquor to appear always of a Yellowiſh Colour and no other: Upon this I imagin'd that the Acid Salts of the Vinegar having been able to deprive the Liquor of its Cœruleous Colour, a Sulphureous Salt being of a contrary Nature, would be able to Mortifie the Saline Particles of Vinegar, and Deſtroy their Effects;

Effects; And accordingly having plac'd my Self betwixt the Window, and the Vial, and into the same Liquor dropt a few drops of Oyl of Tartar *per Deliquium*, (as *Chymists* call it) I observ'd with pleasure, that immediately upon the Diffusion of this Liquor, the Impregnated Water was restor'd to its former Cœruleous Colour; And this Liquor of *Tartar* being very Ponderous, and falling at first to the Bottom of the Vial, it was easie to observe that for a little while the Lower part of the Liquor appear'd deeply Cœruleous, whilst all the Upper part retain'd its former Yellowness, which it immediately lost as soon as either Agitation or Time had made a competent Diffusion of the Liquor of *Tartar* through the Body of the former Tincture; and this restor'd Liquor did, as it was Look'd upon against or from the Light, exhibit the same *Phænomena* as the Tincted Water did, before either of the Adventitious Liquors was pour'd into it.

Having made, *Pyrophilus*, divers Tryals upon this Nephritick Wood, we found mention made of it by the Industrious Jesuit *Kircherus*, who having receiv'd a Cup Turned of it from the *Mexican* Procurator of his Society, has probably receiv'd also from him the Information he gives us concerning

cerning that *Exotick* Plant; and therefore partly for that Reaſon, and partly becauſe what he Writes concerning it, does not perfectly agree with what we have delivered, we ſhall not ſcruple to acquaint you in his own Words, with as much of what he writes concerning our Wood, as is requiſite to our preſent purpoſe. *Hoc loco* (ſays he) *neutiquam omittendum duximus quoddam ligni candidi Mexicani genus, quod Indigenæ Coalle & Tlapazatli vocant, quod etſi experientia hucuſque non niſi Cæruleo aquam colore tingere docuerit, nos tamen continua experientia invenimus id aquam in omne Colorum genus transformare, quod merito cuipiam Paradoxum videri poſſet; Ligni frutex grandis, ut aiunt, non rarò in molem arboris excreſcit, truncus illius eſt craſſus, enodis, inſtar piri arboris, folia ciceris foliis, aut rutæ haud abſimilia, flores exigui, oblongi, lutei & ſpicatim digeſti; eſt frigida & humida planta, licet parum recedat à medio temperamento. Hujus itaque deſcriptæ arboris lignum in poculum efformatum, aquam eidem infuſam primo in aquam intenſe Cæruleam, colore floris Bugloſſæ, tingit, & quo diutius in eo ſteterit, tanto intenſiorem colorem acquirit. Hanc igitur aquam ſi Vitriæ Sphæræ infuderis, luciq; expoſueris, ne ullum quidem Cærulei coloris*

Kircher. Art. Mag. lucis & umbræ, *lib.* 1. *part.* 3.

loris vestigium apparebit, sed instar aquæ puræ putæ fontanæ limpidam claramque aspicientibus se præbebit. Porro si hanc phialam vitream versus locum magis umbrosum direxeris, totus humor gratissimum virorem referet; si adhuc umbrostoribus locis, subrubrum, & sic pro rerum objectarum conditione, mirum dictu, colorem mutabit; in tenebris verò vel in vase opaco posita, Cæruleum colorem suum resumet.

In this passage we may take notice of the following Particulars. And first, he calls it a White *Mexican* Wood, whereas (not to mention that *Monardes* informs us that it is brought out of *Nova Hispania*) the Wood that we have met with in several places, and employ'd as *Lignum Nephriticum*, was not White, but for the most part of a much Darker Colour, not unlike that of the Sadder Colour'd Wood of Juniper. 'Tis true, that *Monardes* himself also says, that the Wood is White; and it is affirm'd, that the Wood which is of a Sadder Colour is Adulterated by being Imbu'd with the Tincture of a Vegetable, in whose Decoction it is steep'd. But having purposely enquir'd of the Eminentest of our *English* Druggists, he peremptorily deny'd it. And indeed, having consider'd some of the fairest Round pieces of this Wood

Wood that I could meet with in these Parts, I had Opportunity to take notice that in one or two of them it was the External part of the Wood that was White, and the more Inward part that was of the other colour, the contrary of which would probably have appear'd, if the Wood had been Adulterated after the afore-mention'd manner. And I have at present by me a piece of such Wood, which for about an Inch next the Bark is White, and then as it were abruptly passes to the above-mention'd colour, and yet this Wood by the Tincture, it afforded us in Water, appears to have its coloured part Genuine enough; for as for the White part, it appears upon trial of both at once, much less enriched with the tingent Property.

Next, whereas our Author tells us, that the Infusion of this Wood expos'd in a Vial to the Light, looks like Spring-water, in which he afterwards adds, that there is no Tincture to be seen in it, our Observation and his agree not, for the Liquor, which opposed to the Darker part of a Room exhibits a Sky-colour, did constantly, when held against the Light, appear Yellowish or Reddish, according as its Tincture was more Dilute or Deep; and

then, whereas it has been already ſaid, that the Cœruleous Colour was by Acid Salts aboliſhed, this Yellowiſh one ſurviv'd without any conſiderable Alteration, ſo that unleſs our Author's Words be taken in a very Limited Senſe, we muſt conclude, that either his Memory miſ-inform'd him, or that his White *Nephritick* Wood, and the Sadder Colour'd one which we employ'd, were not altogether of the ſame Nature: What he mentions of the Cup made of *Lignum Nephriticum*, we have not had Opportunity to try, not having been able to procure pieces of that Wood great enough, and otherwiſe fit to be turned into Cups; but as for what he ſays in the Title of his Experiment, that this Wood tinges the Water with all ſorts of Colours, that is much more than any of thoſe pieces of Nephritick Wood that we have hitherto employ'd, was able to make good; The change of Colours diſcernable in a Vial full of Water, Impregnated by any of them, as it is directed towards a place more Lightſome or Obſcure, being far from affording a Variety anſwerable to ſo promiſing a Title. And as for what he tells us, that in the Dark the Infuſion of our Wood will reſume a Cœruleous Colour, I wiſh he had Inform'd us how he Try'd it.

But

But this brings into my mind, that having sometimes for Curiosity sake, brought a round Vial with a long Neck fill'd with the Tincture of *Lignum Nephriticum* into the Darken'd Room already often mention'd, and holding it sometimes in, sometimes near the Sun-beams that enter'd at the hole, and sometimes partly in them, and partly out of them, the Glass being held in several postures, and look'd upon from several Neighbouring parts of the Room, disclos'd a much greater Variety of Colours than in ordinary inlightn'd Rooms it is wont to do; exhibiting, besides the usual Colours, a Red in some parts, and a Green in others, besides Intermediate Colours produc'd by the differing Degrees, and odd mixtures of Light and Shade.

By all this You may see, *Pyrophilus*, the reasonableness of what we elsewhere had occasion to mention, when we have divers times told you, that it is useful to have New Experiments try'd over again, though they were, at first, made by Knowing and Candid Men, such Reiterations of Experiments commonly exhibiting some New Phænomena, detecting some Mistake or hinting some Truth, in reference to them, that was not formerly taken notice of. And some of our friends have been pleas'd to

think, that we have made no unuſeful addition to this Experiment, by ſhewing a way, how in a moment our Liquor may be depriv'd of its Blewneſs, and reſtor'd to it again by the affuſion of a very few drops of Biquors, which have neither of them any Colour at all of their own. And that which deſerves ſome particular wonder, is, that the Cœruleous Tincture of our Wood is ſubject by the former Method to be deſtroyed or reſtor'd, the Yellowiſh or Reddiſh Tincture continuing what it was. And that you may ſee, that Salts are of a conſiderable uſe in the ſtriking of Colours, let me add to the many Experiments which may be afforded us to this purpoſe by the Dyers Trade, this Obſervation; that as far as we have hitherto try'd, thoſe Liquors in general that are ſtrong of Acid Salts have the power of Deſtroying the Blewneſs of the Infuſion of our Wood, and thoſe Liquors indiſcriminately that abound with Sulphureous Salts (under which I comprehend the Urinous and Volatile Salts of Animal Subſtances, and the Alcalizate or fixed Salts that are made by Incineration) have the virtue of Reſtoring it.

A Corollary of the Tenth Experiment.

That this Experiment, *Pyrophilus*, may be as well Useful as Delightful to You, I must mind You, *Pyrophilus*, that in the newly mention'd Observation, I have hinted to You a New and Easie way of Discovering in many Liquors (for I dare not say in all) whether it be an Acid or Sulphureous Salt, that is Predominant; and that such a Discovery is oftentimes of great Difficulty, and may frequently be of great Use, he that is not a Stranger to the various Properties and Effects of Salts, and of how great moment it is to be able to distinguish their Tribes, may readily conceive. But to proceed to the way of trying other Liquors by an Infusion of our Wood, take it briefly thus. Suppose I have a mind to try whether I conjecture aright, when I imagine that Allom, though it be plainly a Mixt Body, does abound rather with Acid than Sulphureous Salt. To satisfie my self herein, I turn my back to the Light, and holding a small Vial full of the Tincture of *Lignum Nephriticum*, which look'd upon in that Position, appears Cœruleous, I drop into it a little of a strong Solution of Allom made in Fair Water, and finding upon the

Affusion and shaking of this New Liquor, that the Blewness formerly conspicuous in our Tincture does presently vanish, I am thereby incited to suppose, that the Salt prædominant in Allom belongs to the Family of Sour Salts; but if on the other side I have a mind to examine whether or no I rightly conceive that Salt of Urine, or of Harts-horn is rather of a Saline Sulphureous (if I may so speak) than of an Acid Nature, I drop a little of the Saline Spirit of either into the Nephritick Tincture, and finding that the Cœruleous Colour is rather thereby Deepned than Destroy'd, I collect that the Salts, which constitute these Spirits, are rather Sulphureous than Acid. And to satisfie my self yet farther in this particular, I take a small Vial of fresh Tincture, and placing both it and my self in reference to the Light as formerly, I drop into the Infusion just as much Distill'd Vinegar, or other Acid Liquor as will serve to Deprive it of its Blewness (which a few drops, if the Sour Liquor be strong, and the Vial small, will suffice to do) then without changing my Posture, I drop and shake into the same Vial a small proportion of Spirit of Harts-horn or Urine, and finding that upon this affusion, the Tincture immediately recovers its Cœruleous Colour, I am thereby confirm'd

firm'd in my former Opinion, of the Sulphureous Nature of these Salts. And so, whereas it is much doubted by some Modern Chymists to what sort of Salt, that which is Prædominant in Quick-lime belongs, we have been perswaded to refer it rather to Lixiviate than Acid Salts, by having observ'd, that though an Evaporated Infusion of it will scarce yield such a Salt, as Ashes and other Alcalizate Bodies are wont to do, yet if we deprive our Nephritick Tincture of its Blewness by just so much Distill'd Vinegar as is requisite to make that colour vanish, the *Lixivium* of Quick-lime will immediately upon its Affusion recall the banished Colour; but not so powerfully as either of the Sulphureous Liquors formerly mention'd. And therefore I allow my self to guess at the *Strength* of the Liquors examin'd by this Experiment, by the *Quantity* of them which is sufficient to Destroy or Restore the Cœruleous Colour of our Tincture. But whether concerning Liquors, wherein neither Acid nor Alcalizate Salts are eminently Prædominant, our Tincture will enable us to conjecture any thing more than that such Salts are not Prædominant in them, I take not upon me to determine here, but leave to further Tryal; For I find not that Spirit of

Wine, Spirit of Tartar freed from Acidity, or Chymical Oyl of Turpentine, (although Liquors which must be conceiv'd very Saline, if Chymists have, which is here no place to Dispute, rightly ascrib'd tasts to the Saline Principle of Bodies,) have any Remarkable power either to deprive our Tincture of its cœruleous colour, or restore it, when upon the Affusion of Spirit of Vinegar it has disappear'd.

EXPERIMENT XI.

And here I must not omit, *Pyrophilus*, to inform You, that we can shew you even in a Mineral Body something that may seem very near of Kin to the changeable Quality of the Tincture of *Lignum Nephriticum*, for we have several flat pieces of Glass, of the thickness of ordinary Panes for Windows, one of which being interposed betwixt the Eye and a clear Light, appears of a Golden Colour, not much unlike that of the moderate Tincture of our Wood, but being so look'd upon as that the Beams of light are not so much Trajected through it as Reflected from it to the Eye, that Yellow seems to degenerate into a pale Blew, somewhat like that of a Turquoise. And that which may also appear strange, is this, that

that if in a certain posture you hold one of these Plates Perpendicular to the Horizon, so that the Sun-beams shine upon half of it, the other half being Shaded, You may see that the part Shin'd upon will be of a much Diluter Yellow than the shaded part, which will appear much more Richly Colour'd; and if you alter the Posture of the Glass, so that it be not held Perpendicular, but Parallel in reference to the Horizon, you may see, (which perhaps you will admire) the Shaded part look of a Golden Colour, but the other that the Sun shines freely on, will appear considerably Blew, and as you remove any part of the Glass thus held Horizontally into the Sun-beams or Shade, it will in the twinkling of an Eye seem to pass from one of the above mention'd Colours to the other, the Sun beams Trajected through it upon a sheet of White-Paper held near it, do colour it with a Yellow, somewhat bordering upon a Red, but yet the Glass may be so oppos'd to the Sun, that it may upon Paper project a mix'd Colour here and there more inclin'd to Yellow, and here and there more to Blew. The other Phænomena of this odd Glass, I fear it would be scarce worth while to Record, and therefore I shall rather advertise you, *First*, that in the trying of these Experiments

ments with it, you must take notice that one of the sides has either alone, or at least principally its Superficial parts disposd to the Reflection of the Blew Colour above nam'd, and that therefore you must have a care to keep that side neareſt to the Eye. And next, that we have our selves made Glasses not unfit to exhibit an Experiment not unlike that I have been speaking of, by laying upon pieces of Glass some very finely foliated Silver, and giving it by degrees a much stronger Fire than is requisite or usual for the Tinging of Glasses of other Colours. And this Experiment, not to mention that it was made without a Furnace in which Artificers that Paint Glass are wont to be very Curious, is the more considerable, because, that though a Skilful Painter could not deny to me that 'twas with Silver he Colour'd his Glasses Yellow; yet he told me, that when to Burn them (as they speak) he lays on the plates of Glass nothing but a *Calx* of Silver Calcin'd without Corrosive Liquors, and Temper'd with Fair Water, the Plates are Ting'd of a fine Yellow that looks of a Golden Colour, which part soever of it you turn to or from the Light; whereas (whether it be what an Artificer would call Over-doing, or Burning, or else the imploying the Silver Crude

Crude that makes the Difference,) we have found more than once, that some Pieces of Glass prepar'd as we have related, though held against the Light they appear'd of a Transparent Yellow, yet look'd on with ones back turn'd to the light they exhibited an Untransparent Blew.

EXPERIMENT XII.

If you will allow me, *Pyrophilus*, for the avoiding of Ambiguity, to imploy the Word Pigments, to signifie such prepared materials (as Cochinele, Vermilion Orpiment,) as Painters, Dyers, and other Artificers make use of to impart or imitate particular Colours, I shall be the better understood in divers passages of the following papers, and particularly when I tell you, That the mixing of Pigments being no inconsiderable part of the Painters Art, it may seem an Incroachment in me to meddle with it. But I think I may easily be excus'd (though I do not altogether pass it by (if I restrain my self to the making of a Transient mention of some few of their Practices about this matter; and that only so far forth, as may warrant me to observe to you, that there are but few Simple and Primary Colours (if I may so call them)

from

from whose Various Compositions all the rest do as it were Result. For though Painters can imitate the Hues (though not always the Splendor) of those almost Numberless differing colours that are to be met with in the Works of Nature, and of Art, I have not yet found, that to exhibit this strange Variety they need imploy any more than *White*, and *Black*, and *Red*, and *Blew*, and *Yellow*; these *five*, Variously *Compounded*, and (if I may so speak) *Decompounded*, being sufficient to exhibit a Variety and Number of Colours, such, as those that are altogether Strangers to the Painters pallets, can hardly imagine.

Thus (for Instance) Black and White differingly mix'd, make a Vast company of Lighter and Darker Grays.

Blew and Yellow make a huge Variety of Greens.

Red and Yellow make Orange Tawny.

Red with a little White makes a Carnation.

Red with an Eye of Blew, makes a Purple; and by these simple Compositions again Compounded among themselves, the Skilful Painter can produce what kind of Colour he pleases, and a great many more than we have yet Names for. But, as I intimated above, 'tis not my Design

sign to prosecute this Subject, though I thought it not unfit to take some Notice of it, because we may hereafter have occasion to make use of what has been now deliver'd, to illustrate the Generation of Intermediate Colours; concerning which we must yet subjoin this Caution, that to make the Rules about the Emergency of Colours, fit to be Relied upon, the Corpuscles whereof the Pigments consist must be such as do not Destroy one anothers Texture, for in case they do, the produced Colour may be very Different from that which would Result from the Mixture of other harmless Pigments of the same Colours, as I shall have Occasion to shew ere long.

EXPERIMENT XIII.

It may also give much light to an Enquirer into the Nature of Colours, to know that not only in Green, but in many (if not all) other Colours, the Light of the Sun passing through Diaphanous Bodies of Differing Hues may be tinged of the same compound colour, as if it came from some Painters colours of the same Denomination, though this later be exhibited by Reflection, and be (as the former

former Experiment declares) manifestly Compounded of material Pigments. Wherefore to try the Composition of Colours by Trajection, we provided several Plates of Tinged Glass, which being laid two at a time one on the top of another, the Object look'd upon through them both, appear'd of a compounded colour, which agrees well with what we have observ'd in the second Experiment, of Looking against the Light through differingly Colour'd Papers. But we thought the Experiment would be more Satisfactory, if we procur'd the Sun-beams to be so Ting'd in their passage through Plates of Glass, as to exhibit the Compounded Colour upon a Sheet of White Paper. And though by reason of the Thickness of the Glasses, the Effect was but Faint, even when the Sun was High and Shin'd forth clear, yet, we easily remedied that by Contracting the Beams we cast on them by means of a Convex Burning-glass, which where it made the Beams much converge increas'd the Light enough to make the Compounded colour very manifest upon the Paper. By this means we observ'd, that the Beams trajected through Blew and Yellow compos'd a Green, that an intense and moderate Red did with Yellow make differing

degrees

degrees of Saffron, and Orange Tawny colours, that Green and Blew made a colour partaking of both, such as that which some Latin VVriters call *Pavonaceus*, that Red and Blew made a Purple, to which we might add other Colours, that we produc'd by the Combinations of Glasses differingly Ting'd, but that I want proper words to express them in our Language, and had not when we made the Tryals, the Opportunity of consulting with a Painter, who perchance might have suppli'd me with some of the terms I wanted.

I know not whether it will be requisite to subjoin on this Occasion, what I tried concerning Reflections from coloured Glasses, and other Transparent Bodies, namely, that having expos'd four or five sorts of them to the Sun, and cast the Reflected Beams upon white Paper held near at hand, the Light appear'd not manifestly Ting'd, but as if it had been Reflected from the Impervious parts of a colourless Glass, only that Reflected from the Yellow was here and there stain'd with the same Colour, as if those Beams were not all Reflected from the Superficial, but some from the Internal parts of the Glass; upon which Occasion you may take notice, that a Skilful Tradesman, who makes such Co-

lour'd

lour'd Glass told me, that where as the Red Pigment was but Superficial, the Yellow penetrated to the very midst of the Plate. But for further satisfaction, not having the Opportunity to Foliate those Plates, and so turn them into Looking-glasses, we Foliated a Plate of *Muscovy* Glass, and then laying on it a little Transparent Varnish of a Gold Colour, we expos'd it to the Sun-beams, so as to cast them upon a Body fit to receive them, on which the Reflected Light, appearing, as we expected, Yellow, manifested that Rebounding from the Specular part of the *Selenitis*, it was Ting'd in its return with the Colour of the Transparent Varnish through which it pass'd.

EXPERIMENT XIV.

After what we have said of the Composition of Colours, it will now be seasonable to annex some Experiments that we made in favour of those Colours, that are taught in the Schools not to be Real, but only Apparent and Phantastical; For we found by Tryals, that these Colours might be compounded, both with True and Stable colours, and with one another, as well as unquestionably Genuine and lasting colours, and that the colours resulting

resulting from such Compositions, would respectively deserve the same Denominations.

For first, having by the Trajection of the Sun-beams through a Glass-prism thrown an Iris on the Floor, I found that by placing a Blew Glass at a convenient distance betwixt the Prism and the Iris, that part of the Iris that was before Yellow, might be made to appear Green, though not of a Grass Green, but of one more Dilute and Yellowish. And it seems not improbable, that the narrow Greenish List (if I may so call it) that is wont to be seen between the Yellow and Blew parts of the Iris, is made by the Confusion of those two Bordering Colours.

Next, I found, that though the want of a sufficient liveliness in either of the Compounding Colours, or a light Error in the manner of making the following Tryals, was enough to render some of them Unsuccessful, yet when all necessary Circumstances were duly observ'd, the Event was answerable to our Expectation and Desire.

And (as I formerly Noted) that Red and Blew compound a Purple, so I could produce this last nam'd Colour, by casting at some distance from the Glass the Blew

part of the Prismatical Iris (as I think it may be call'd for distinction sake) upon a lively Red, (for else the Experiment succeeds not so well.) And I remember, that sometimes when I try'd this upon a piece of Red Cloath, *that* part of the Iris which would have been Blew, (as I try'd by covering that part of the Cloath with a piece of White Paper) and compounded with the Red, wherewith the Cloath was Imbued before, appear'd of a fair Purple, did, when I came to view it neer at hand, look very odly, as if there were some strange Reflection or Refraction or both made in the Hairs of which that Cloath was composed.

Casting likewise the Prismatical Iris upon a very Vivid Blew, I found that part of it, which would else have been the Yellow, appear Green. (Another somewhat differing Tryal, and yet fit to confirm this, you will find in the fifteenth Experiment.)

But it may seem somewhat more strange, that though the Prismatical Iris being made by the Refraction of Light through a Body that has no colour at all, must according to the Doctrine of the Schools consist of as purely Emphatical Colours, as may be, yet even these may be compounded with one another, as well as Real Colours in the

the Groſſeſt Pigments. For I took at once two Triangular Glaſſes, and one of them being kept fixt in the ſame Poſture, that the Iris it projected on the Floor might not Waver, I caſt on the ſame Floor another Iris with the other Priſm, and Moving it to and fro to bring what part of the ſecond Iris I pleas'd, to fall upon what part of the firſt I thought fit, we did ſometimes (for a ſmall Errour ſuffices to hinder the Succeſs) obtain by this means a Green Colour in that part of the more Stable Iris, that before was Yellow, or Blew, and frequently by caſting thoſe Beams, that in one of the Iris's made the Blew upon the Red parts of the other Iris, we were able to produce a lovely Purple, which we can Deſtroy or Recompoſe at pleaſure, by Severing and Re-approaching the Edges of the two Iris's.

EXPERIMENT XV.

On this occaſion, *Pyrophilus*, I ſhall add, that finding the Glaſs-priſm to be the uſefulleſt Inſtrument men have yet imploy'd about the Contemplation of Colours, and conſidering that Priſms hitherto in uſe are made of Glaſs Tranſparent and Colourleſs, I thought it would not be amiſs to try,

what change the Superinduction of a Colour, without the Deſtruction of the Diaphaneity, would produce in the Colours exhibited by the Priſm. But being unable to procure one to be made of Colour'd Glaſs, and fearing alſo that if it were not carefully made, the Thickneſs of it would render it too Opacous, I endeavoured to ſubſtitute one made of Clarify'd Roſin, or of Turpentine brought (as I elſewhere teach) to the conſiſtence of a Tranſparent Gum. But though theſe Endeavours were not wholly loſt, yet we found it ſo difficult to give theſe Materials their true Shape, that we choſe rather to Varniſh over an ordinary Priſm with ſome of thoſe few Pigments that are to be had Tranſparent; as accordingly we did firſt with Yellow, and then with Red, or rather Crimſon, made with Lake temper'd with a convenient Oyl, and the Event was, That for want of good Tranſparent Colours (of which you know there are but very few) both the Yellow and the Red made the Glaſs ſo Opacous, (though the Pigment were laid on but upon two Sides of the Glaſs, no more being abſolutely neceſſary) that unleſs I look'd upon an Inlightned Window, or the Flame of a Candle, or ſome other Luminous or very Vivid object,

I could ſcarce diſcern any Colours at all, eſpecially when the Glaſs was cover'd with Red. But when I did look on ſuch Objects, it appear'd (as I expected) that the Colour of the Pigment had Vitiated or Drown'd ſome of thoſe which the Priſm would according to its wont have exhibited, and mingling with others, Alter'd them: as I remember, that both to my Eyes, and others to whom I ſhew'd it, when the Priſm was cover'd with Yellow, it made thoſe Parts of bright Objects, where the Blew would elſe have been Conſpicuous, appear of a light Green. But, *Pyrophilus*, both the Nature of the Colours, and the Degree of Tranſparency, or of Darkneſs in the Pigment, beſides divers other Circumſtances, did ſo vary the *Phænomena* of theſe Tryals, that till I can procure ſmall Colour'd Priſms, or Hollow ones that may be filled with Tincted Liquor, or obtain ſome better Pigments than thoſe I was reduc'd to imploy, I ſhall forbear to build any thing upon what has been deliver'd, and ſhall make no other uſe of it, than to invite you to proſecute the Inquiry further.

EXPERIMENT XVI.

And here, *Pyrophilus*, since we are treating of Emphatical Colours, we shall add what we think not unworthy your Observation, and not unfit to afford some Exercise to the Speculative. For there are some Liquors, which though Colourless themselves, when they come to be Elevated, and Dispersed into Exhalations, exhibit a conspicuous Colour, which they lose again, when they come to be Reconjoyn'd into a Liquor, as good Spirit of *Nitre*, or upon its account strong *Aqua-Fortis*, though devoyd of all appearance of Redness whilst they continue in the form of a Liquor, if a little Heat chance to turn the Minute parts of them into Vapours, the Steam will appear of a Reddish or deep Yellow Colour, which will Vanish when those Exhalations come to resume the form of a Liquor.

And not only if you look upon a Glass half full of *Aqua-fortis*, or Spirit of *Nitre*, and half full of *Nitrous* steams proceeding from it, you will see the Upper part of the Glass of the Colour freshly mention'd, if through it you look upon the Light. But which is much more considerable, I have

have tried, that putting *Aqua-fortis* in a long clear Glass, and adding a little Copper or some such open Metal to it, to excite Heat and Fumes, the Light trajected through those Fumes, and cast upon a sheet of White Paper, did upon that appear of the colour that the Fumes did, when directly Look'd upon, as if the Light were as well Ting'd in its passage through these Fumes, as it would have been by passing through some Glass or Liquor in which the same Colour was Inherent.

To which I shall further add, that having sometimes had the Curiosity to observe whether the Beams of the Sun near the Horizon trajected through a very Red Sky, would not (though such Redness are taken to be but Emphatical Colours) exhibit the like colour, I found that the Beams falling within a Room upon a very White Object, plac'd directly opposite to the Sun, disclos'd a manifest Redness, as if they had pass'd through a colour'd *Medium*.

EXPERIMENT XVII.

The emergency, *Pyrophilus*, of Colours upon the Coalition of the Particles of such Bodies as were neither of them of the Colour of that Mixture whereof they are the

Ingredients, is very well worth our attentive Obſervation, as being of good uſe both Speculative and Practical; For much of the Mechanical uſe of Colours among Painters and Dyers, doth depend upon the Knowledge of what colours may be produc'd by the mixtures of Pigments ſo and ſo colour'd. And (as we lately intimated) 'tis of advantage to the contemplative Naturaliſt, to know how many and which Colours are Primitive (if I may ſo call them) and Simple, becauſe it both eaſes his Labour by confining his moſt ſollicitous Enquiry to a ſmall Number of Colours upon which the reſt depend, and aſſiſts him to judge of the nature of particular compounded Colours, by ſhewing him from the Mixture of what more Simple ones, and of what Proportions of them to one another, the particular Colour to be conſidered does reſult. But becauſe to inſiſt on the Proportions, the Manner and the Effects of ſuch Mixtures would oblige me to conſider a greater part of the Painters Art and Dyers Trade, than I am well acquainted with, I confin'd my ſelf to make Trial of *ſeveral ways to produce Green*, by the compoſition of Blew and Yellow. And ſhall in this place both Recapitulate moſt of the things I have Diſperſedly deliver'd

ver'd already concerning that Subject, and Recruit them.

And first, whereas Painters (as I noted above) are wont to make Green by tempering Blew and Yellow, both of them made into a soft consistence, with either Water or Oyl, or some Liquor of Kin to one of those two, according as the Picture is to be Drawn with those they call *Water-Colours*, or those they term *Oyl-Colours*, I found that by chusing fit Ingredients, and mixing them in the form of Dry Powders, I could do, what I could not if the Ingredients were tempered up with a Liquor; But the Blew and Yellow Powders must not only be finely Ground, but such as that the Corpuscles of the one may not be too unequal to those of the other, lest by their Disproportionate Minuteness the Smaller cover and hide the Greater. We us'd with good success a slight Mixture of the fine Powder of Bise, with that of Orpiment, or that of good Yellow Oker, I say a *slight* Mixture, because we found that an *exquisite* Mixture did not do so well, but by lightly mingling the two Pigments in several little Parcels, those of them in which the Proportion and Manner of Mixture was more Lucky, afforded us a good Green.

2. We

2. We also learn'd in the Dye-houses, that Cloth being Dy'd Blew with Woad, is afterwards by the Yellow Decoction of Woud-wax or Wood-wax Dy'd into a Green Colour.

3. You may also remember what we above Related, where we intimated, that having in a darkn'd Room taken two Bodies, a Blew and a Yellow, and cast the light Reflected from the one upon the other, we likewise obtain'd a Green.

4. And you may remember, that we observ'd a Green to be produc'd, when in the same darkn'd Room we look'd at the Hole at which alone the Light enter'd, through the Green and Yellow parts of a sheet of Marbl'd Paper laid over one another.

5. We found too, that the Beams of the Sun being trajected through two pieces of Glass, the one Blew and the other Yellow, laid over one another, did upon a sheet of White paper on which they were made to fall, exhibit a lovely Green.

6. I hope also, that you have not already forgot, what was so lately deliver'd, concerning the composition of a Green, with a Blew and Yellow; of which most Authors would call the one a *Real*, and the other an *Emphatical*.

7. And

7. And I presume, you may have yet fresh in your memory, what the fourteenth Experiment informs you, concerning the exhibiting of a Green, by the help of a Blew and Yellow, that were both of them Emphatical.

8. Wherefore we will proceed to take notice, that we also devis'd a way of trying whether or no Metalline Solutions though one of them at least had its Colour Adventitious, by the mixture of the *Menstruum* employ'd to dissolve it, might not be made to compound a Green after the manner of other Bodies. And though this seem'd not easie to be perform'd by reason of the Difficulty of finding Metalline Solutions of the Colour requisite, that would mix without Præcipitating each other; yet after a while having consider'd the matter, the first Tryal afforded me the following Experiment. I took a High Yellow Solution of good Gold in *Aqua Regis* (made of *Aqua-fortis*, and as I remember half its weight of Spirit of Salt) To this I put a due Proportion of a deep and lovely Blew Solution of Crude Copper, (which I have elsewhere taught to be readily Dissoluble in strong Spirit of Urine) and these two Liquors though at first they seem'd a little to Curdle one another, yet being throughly mingl'd by Sha-

king,

king, they presently, as had been Conjectur'd, united into a Transparent Green Liquor, which continu'd so for divers days that I kept it in a small Glass wherein 'twas made, only letting fall a little Blackish Powder to the Bottom. The other *Phænomena* of this Experiment belong not to this place, where it may suffice to take notice of the Production of a Green, and that the Experiment was more than once repeated with Success.

9. And lastly, to try whether this way of compounding Colours would hold ev'n in Ingredients actually melted by the Violence of the Fire, provided their Texture were capable of safely induring Fusion, we caused some Blew and Yellow Ammel to be long and well wrought together in the flame of a Lamp, which being Strongly and Incessantly blown on them kept them in some degree of Fusion, and at length (for the Experiment requires some Patience as well as Skill) we obtain'd the expected Ammel of a Green Colour.

I know not, *Pyrophilus*, whether it be worth while to acquaint you with the ways that came into my Thoughts, whereby in some measure to explicate the first of the mention'd ways of making a Green; for I have sometimes Conjectur'd, that the mixture

ture of the Biſe and the Orpiment produc'd a Green by ſo altering the Superficial Aſperity, which each of thoſe Ingredients had apart, that the Light incident on the mixture was Reflected with differing Shades, as to Quantity, or Order, or both, from thoſe of either of the Ingredients, and ſuch as the Light is wont to be Modify'd with, when it Reflects from Graſs, or Leaves, or ſome of thoſe other Bodies that we are wont to call Green. And ſometimes too I have doubted, whether the produced Green might not be partly at leaſt deriv'd from this, That the Beams that Rebound from the Corpuſcles of the Orpiment, giving one kind of Stroak upon the *Retina*, whoſe Perception we call Yellow, and the Beams Reflected from the Corpuſcles of the Biſe giving another ſtroak upon the ſame *Retina*, like to Objects that are Blew, the Contiguity and Minuteneſs of theſe Corpuſcles may make the Appulſe of the Reflected Light fall upon the *Retina* within ſo narrow a Compaſs that the part they beat upon being as it were a Phyſical point, they may give a Compounded ſtroak, which may conſequently exhibit a Compounded and new Kind of Senſation, as we ſee that two Strings of a Muſical Inſtrument being ſtruck together, making two

Noiſes

Noiſes that arrive at the Ear at the ſame time as to Senſe, yield a Sound differing from either of them, and as it were Compounded of both; Inſomuch that if they be diſcordantly tun'd, though each of them ſtruck apart would yield a Pleaſing Sound, yet being ſtruck together they make but a harſh and troubleſom Noiſe. But this not being ſo fit a place to proſecute Speculations, I ſhall not inſiſt, neither upon theſe Conjectures nor any others, which the Experiment we have been mentioning may have ſuggeſted to me. And I ſhall leave it to you, *Pyrophilus*, to derive what Inſtruction you can from comparing together the Various ways whereby a Yellow and a Blew can be made to compound a Green. That which I now pretend to, being only to ſhew that the firſt of thoſe mention'd ways, (not to take at preſent notice of the reſt) does far better agree with our Conjectures about Colours, than either with the Doctrine of the Schools, or with that of the *Chymiſts*, both which ſeem to be very much Disfavour'd by it.

For firſt, ſince in the Mixture of the two mention'd Powders I could by the help of a very excellent *Microſcope* (for ordinary ones will ſcarce ſerve the turn) diſcover that which ſeem'd to the naked Eye a Green

Body,

Body, to be but a heap of Distinct, though very small Grains of Yellow Orpiment and Blew Bise confusedly enough blended together, it appears that the coloured Corpuscles of either kind did each retain its own Nature and Colour; by which it may be guess'd, what meer Transposition and Juxtaposition of Minute and Singly unchang'd Particles of Matter can do to produce a new Colour; for that this Local Motion and new Disposition of the small parts of the Orpiment did Intervene is much more manifest than it is easie to Explicate how they should produce this new Green otherwise than by the new Manner of their being put together, and consequently by their new Disposition to Modifie the Incident Light by Reflecting it otherwise than they did before they were Mingl'd together.

Secondly, The Green thus made, being (if I may so speak) Mechanically produc'd, there is no pretence to derive it from I know not what incomprehensible Substantial Form, from which yet many would have us believe that Colours must flow; Nor does this Green, though a Real and Permanent, not a Phantastical and Vanid Colour, seem to be such an Inherent Quality as they would have it, since not only each part of the

the Mixture remains unalter'd in Colour, and consequently of a differing colour from the Heap they compose, but if the Eye be assisted by a *Microscope* to discern things better and more distinctly than before it could, it sees not a Green Body, but a Heap of Blew and Yellow Corpuscles.

And in the third place, I demand what either Sulphur, or Salt, or Mercury has to do in the Production of this Green; For neither the Bise nor the Orpiment were indu'd with that Colour before, and the bare Juxtaposition of the Corpuscles of the two Powders that work not upon each other, but might, if we had convenient Instruments, be separated, unalter'd, cannot with any probability be imagin'd either to Increase or Diminish any of the three Hypostatical Principles, (to which of them soever the *Chymists* are pleas'd to ascribe Colours) nor does there here Intervene so much as Heat to afford them any colour to pretend, that at least there is made an Extraversion (as the *Helmontians* speak) of the Sulphur or of any of the two other supposed Principles; But upon this Experiment we have already Reflected enough, if not more than enough for once.

EXPE-

EXPERIMENT XVIII.

But here, *Pyrophilus*, I must advertise you, that 'tis not every Yellow and every Blew that being mingl'd will afford a Green; For in case one of the Ingredients do not act only as endow'd with such a Colour, but as having a power to alter the Texture of the Corpuscles of the other, so as to Indispose them to Reflect the Light, as Corpuscles that exhibit a Blew or a Yellow are wont to Reflect it, the emergent Colour may be not Green, but such as the change of Texture in the Corpuscles of one or both of the Ingredients qualifies them to shew forth; as for instance, if you let fall a few Drops of Syrrup of Violets upon a piece of White Paper, though the Syrrup being spread will appear Blew, yet mingling with it two or three Drops of the lately mention'd Solution of Gold, I obtain'd not a Green but a Reddish mixture, which I expected from the remaining Power of the Acid Salts abounding in the Solution, such Salts or Saline Spirits being wont, as we shall see anon, though weakn'd, so to work upon that Syrrup as to change it into a Red or Reddish Colour. And to confirm that for which I alledge the former

Experiment, I shall add this other, that having made a very strong and high-colour'd Solution of Filings of Coper with Spirit of Urine, though the *Menstruum* seem'd Glutted with the Metal, because I put in so much Filings that many of them remain'd for divers days Undissolv'd at the Bottom, yet having put three or four drops of Syrrup of Violets upon White Paper, I found that the deep Blew Solution proportionably mingl'd with this other Blew Liquor did not make a Blew mixture, but, as I expected, a fair Green, upon the account of the Urinous Salt that was in the *Menstruum*.

EXPERIMENT XIX.

To shew the *Chymists*, that Colours may be made to appear or Vanish, where there intervenes no Accession or Change either of the Sulphureous, or the Saline, or the Mercurial principle (as they speak) of Bodies: I shall not make use of the Iris afforded by the Glass-prism, nor of the Colours to be seen in a fair Morning in those drops of Dew that do in a convenient manner Reflect and Refract the Beams of Light to the Eye; But I will rather mind them of what they may observe in their own

own Laboratories, namely, that divers, if not all, Chymical Essential Oyls, as also good Spirit of Wine, being shaken till they have good store of Bubbles, those Bubbles will (if attentively consider'd) appear adorn'd with Various and Lovely Colours, which all immediately Vanish, upon the relapsing of the Liquor that affords those Bubbles their Skins, into the rest of the Oyl, or Spirit of Wine, so that a Colourless Liquor may be made in a trice to exhibit variety of Colours, and may lose them in a moment without the Accession or Diminution of any of its Hypostatical principles. And, by the way, 'tis not unworthy our notice, that some Bodies, as well Colourless, as Colour'd, by being brought to a great Thinness of parts, acquire Colours though they had none before, or Colours differing from them they were before endued with: For, not to insist on the Variety of Colours, that Water, made somewhat Glutinous by Sope, acquires when 'tis blown into such Sphærical Bubbles as Boys are wont to make and play with; Turpentine (though it have a Colour deep enough of its own) may (by being blown into after a certain manner) be brought to afford Bubbles adorn'd with variety of Orient Colours, which though

they Vaniſh after ſome while upon the Breaking of the Bubbles yet they would in likelihood always exhibit Colours upon their *Superficies*, (though not always the ſame in the ſame Parts of them, but Vary'd according to the Incidence of the Sight, and the Poſition of the Eye) if their Texture were durable enough: For I have ſeen one that was Skill'd at faſhioning Glaſſes by the help of a Lamp, blowing ſome of them ſo ſtrongly as to burſt them, whereupon it was found, that the Tenacity of the Metal was ſuch, that before it broke it ſuffer'd it ſelf to be reduc'd into Films ſo extremely thin, that being kept clean they conſtantly ſhew'd on their Surfaces but after the manner newly mention'd) the varying Colours of the Rain-bow, which were exceedingly Vivid, as I had often opportunity to obſerve in ſome, that I caus'd purpoſely to be made, to keep by me.

But leſt it ſhould be objected, that the above-mention'd Inſtances are drawn from Tranſparent Liquors, it may poſſibly appear, not impertinent to add, what I have ſometimes thought upon, and ſeveral times tried, when I was conſidering the Opinions of the *Chymiſts* about Colours, I took then a Feather of a convenient Bigneſs

neſs and Shape, and holding it as a fit diſtance betwixt my Eye and the Sun when he was near the Horizon, me thought there appear'd to me a Variety of little Rainbows, with differing and very vivid Colours, of which none was conſtantly to be ſeen in the Feather; the like *Phænomenon* I have at other times (though not with altogether ſo good ſucceſs) produc'd, by interpoſing at a due diſtance a piece of Black Ribband betwixt the almoſt ſetting Sun and my Eye, not to mention the Trials I have made to the ſame purpoſe, with other Bodies.

EXPERIMENT XX.

Take good Syrrup of Violets, Impregnated with the Tincture of the flowers, drop a little of it upon a White Paper (for by that means the Change of Colour will be more conſpicuous, and the Experiment may be practis'd in ſmaller Quantities) and on this Liquor let fall two or three drops of Spirit either of Salt or Vinegar, or almoſt any other eminently Acid Liquor, and upon the Mixture of theſe you ſhall find the Syrrup immediatly turn'd Red, and the way of Effecting ſuch a Change has not been unknown to divers Perſons

who have produc'd the like, by Spirit of Vitriol, or juice of Limmons, but have Groundlesly ascrib'd the Effect to some Peculiar Quality of those two Liquors, whereas, (as we have already intimated) almost any Acid Salt will turn Syrrup of Violets Red. But to improve the Experiment, let me add what has not (that I know of) been hitherto observ'd, and has, when we first shew'd it them, appear'd something strange, even to those that have been inquisitive into the Nature of Colours; namely, that if instead of Spirit of Salt, or that of Vinegar, you drop upon the Syrrup of Violets a little Oyl of Tartar *per Deliquium*, or the like quantity of Solution of Pot-ashes, and rub them together with your finger, you shall find the Blew Colour of the Syrrup turn'd in a moment into a perfect Green, and the like may be perform'd by divers other Liquors, as we may have occasion elsewhere to Inform you.

Annotation upon the Twentieth Experiment.

The use of what we lately deliver'd concerning the way of turning Syrrup of Violets, Red or Green, may be this; That, though it be a far more common and procurable

curable Liquor than the Infusion of *Lignum Nephriticum*, it may yet be easily substituted in its Room, when we have a mind to examine, whether or no the Salt predominant in a Liquor or other Body, wherein 'tis Loose and Abundant, belong to the Tribe of *Acid* Salts or not. For if such a Body turn the Syrrup of a Red or Reddish Purple Colour, it does for the most part argue the body (especially if it be a distill'd Liquor) to abound with Acid Salt. But if the Syrrup be made Green, that argues the Predominant Salt to be of a Nature repugnant to that of the Tribe of Acids. For, as I find that either Spirit of Salt, or Oyl of Vitriol, or *Aqua-fortis*, or Spirit of Vinegar, or Juice of Lemmons, or any of the Acid Liquors I have yet had occasion to try, will turn Syrrup of Violets, of a *Red*, (or at least) of a *Reddish* Colour, so I have found, that not only the Volatile Salts of all Animal Substances I have us'd, as Spirit of Harts-horn, of Urine, of Sal-Armoniack, of Blood, &c. but also all the Alcalizate Salts I have employ'd, as the Solution of Salt of Tartar, of Pot-ashes, of common Wood-ashes, Lime-water, &c. will immediately change the Blew Syrrup, into a perfect Green. And by the same way (to hint that upon

the by) I elsewhere shew you, both the changes that Nature and Time produce, in the more Saline parts of some Bodies, may be discover'd, and also how even such Chymically prepar'd Bodies, as belong not either to the Animal Kingdom, or to the Tribe of *Alcali*'s, may have their new and superinduc'd Nature successfully examin'd. In this place I shall only add, that not alone the changing the Colour of the Syrrup, requires, that the changing Body be more strong of the Acid, or other sort of Salt, that is Predominant in it, than is requisite for the working upon the Tincture of *Lignum Nephriticum*; but that in this also, the Operation of the formerly mention'd Salts upon our Syrrup, differs from their Operation upon our Tinctures, that in this Liquor, if the cœruleous colour be *destroyed* by an Acid Salt, it may be *Restored* by one that is either Volatile, or Lixiviate; whereas in Syrrup of Violets, though one of these contrary Salts will *destroy* the Action of the other, yet neither of them will *restore* the Syrrup to its native Blew; but each of them will change it into the Colour which it self doth (if I may so speak) affect, as we shall have occasion to shew in the Notes on the twenty fifth Experiment.

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EXPERIMENT XXI.

There is a Weed, more known to Plowmen than belov'd by them, whose Flowers from their Colour are commonly called *Blew-bottles*, and *Corn-weed* from their Growing among Corn. These Flowers some Ladies do, upon the account of their lovely Colour, think worth the being Candied, which when they are, they will long retain so fair a Colour, as makes them a very fine Sallad in the Winter. But I have try'd, that when they are freshly gathered, they will afford a Juice, which when newly express'd, (for in some cases 'twill soon enough degenerate) affords a very deep and pleasant Blew. Now, (to draw this to our present Scope) by dropping on this fresh Juice, a little Spirit of Salt, (that being the Acid Spirit I had then at hand) it immediately turn'd (as I predicted) into a Red. And if instead of the Sowr Spirit I mingled with it a little strong Solution of an Alcalizate Salt, it did presently disclose a lovely Green; the same changes being by those differing sorts of Saline Liquors, producible in this *Natural juice*, that we lately mention'd to have

Herbarists are wont to call this Plant *Cyanus vulgaris minor.*

have happen'd to that *factitious Mixture*, the Syrrup of Violets. And I remember, that finding this Blew Liquor, when freſhly made, to be capable of ſerving in a Pen for an Ink of that Colour, I attempted by moiſtning one part of a piece of White Paper with the Spirit of Salt I have been mentioning, and another with ſome Alcalizate or Volatile Liquor, to draw a Line on the leiſurely dry'd Paper, that ſhould ev'n before the Ink was dry, appear partly Blew, partly Red, and partly Green: but though the Latter part of the Experiment ſucceeded not well, (whether becauſe Volatile Salts are too Fugitive to be retain'd in the Paper, and Alcalizate ones are too Unctuous, or ſo apt to draw Moiſture from the Air, that they keep the Paper from drying well) yet the former Part ſucceeded well enough; the Blew and Red being conſpicuous enough to afford a ſurprizing Spectacle to thoſe, I acquaint not with (what I willingly allow you to call) the *Trick*.

Annotation upon the one and twentieth Experiment.

But leſt you ſhould be tempted to think (*Pyrophilus*) that Volatile or Alcalizate Salts

Salts change Blews into Green, rather upon the score of the easie Transition of the former Colour into the latter, than upon the account of the Texture, wherein most Vegetables, that afford a Blew, seem, though otherwise differing, to be Allied; I will add, that when I purposely dissolv'd Blew Vitrial in fair Water, and thereby imbu'd sufficiently that Liquor with that Colour, a Lixiviate Liquor, and a Urinous Salt being Copiously pour'd upon distinct Parcels of it, did each of them, though perhaps with some Difference, turn the Liquor not Green, but of a deep Yellowish Colour, almost like that of Yellow Oker, which Colour the Precipitated Corpuscles retain'd, when they had Leisurely subsided in the Bottom. What this Precipitated Substance is, it is not needful now to Enquire in this place; and in another, I have shewn you, that notwithstanding its Colour, and its being Obtainable from an Acid *Menstruum* by the help of Salt of Tartar, it is yet far enough from being the true Sulphur of Vitriol.

EXPERIMENT XXII.

Our next Experiment (*Pyrophilus*) will perhaps seem to be of a contrary Nature to

to the two former, made upon Syrrup of Violets, and Juice of Blew-bottles. For, as in them by the Affusion of Oyl of Tartar, a Blewish Liquor is made Green, so in this by the sole Mixture of the same Oyl, a Greenish Liquor becomes Blew. The hint of this Experiment was given us by the practice of some *Italian* Painters, who being wont to Counterfeit *Ultra-marine Azure* (as they call it) by Grinding Verdigrease with Sal-Armoniack, and some other Saline Ingredients, and letting them Rot (as they imagine) for a good while together in a Dunghill, we suppos'd that the change of Colour wrought in the Verdigrease by this way of Preparation, must proceed from the Action of certain Volatile and Alcalizate Salts, abounding in some of the mingled Concretes, and brought to make a further Dissolution of the Copper abounding in the Verdigrease, and therefore we conjectur'd, that if both the Verdigrease, and such Salts were dissolv'd in fair Water, the small Parts of both being therein more subdivided, and set at liberty, would have better access to each other, and thereby Incorporate much the more suddenly; And accordingly we found, that if upon a strong Solution of good Frence Verdigrease (for 'tis that we

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are wont to imploy, as the beſt) you pour a juſt quantity of Oyl of Tartar, and ſhake them well together, you ſhall immediately ſee a notable Change of Colour, and the Mixture will grow thick, and not tranſparent, but if you ſtay a while, till the Groſſer part be Precipitated to, and ſetled in the Bottom, you may obtain a clear Liquor of a very Lovely Colour, and exceeding delightful to the Eye. But, you muſt have a care to drop in a competent Quantity of Oyl of Tartar, for elſe the Colour will not be ſo Deep and Rich; and if inſtead of this Oyl you imploy a clear *Lixivium* of Pot-aſhes, you may have an Azure ſomewhat Lighter or Paler than, and therefore differing from, the former. And if inſtead of either of theſe Liquors, you make uſe of Spirit of Urine, or of Harts-horn, you may according to the Quantity and Quality of the Spirit you pour in, obtain ſome further Variety (though ſcarce conſiderable) of Cœruleous Liquors. And yet lately by the help of this Urinous Spirit we made a Blew Liquor, which not a few Ingenious Per-Perſons, and among them, ſome, whoſe Profeſſion makes them very Converſant with Colours, have looked upon with ſome wonder. But theſe Azure Colour'd Li-

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quors ſhould be freed from the Subſiding matter, which the Salts of Tartar or Urine precipitate out of them, rather by being Decanted, than by Filtration. For by the latter of theſe ways, we have ſometimes found, the Colour of them very much Impair'd, and little Superiour to that of the groſſer Subſtance, that is left in the Filtre.

EXPERIMENT XXIII.

That Roſes held over the Fume of Sulphur, may quickly by it be depriv'd of their Colour, and have as much of their Leaves, as the Fume works upon; burn'd pale, is an Experiment, that divers others have tryed, as well as I. But (*Pyrophilus*) it may ſeem ſomewhat ſtrange to one that has never conſider'd the Compounded nature of Brimſtone, That, whereas the Fume of Sulphur will, as we have ſaid, Whiten the Leaves of Roſes; That Liquor, which is comonly call'd, Oyl of Sulphur *per Campanam*, becauſe it is ſuppos'd to be made by the Condenſation of theſe Fumes in Glaſſes ſhap'd like Bells, into a Liquor, does powerfully heighten the Tincture of Red Roſes, and make it more Red and Vivid, as we have eaſily tried by putting ſome Red-Roſe Leaves, that

that had been long dried, (and so had lost much of their Colour) into a Vial of fair Water. For a while after the Affusion of a convenient Quantity of the Liquor we are speaking of, both the Leaves themselves, and the Water they were Steep'd in, discover'd a very fresh and lovely Colour.

EXPERIMENT XXVIII.

It may (*Pyrophilus*) somewhat serve to Illustrate, not only the Doctrine of *Pigments*, and of *Colours*, but divers other Parts of the *Corpuscular Phyloſophy*; as that explicates Odours, and many other things, not as the Schools by Aery Qualities, but by Real, though extremely Minute Bodies; to examine, how much of the colourless Liquor, a very small Parcel of a Pigment may Imbue with a *discernable* Colour. And though there be scarce any thing of Preciseness to be expected from such Trials, yet I presum'd, that (at least) I should be able to show a much further Subdivision of the Parts of Matter into *Visible* Particles, than I have hitherto found taken notice of, and than most men would imagine; no Body, that I know of, having yet attempted to reduce this Matter to any measure.

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The Bodies, the most promising for such a purpose, might seem to be the Metals, especially Gold, because of the Multitude, and Minuteness of its parts, which might be argu'd from the incomparable Closeness of its Texture: But though we tried a Solution of Gold made in *Aqua Regia* first, and then in fair Water; yet in regard we were to determine the Pigment we employ'd, not by *Bulk* but *Weight*, and because also, that the Yellow Colour of Gold is but a faint one in Comparison of the deep Colour of *Cochineel*, we rather chose this to make our Trials with. But among divers of these it will suffice to set down one, which was carefully made in Vessels conveniently Shap'd; (and that in the presence of a Witness, and an Assistant) the Sum whereof I find among my *Adversaria*, Registred in the following Words. To which I shall only premise, (to lessen the wonder of so strange a diffusion of the Pigment) That *Cochineel* will be better dissolv'd, and have its Colour far more heightned by Spirit of Urine, than (I say not by common Water, but) by Rectify'd Spirit of Wine it self.

The Note I spoke of is this. [One Grain of *Cochineel* dissolv'd in a pretty Quantity of Spirit of Urine, and then dissolv'd

solv'd further by degrees in fair Water, imparted a discernable, though but a very faint Colour, to about six Glass-fulls of Water, each of them containing about forty three Ounces and an half, which amounts to above a hundred twenty five thousand times its own Weight.]

EXPERIMENT XXV.

It may afford a considerable Hint (*Pyrophilus*) to him, that would improve the Art of Dying, to know what change of Colours may be produc'd by the three several sorts of Salts already often mention'd, (some or other of which may be procur'd in Quantity at reasonable Rates) in the Juices, Decoctions, Infusions, and (in a word) the more soluble parts of Vegetables. And, though the design of this Discourse be the Improvement of Knowledge, not of Trades: yet thus much I shall not scruple to intimate here, That the Blew Liquors, mentioned in the twentieth and one and twentieth Experiments, are far from being the only Vegetable Substances, upon which Acid, Urinous, and Alcalizate Salts have the like Operations to those recited in those two Experiments. For Ripe *Privet Berries* (for instance) being crush'd

upon White Paper, though they ſtain it with a Purpliſh Colour, yet if we let fall on ſome part of it two or three drops of Spirit of Salt, and on the other part a little more of the ſtrong Solution of Pot-aſhes, the former Liquor immediately turn'd that part of the Thick Juice or Pulp, on which it fell, into a lovely Red, and the latter turn'd the other part of it into a delightful Green. Though I will not undertake, that thoſe Colours in that Subſtance ſhall not be much more Orient, than laſting; and though (*Pyrophilus*) this Experiment may ſeem to be almoſt the ſame with thoſe already deliver'd concerning Syrrup of Violets, and the Juice of Blew-bottles, yet I think it not amiſs to take this Occaſion to inform you, that this Experiment reaches much farther, than perhaps you yet imagine, and may be of good Uſe to thoſe, whom it concerns to know, how Dying Stuffs may be wrought upon by Saline Liquors. For, I have found this Experiment to ſucceed in ſo many Various Berries, Flowers, Bloſſoms, and other finer Parts of Vegetables, that neither my Memory, nor my Leiſure ſerves me to enumerate them. And it is ſomewhat ſurprizing to ſee, by how differingly-colour'd Flowers, or Bloſſoms, (for example) the Paper being ſtain'd,

ſtain'd, will by an Acid Spirit be immediately turn'd Red, aud by any *Alcaly* or any Urinous Spirit turn'd Green; inſomuch that ev'n the cruſh'd Bloſſoms of *Meſerion*, (which I gather'd in Winter and froſty Weather) and thoſe of Peaſe, cruſh'd upon White Paper, how remote ſoever their Colours be from Green, would in a moment paſs into a deep Degree of that Colour, upon the Touch of an Alcalizate Liquor. To which let us add, That either of thoſe new Pigments (if I may ſo call them) may by the Affuſion of enough of a contrary Liquor, be preſently chang'd from Red into Green, and from Green into Red, which Obſervation will hold alſo in Syrrup of Violets, Juices of Blew-bottles, &c.

Annotation.

After what I have formerly deliver'd to evince, That there are many Inſtances wherein new Colours are produc'd or acquir'd by Bodies, which *Chymiſts* are wont to think deſtitute of Salt, or to whoſe change of Colours no new Acceſſion of Saline Particles does appear to contribute, I think we may ſafely enough acknowledge,

that we have taken notice of so many Changes made by the Intervention of Salts in the Colours of Mix'd Bodies, that it has lessen'd our Wonder, That though *many Chymists* are wont to ascribe the Colours of such Bodies to their Sulphureous, and *the rest* to their Mercurial Principle; yet *Paracelsus* himself directs us in the Indagation of Colours, to have an Eye principally upon Salts, as we find in that passage of his, wherein he takes upon him to Oblige his Readers much by Instructing them, of what things they are to expect the Knowledge from each of the three distinct Principles of Bodies. *Alias* (says he) *Colorum similis ratio est: De quibus brevem institutionem hanc attendite, quod scilicet colores omnes ex Sale prodeant. Sal enim dat colorem, dat Balsamum.* And a little beneath. *Jam natura Ipsa colores protrahit ex sale, cuique speciei dans illum, qui ipsi competit*, &c. After which he concludes; *Itaque qui rerum omnium corpora cognoscere vult, huic opus est, ut ante omnia cognoscat Sulphur, Ab hoc, qui desiderat novisse Colores is scientiam istorum petat à Sale, Qui scire vult Virtutes, is scrutetur arcana Mercurii. Sic nimirum fundamentum hauserit Mysteriorum, in quolibet crescenti indagandorum,*

Paracelsus de Mineral tract. 1. pag. m. 242.

prout

prout natura cuilibet speciei ea ingesſit. But though *Paracelſus* aſcribes to each of his belov'd Hypoſtatical Principles, much more than I fear will be found to belong to it; yet if we pleaſe to conſider Colours, not as *Philoſophers*, but as *Dyers*, the concurrence of Salts to the ſtriking and change of Colours, and their Efficacy, will, I ſuppoſe, appear ſo conſiderable, that we ſhall not need to quarrel much with *Paracelſus*, for aſcribing in this place (for I dare not affirm that he uſes to be ſtill of one Mind) the Colours of Bodies to their Salts, if by Salts he here underſtood, not only Elementary Salts, but ſuch alſo as are commonly taken for Salts, as Allom, Cryſtals of Tartar, Vitriol, &c. becauſe the Saline principle does chiefly abound in them, though indeed they be, as we elſewhere declare, mix'd Bodies, and have moſt of them, beſides what is Saline, both Sulphureous, Aqueous, and Groſs or Earthy parts.

But though (*Pyrophilus*) I have obſerv'd a Red and Green to be produc'd, the former, by Acid Salts, the later by Salts not Acid, in the expreſt Juices of ſo many differing Vegetable Subſtances, that the Obſervation, if purſued, may prove (as I ſaid) of good Uſe: yet to ſhow you how much ev'n theſe Effects depend upon the

particular Texture of Bodies, I must subjoyn some cases wherein I (who am somewhat backwards to admit Observations for Universal) had the Curiosity to discover, that the Experiments would not Uniformly succeed, and of these Exceptions, the chief that I now remember, are reducible to the following three.

EXPERIMENT XXVI.

And, (first) I thought fit to try the Operation of Acid Salts upon Vegetable Substances, that are already and by their own Nature Red. And accordingly I made Trial upon Syrrup of Clove-july-flowers, the clear expres'd Juice of the succulent Berries of *Spina Cervina*, or Buck-thorn (which I had long kept by me for the sake of its deep colour) upon Red Roses, Infusion of Brazil, and divers other Vegetable Substances, on some of which crush'd (as is often mention'd) upon White Paper (which is also to be understood in most of these Experiments, if no Circumstance of them argue otherwise) Spirit of Salt either made no considerable Change, or alter'd the Colour but from a Darker to a Lighter Red. How it will succeed in many other Vegetable Juices,

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and Infusions of the same Colour, I have at present so few at hand, that I must leave you to find it out your self. But as for the Operation of the other sorts of Salts upon these Red Substances, I found it not very Uniform, some Red, or Reddish Infusions, as of Roses, being turn'd thereby into a dirty Colour, but yet inclining to Green. Nor was the Syrrup of Clove-july-flowers turn'd by the Solution of Pot-ashes to a much better, though somewhat a Greener, Colour. Another sort of Red Infusions was by an *Alcaly* not turn'd into a Green, but advanc'd into a Crimson, as I shall have occasion to note e're long. But there were other sorts, as particularly the lovely colour'd juice of Buckthorn Berries, that readily pass'd into a lovely Green.

EXPERIMENT XXVII.

Among other Vegetables, which we thought likely to afford Exceptions to the General Observation about the differing Changes of Colours produc'd by Acid and Sulphureous Salts, we thought fit to make Trial upon the Flowers of *Jasmin*, they being both White as to Colour, and esteem'd to be of a more Oyly nature than other Flowers. Whereupon having taken

the White parts only of the Flowers, and rubb'd them somewhat hard with my Finger upon a piece of clean Paper, it appear'd very little Discolour'd. Nor had Spirit of Salt, wherewith I moistned one part of it, any considerable Operation upon it. But Spirit of Urine, and somewhat more effectually a strong Alcalizate Solution, did immediately turn the almost Colourless Paper moisten'd by the Juice of the *Jasmin*, not as those Liquors are wont to do, when put upon the Juices of other Flowers, of a good Green, but of a Deep, though somewhat Greenish Yellow, which Experiment I did afterwards at several times repeat with the like success. But it seems not that a great degree of Unctuousness is necessary to the Production of the like effects, for when we try'd the Experiment with the Leaves of those purely White Flowers that appear about the end of Winter, and are commonly call'd *Snow-drops*, the event, was not much unlike that, which, we have been newly mentioning.

EXPERIMENT XXVIII.

Another sort of Instances to show, how much changes of Colours effected by Salts, depend upon the particular Texture of the Coloured

Colour'd Bodies, has been afforded me by several *Yellow* Flowers, and other Vegetables, as Mary-gold Leaves, early Primroses, fresh Madder, &c. For being rubb'd upon White Paper, till they imbued it with their Colour, I found not, that by the addition of Alcalizate Liquors, nor yet by that of an Urinous Spirit, they would be turn'd either Green or Red: nor did so Acid a Spirit as that of Salt, considerably alter their colour, save that it seem'd a little to Dilute it. Only in some early Primroses it destroyed the greatest part of the Colour, and made the Paper almost White agen. And Madder also afforded some thing peculiar, and very differing from what we have newly mention'd: For having gather'd some Roots of it, and, (whilst they were recent) express'd upon White Paper the Yellow Juice, an Alcalizate Solution dropt upon it did not turn it either Green or White, but Red. And the bruis'd Madder it self being drench'd with the like Alcalizate Solution, exchang'd also its Yellowishness for a Redness.

An admonition touching the four preceding Experiments.

Having thus (*Pyrophilus*) given you divers Instances, to countenance the general observation deliver'd in the twenty fifth Experiment, and divers Exceptions whereby it ought to be Limited; I must leave the further enquiry into these Matters to your own Industry. For not remembring at present many of those other Trials, long since made to satisfie my self about Particulars, and not having now the Opportunity to repeat them, I must content my self to have given you the Hint, and the ways of prosecuting the search your self; and only declare to you in general, that, As I have made many Trials, unmention'd in this Treatise, whose Events were agreeable to those mention'd in the twenty fifth Experiment, so (to name now no other Instances) what I have try'd with Acid and Sulphureous Salts upon the Pulp of Juniper Berries, rubb'd upon White Paper, inclines me to think, That among that vast Multitude, and strange Variety of Plants that adorn the face of the Earth, perhaps many other Vegetables may be found, on which such *Menstruums* may not have

have such Operations, as upon the juice of Violets, Pease-blossoms, &c. no nor upon any of those three other sorts of Vegetables, that I have taken notice of in the three fore-going Experiments. It sufficiently appearing even by these, that the effects of a Salt upon the Juices of particular Vegetables do very much depend upon their particular Textures.

EXPERIMENT XXIX.

It may be of some Use towards the discovery of the nature of these Changes, which the Alimental Juice receives in some Vegetables, according to the differing degrees of their Maturity, and according to the differing kinds of Plants of the same Denomination, to observe what Operation Acid, Urinous, and Alcalizate Salts will have upon the Juices of the several sorts of the Vegetable Substances I have been mentioning.

To declare my meaning by an Example, I took from the same Cluster, one Blackberry full Ripe, and another that had not yet gone beyond a Redness, and rubbing a piece of White Paper, with the former, I observ'd that the Juice adhering to it was of a dark Reddish Colour, full of little Black

Black Specks, and that this Juice by a drop of a ſtrong *Lixivium*, was immediately turn'd into a Greeniſh Colour deep enough, by as much Urinous Spirit into a Colour much of Kin to the former, though ſomewhat differing, and fainter; and by a drop of Spirit of Salt into a fine and lightſome Red: whereas the Red Berry being in like manner rubb'd upon Paper, left on it a Red Colour, which was very little alter'd by the Acid Spirit newly nam'd, and by the Urinous and Lixiviate Salts receiv'd changes of Colour differing from thoſe that had been juſt before produc'd in the dark Juice of the Ripe Blackberry.

I remember alſo, that though the Infuſion of Damask-Roſes would as well, though not ſo much, as that of Red, be heightned by Acid Spirits to an intenſe degree of Redneſs, and by Lixiviate Salts be brought to a Darkiſh Green; yet having for Trials ſake taken a Roſe, whoſe Leaves, which were large and numerous, like thoſe of a Province Roſe, were perfectly Yellow, though in a Solution of Salt of Tartar, they afforded a Green Blewiſh Tincture, yet I did not by an Acid Liquor obtain a Red one; all that the Saline Spirit I employ'd, perform'd, being (if I much miſ-remem-

ber not) to Dilute somewhat the Yellowness of the Leaves. I would also have tried the Tincture of Yellow Violets, but could procure none. And if I were in those Islands of *Banda*, which are made Famous as well as Rich, by being the almost only places, where Cloves will prosper, I should think it worth my Curiosity to try, what Operation the three differing Kinds of Salts, I have so often mention'd, would have upon the Juice of this Spice, (express'd at the several Seasons of it) as it grows upon the Tree. Since good Authors inform us, (of what is remarkable) that these whether Fruits, or Rudiments of Fruits, are at first *White*, afterward *Green*, and then *Reddish*, before they be beaten off the Tree, after which being Dry'd before they are put up, they grow *Blackish* as we see them. And one of the receneteſt *Herbarists* inform us, that the Flower grows upon the top of the Clove it self, consisting of four small Leaves, like a Cherry Blossom, but of an excellent *Blew*. But (*Pyrophilus*) to return to our own Observations, I shall add, that I the rather chuse to mention to you an Example drawn from Roses, because that though I am apt to think, as I elsewhere advertise, that something may be gues's'd at about some

ſome of the Qualities of the Juices of Vegetables, by the Reſemblance or Diſparity that we meet with in the Changes made of their Colours, by the operation of the ſame kinds of Salts; yet that thoſe Conjectures ſhould be very warily made, may appear among other things, by the Inſtance I have choſen to give in Roſes. For though, (as I formerly told you) the Dry'd Leaves, both of the Damask, and of Red ones, give a Red Tincture to Water ſharpen'd with Acid Salts, yet the one ſort of Leaves is known to have a purgative faculty, and the other are often, and divers ways, imploy'd for Binding.

See *Parkinſon* Th. Botan. Trib. 9. cap. 26.

And I alſo chuſe (*Pyrophilus*) to ſubjoyn this twenty ninth Experiment to thoſe that precede it, about the change of the Colours of Vegetables by Salts, for theſe two reaſons: The firſt, that you may not eaſily entertain Suſpitions, if in the Trials of an Experiment of ſome of the Kinds formerly mention'd, you ſhould meet with an Event ſomewhat differing from what my Relations may have made you expect. And the ſecond, That you may hereby be invited to diſcern, that it may not be amiſs to take notice of the particular Seaſons wherein you gather the Vegetables which

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in Nicer Experiments you make use of. For, if I were not hindred both by haste and some justifiable Considerations, I could perhaps add considerable Instances, to those lately deliver'd, for the making out of this Observation; but for certain reasons I shall at present substitute a remarkable passage to be met with in that Laborious Herbarist Mr. *Parkinson*, where treating of the Virtues of the (already divers times mention'd) Buckthorn Berries, he subjoyns the following account of several Pigments that are made of them, not only according to the several ways of handling them, but according to the differing Seasons of Maturity, at which they are Gather'd; *Of these Berries*, (says he) *are made three several sorts of Colours as they shall be gathered, that is, being gather'd while they are Green, and kept dry, are call'd Sap-berries, which being steep'd into some Allom-water, or fresh bruis'd into Allom-water, they give a reasonable fair Yellow Colour which Painters use for their Work, and Book-binders to Colour the edges of Books, and Leather-dressers to Colour Leather, as they use also to make a Green Colour, call'd Sap-green, taken from the Berries when they are Black, being bruis'd and put into a Brass or Copper Kettle or Pan, and there suffer'd to abide three or four Days,*

Days, or a little heated upon the Fire, and some beaten Allom put unto them, and afterwards pres's'd forth, the Juice or Liquor is usually put in great Bladders tied with strong thred at the Head and hung up until it be Dry, which is dissolv'd in Water or Wine, but Sack (he affirms) *is the best to preserve the Colour from Starving,* (*as they call it*) *that is, from Decaying, and make it hold fresh the longer. The third Colour* (*whereof none* (says he) *that I can find have made mention but only* Tragus) *is a Purplish Colour, which is made of the Berries suffered to grow upon the Bushes until the middle or end of* November, *that they are ready to drop from the Trees.*

And, I remember (*Pyrophilus*) that I try'd, with a success that pleas'd me well enough, to make such a kind of Pigment, as Painters call Sap-green, by a way not unlike that, deliver'd here by our Author, but I cannot now find any thing relating to that matter among my loose Papers. And my Trials were made so many years ago, that I dare not trust my Memory for Circumstances; but will rather tell you, that in a noted Colour-shop, I brought them by Questions to confess to me, that they made their Sap-green much after the ways by our *Botanist* here mention'd. And on this occasion

casion I shall add an Observation, which though it does not strictly belong to this place, may well enough be mention'd here, namely, that I find by an account given us by the Learned *Clusius*, of *Alaternus*, that ev'n the Grosser parts of the same Plant, are some of them one Colour, and some another; For speaking of that Plant, he tells us, that the *Portugals* use the Bark to Dye their Nets into a Red Colour; and with the Chips of the Wood, which are Whitish, they Dye a Blackish Blew.

EXPERIMENT XXX.

Among the Experiments that tend to shew that the change of Colours in Bodies may proceed from the Vary'd Texture of their Parts, and the consequent change of their Disposition to Reflect or Refract the Light, that sort of Experiments must not be left unmention'd, which is afforded us by Chymical Digestions. For, if *Chymists* will believe several famous Writers about what they call the Philosophers Stone, they must acknowledge that the same Matter, seal'd up Hermetically in a Philosophical Egg, will by the continuance of Digestion, or if they will have it so (for it is not Material in our case which of the two it be)

of Decoction, run through a great Variety of differing Colours, before it come to that of the Nobleſt *Elixir*; whether that be Scarlet, or Purple, or what ever other kind of Red. But without building any thing on ſo Obruſe and Queſtionable an Operation, (which yet may be pertinently repreſented to thoſe that believe the thing) we may obſerve, that divers bodies digeſted in carefully clos'd Veſſels, will in tract of time, change their Colour: As I have elſewhere mention'd my having obſerv'd ev'n in Rectify'd Spirit of Harts-horn, and as is evident in the Precipitations of Amalgams of Gold, and Mercury, without Addition, where by the continuance of a due Heat the Silver-Colour'd Amalgam is reduc'd into a ſhining Red Powder. Further Inſtances of this kind you may find here and there in divers places of my other Eſſays. And indeed it has been a thing, that has much contributed to deceive many *Chymiſts*, that there are more Bodies than one, which by digeſtion will be brought to exhibit that Variety and Succeſſion of Colours, which they imagine to be Peculiar to what they call the *True matter of the Philoſophers*. But concerning this, I ſhall refer you to what you may elſewhere find in the Diſcourſe written touching the paſſive

passive Deceptions of *Chymists*, and more about the Production of Colours by Digestion you will meet with presently. Wherefore I shall now make only this Observation from what has been deliver'd, That in these Operations there appears not any cause to attribute the new Colours emergent to the Action of a new Substantial form, nor to any Increase or Decrement of either the Salt, Sulphur, or Mercury of the Matter that acquires new Colours: For the Vessels are clos'd, and these Principles according to the *Chymists* are Ingenerable and Incorruptible; so that the Effect seems to proceed from hence, that the Heat agitating and shuffling the Corpuscles of the Body expos'd to it, does in process of time so change its Texture, as that the Transposed parts do Modifie the incident Light otherwise, than they did when the Matter appear'd of another Colour.

EXPERIMENT XXXI.

Among the several changes of Colour, which Bodies acquire or disclose by Digestion, it is very remarkable, that *Chymists* find a Redness rather than any other Colour in most of the Tinctures they Draw, and ev'n in the more Gross Solutions they

make of almoſt all Concretes, that abound either with Mineral or Vegetable Sulphur, though the *Menſtruum* imploy'd about theſe Solutions or Tinctures be never ſo Limpid or Colourleſs.

This we have obſerv'd in I know not how many Tinctures drawn with Spirit of Wine from *Jalap*, *Guaicum*, and ſeveral other Vegetables; and not only in the Solutions of *Amber*, *Benzoin*, and divers other Concretes made with the ſame *Menſtruum*, but alſo in divers Mineral Tinctures. And, not to urge that familiar Inſtance of the Ruby of Sulphur, as *Chymiſts* upon the ſcore of its Colour, call the Solution of Flowers of Brimſtone, made with the Spirit of Turpentine, nor to take notice of other more known Examples of the aptneſs of Chymical Oyls, to produce a Red Colour with the Sulphur they extract, or diſſolve; not to inſiſt (I ſay) upon Inſtances of this nature, I ſhall further repreſent to you, as a thing remarkable, that, both Acid and Alcalizate Salts, though in moſt other caſes of ſuch contrary Operations, in reference to Colours, will with many Bodies that abound with Sulphureous, or with Oyly parts, produce a Red; as is manifeſt partly in the more Vulgar Inſtances of the Tinctures, or Solutions of

Sulphur

Sulphur made with *Lixiviums*, either of Calcin'd Tartar or Pot-aſhes, and other Obvious examples, partly by this, that the true Glaſs of Antimony extracted with ſome Acid Spirits, with or without Wine, will yield a Red Tincture, and that I know an Acid Liquor, which in a moment will turn Oyl of Turpentine into a deep Red. But among the many Inſtances I could give you of the eaſie Production of Redneſs by the Operation of Saline Spirit, as well as of Spirit of Wine; I remember two or three of thoſe I have tried, which ſeem remarkable enough to deſerve to be mention'd to you apart.

EXPERIMENT XXXII.

But before we ſet them down, it will not perhaps appear impertinent to premiſe;

That there ſeems to be a manifeſt Diſparity betwixt Red Liquors, ſo that ſome of them may be ſaid to have a Genuine Redneſs in compariſon of others, that have a Yellowiſh Redneſs: For if you take (for example) a good Tincture of *Cochineel*, dilute it never ſo much with fair Water, you will not (as far as I can judge by what I have tried) be able to make it a Yellow Liquor. Inſomuch that a Single

drop of a rich Solution of *Cochineel* in Spirit of Urine, being Diluted with above an Ounce of fair Water, exhibited no Yellowiſhneſs at all, but a fair (though ſomewhat faint) Pinck or Carnation; and even when *Cochineel* was by degrees Diluted much beyond the newly mention'd Colour, by the way formerly related to you in the twenty fourth Experiment, I remember not, that there appear'd in the whole Trial any Yellow. But if you take Balſom of Sulphur (for Inſtance) though it may appear in a Glaſs, where it has a good Thickneſs, to be of a deep Red, yet if you ſhake the Glaſs, or pour a few drops on a ſheet of White Paper, ſpreading them on it with your Finger, the Balſom that falls back along the ſides of the Glaſs, and that which ſtains the Paper, will appear Yellow, not Red. And there are divers Tinctures, ſuch as that of Amber made with Spirit of Wine (to name now no more) that will appear either Yellow or Red, according as the Veſſels that they fill, are Slender or Broad.

EXPERIMENT XXXIII.

But to proceed to the Experiments I was about to deliver: *Firſt*, Oyl or Spirit

of

of Turpentine, though clear as fair Water, being digeſted upon the purely White Sugar of Lead, has, in a ſhort time, afforded us a high Red Tincture, that ſome Artiſts are pleas'd to call the Balſom of *Saturn*, which they very much (and probably not altogether without cauſe) extol as an excellent Medicine in divers outward affections.

EXPERIMENT XXXIV.

Next, take of common Brimſtone finely powdred five Ounces, of Sal-Armoniack likewiſe pulveriz'd an equal weight, of beaten Quick-lime ſix Ounces, mix theſe Powders exquiſitely, and Diſtill them through a Retort plac'd in Sand by degrees of Fire, giving at length as intenſe a Heat as you well can in Sand, there will come over (if you have wrought well) a Volatile Tincture of Sulphur, which may probably prove an excellent Medicine, and ſhould have been mention'd among the other Preparations of Sulphur, which we have elſewhere imparted to you, but that it is very pertinent to our preſent Subject, The change of Colours. For though none of the Ingredients be Red, the Diſtill'd Liquor will be ſo: and this Liquor if it

be well drawn, will upon a little Agitation of the Vial first unstop'd (especially if it be held in a Warmer hand) send forth a copious Fume, not Red, like that of Nitre, but White; And sometimes this Liquor may be so Drawn, that I remember, not long since, I took pleasure to observe in a parcel of it, that Ingredients not Red, did not only yield by Distillation a Volatile Spirit that was Red, but though that Liquor did upon the bare opening of the Bottle it was kept in, drive us away with the plenty and Sulphureous scent of a White steam which it sent forth, yet the Liquor it self being touch'd by our Fingers, did immediately Dye them Black.

EXPERIMENT XXXV.

The third and *last* Experiment I shall now mention to shew, how prone Bodies abounding in Sulphureous parts are to afford a Red Colour, is one, wherein by the Operation of a Saline Spirit upon a White or Whitish Body, which according to the *Chymists* should be altogether Sulphureous, a Redness may be produc'd, not (as in the former Experiments) slowly, but in the twinkling of an Eye. We took then of the Essential Oyl of Anniseeds,

ſeeds, which has this Peculiarity, that in Cold weather it loſes its Fluidity and the greateſt part of its Tranſparency, and looks like a White or Whitiſh Oyntment, and near at hand ſeems to conſiſt of a Multitude of little ſoft Scales: Of this Coagulated Stuff we ſpread a little with a Knife upon a piece of White Paper, and letting fall on it, and mixing with it a drop or two of Oyl of Vitriol, immediately (as we fore-ſaw) there emerg'd together with ſome Heat and Smoak, a Blood-Red Colour, which therefore was in a trice produc'd by two Bodies, whereof the one had but a Whitiſh Colour, and the other (if carefully rectify'd) had no Colour at all.

EXPERIMENT XXXVI.

But on this Occaſion (*Pyrophilus*) we muſt add once for all, that in many of the above-recited Experiments, though the changes of Colour happen'd as we have mention'd them: yet the emergent or produc'd Colour is oft times very ſubject to Degenerate, both quickly and much. Notwithſtanding which, ſince the Changes, we have ſet down, do happen preſently upon the Operation of the Bodies upon each other, or at the times by us ſpecify'd;

that

that is sufficient both to justifie our Veracity, and to shew what we intend; it not being Essential to the Genuineness of a Colour to be Durable. For a fading Leaf, that is ready to Rot, and moulder into dust, may have as true a Yellow, as a Wedge of Gold, which so obstinately resists both Time and Fire. And the reason, why I take occasion from the former Experiment to subjoin this general Advertisement, is, that I have several times observ'd, that the Mixture resulting from the Oyls of Vitriol, and of Anniseeds, though it acquire a thicker consistence than either of the Ingredients had, has quickly lost its Colour, turning in a very short time into a dirty Gray, at least in the Superficial parts, where 'tis expos'd to the Air; which last Circumstance I therefore mention, because that, though it seem probable, that this Degeneration of Colours may oft times and in divers cases proceed from the further Action of the Saline Corpuscles, and the other Ingredients upon one another, yet in many cases much of the Quick change of Colours seems ascribeable to the Air, as may be made probable by several reasons: The first whereof may be fetcht from the newly recited Example of the two Oyls; The next may be, that we have sometimes observ'd

ſerv'd long Window-Curtains of light Colours, to have that part of them, which was expos'd to the Air, when the Window was open, of one Colour, and the lower part, that was ſheltred from the Air by the Wall, of another Colour: And the third Argument may be fetch'd from divers Obſervations, both of others, and our own; For of that Pigment ſo well known in Painters Shops, by the name of *Turnſol*, our Induſtrious *Parkinſon*, in the particular account he gives of the Plant that bears it, tells us alſo, That *the Berries when they are at their full Maturity, have within them between the outer Skin and the inward Kirnel or Seed, a certain Juice or Moiſture, which being rubb'd upon Paper or Cloath, at the firſt appears of a freſh and lovely Green Colour, but preſently changeth into a kind of Blewiſh Purple, upon the Cloath or Paper, and the ſame Cloath afterwards wet in Water, and wrung forth, will Colour the Water into a Claret Wine Colour, and theſe* (concludes he) *are thoſe Raggs of Cloath, which are uſually call'd* Turnſol *in the Druggiſts or Grocers Shops.* And to this Obſervation of our *Botaniſt* we will add an Experiment of our own, (made before we met with That) which, though in many Circumſtances, very differing,

Parkinſon, Thea. Bot. Trib. 4. cap. 12.

differing ſerves to prove the ſame thing; for having taken of the deeply Red Juice of *Buckthorn* Berries, which I bought of the Man that uſes to ſell it to the Apothecaries, to make their Syrrup *de Spina Cervina*, I let ſome of it drop upon a piece of White Paper, and having left it there for many hours, till the Paper was grown dry again, i found what I was inclin'd to ſuſpect, namely, That this Juice was degenerated from a deep Red to a dirty kind of Greyiſh Colour, which, in a great part of the ſtain'd Paper ſeem'd not to have ſo much as an Eye of Red; Though a little Spirit of Salt or diſſolv'd *Alcaly* would turn this unpleaſant Colour (as formerly I told you it would change the not yet alter'd Juice) into a Red or Green. And to ſatisfie my ſelf, that this Degeneration of Colour did not proceed from the Paper, I drop'd ſome of the deep Red or Crimſon Juice upon a White glaz'd Tile, and ſuffering it to dry on there, I found that ev'n in that Body, on which it could not Soak, and by which it could not be wrought, it nevertheleſs loſt its Colour. And theſe Inſtances (*Pyrophilus*) I am the more careful to mention to you, that you may not be much Surpris'd or Diſcourag'd, if you ſhould ſometimes miſs of performing punctually

punctually what I affirm my self to have done in point of changing Colours; since in these Experiments the over-sight or neglect of such little Circumstances, as in many others would not be perhaps considerable, may occasion the mis-carrying of a Tryal. And I was willing also to take this occasion of Advertising you in the repeating of the Experiments mention'd in this Treatise, to make use of the Juices of Vegetables, and other things prepar'd for your Trials, as soon as ever they are ready, lest one or other of them grow less fit, if not quite unfit by delay; and to estimate the Event of the Trials by the Change, that is produc'd presently upon the due and sufficient Application of Actives to Passives (as they speak) because in many cases the effects of such Mixtures may not be lasting, and the newly produc'd Colour may in a little time degenerate. But, (*Pyrophilus*) I forgot to add to the former Observations lately made about Vegetables, a third of the same Import, made in Mineral substances, by telling you, That the better to satisfie a Friend or two in this particular, I sometimes made, according to some Conjectures of mine, this Experiment; That having dissolv'd good Silver in *Aqua-fortis*, and Precipitated it with Spirit of Salt, upon the

the first Decanting of the Liquor, the remaining Matter would be purely White; but after it had lain a while uncover'd, that part of it that was Contiguous to the Air, would not only loſe its Whiteneſs, but appear of a very Dark and almoſt Blackiſh Colour, I ſay that part that was Contiguous to the Air, becauſe if that were gently taken off, the Subjacent part of the ſame Maſs would appear very White, till that alſo, having continu'd a while expos'd to the Air, would likewiſe Degenerate. Now whether the Air perform theſe things by the means of a Subtile Salt, which we elſewhere ſhew it not to be deſtitute of, or by a peircing Moiſture, that is apt eaſily to inſinuate it ſelf into the Pores of ſome Bodies, and thereby change their Texture, and ſo their Colour: Or by ſolliciting the Avolation of certain parts of the Bodies, to which 'tis contiguous; or by ſome other way, (which poſſibly I may elſewhere propoſe and conſider) I have not now the leiſure to diſcourſe. And for the ſame reaſon, though I could add many other Inſtances, of what I formerly noted touching the emergency of Redneſs upon the Digeſtion of many Bodies, inſomuch that I have often ſeen upon the Borders of *France* (and probably we may have the like in *England*)

England) a ſort of Pears, which digeſted for ſome time with a little Wine, in a Veſſel exactly clos'd, will in not many hours appear throughout of a deep Red Colour, (as alſo that of the Juice, wherein they are Stew'd, becomes) but ev'n on pure and white Salt of Tartar, pure Spirit of Wine, as clear as Rock-water, will (as we elſewhere declare) by long digeſtion acquire a Redneſs; Though I ſay ſuch Inſtances might be Multiplied, and though there be ſome other Obvious changes of Colours, which happen ſo frequently, that they cannot but be as well Conſiderable as Notorious; ſuch as is the blackneſs of almoſt all Bodies burn'd in the open Air: yet our haſte invites us to reſign you the Exerciſe of enquiring into the Cauſes of theſe Changes. And certainly, the reaſon both *why* the Soots of ſuch differing Bodies are almoſt all of them all Black, *why* ſo much the greater part of Vegetables ſhould be rather Green than of any other Colour, and particularly (which more directly concerns this place) *why* gentle Heats do ſo frequently in Chymical Operations produce rather a Redneſs than another Colour in digeſted *Menſtruums*, not only Sulphureous, as Spirit of Wine, but Saline, as Spirit of Vinegar, may be very well worth

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a ſerious Inquiry; which I ſhall therefore recommend to *Pyrophilus* and his Ingenious Friends.

EXPERIMENT XXXVII.

It may ſeem ſomewhat ſtrange, that if you take the Crimſon Solution of *Cochineel*, or the Juice of Black Cherries, and of ſome other Vegetables that afford the like Colour, (which becauſe many take but for a deep Red, we do with them ſometimes call it ſo) and let ſome of it fall upon a piece of Paper, a drop or two of an Acid Spirit, ſuch as Spirit of Salt, or *Aqua-fortis*, will immediately turn it into a fair Red. Whereas if you make an Infuſion of Brazil in fair Water, and drop a little Spirit of Salt or *Aqua-fortis* into it, that will deſtroy its Redneſs, and leave the Liquor of a Yellow, (ſometimes Pale) I might perhaps plauſibly enough ſay on this occaſion, that if we conſider the caſe a little more attentively, we may take notice, that the action of the Acid Spirit ſeems in both caſes, but to weaken the Colour of the Liquor on which it falls. And ſo though it deſtroy Redneſs in the Tincture of Brazil, as well as produce Red in the Tincture of *Cochineel*, its Operations may be Uniform

form enough, since as Crimson seems to be little else than a very deep Red, with (perhaps) an Eye of Blew, so some kinds of Red seem (as I have lately noted) to be little else than heightned Yellow. And consequently in such Bodies, the Yellow seems to be but a diluted Red. And accordingly Alcalizate Solutions and Urinous Spirits, which seem dispos'd to Deepen the Colours of the Juices and Liquors of most Vegetables, will not only restore the Solution of *Cochineel* and the Infusion of Brazil to the Crimson, whence the Spirit of Salt had chang'd them into a truer Red; but will also (as I lately told you) not only heighten the Yellow Juice of Madder into Red, but advance the Red Infusion of Brazil to a Crimson. But I know not whether it will not be much safer to derive these Changes from vary'd Textures, than certain kinds of Bodies; and you will perhaps think it worth while, that I should add on this occasion, That it may deserve some Speculation, why, notwithstanding what we have been observing, though Blew and Purple seem to be deeper Colours than Red, and therefore the Juices of Plants of either of the two former Colours may (congruously enough to what has been just now noted) be turn'd Red by

Spirit of Salt or *Aqua-fortis*, yet Blew Syrrup of Violets and ſome Purples ſhould both by Oyl of Tartar and Spirit of Urine be chang'd into Green, which ſeems to be not a deeper, but a more diluted Colour than Blew, if not alſo than Purple.

EXPERIMENT XXXVIII.

It would much contribute to the Hiſtory of Colours, if *Chymiſts* would in their Laboratories take a heedful notice, and give us a faithful account of the Colours obſerv'd in the Steams of Bodies either Sublim'd or diſtill'd, and of the Colours of thoſe Productions of the Fire, that are made up by the Coalition of thoſe Steams. As (for Inſtance) we obſerve in the Diſtilling of pure Salt-petre, that at a certain ſeaſon of the Operation, the Body, though it ſeem either Cryſtalline, or White, affords very Red Fumes: whereas though Vitriol be Green or Blew, the Spirit of it is obſerv'd to come over in Whitiſh Fumes. The like Colour I have taken notice of in the Fumes of ſeveral other Concretes of differing Colours, and Natures, eſpecially when Diſtill'd with ſtrong Fires. And we elſewhere note, that ev'n Soot, as Black as it is, has fill'd our Receivers

ceivers with such copious White Fumes, that they seem'd to have had their In-sides wash'd with Milk. And no less observable may be, the Distill'd Liquors, into which such Fumes convene, (for though we will not deny, that by skill and care a Reddish Liquor may be obtain'd from Nitre) yet the common Spirit of it, in the making ev'n of which store of these Red Fumes are wont to pass over into the Receiver, appears not to be at all Red. And besides, that neither the Spirit of Vitriol, nor that of Soot is any thing White; And, besides also, that as far as I have observ'd, most (for I say not all) of the Empyreumatical Oyls of Wood, and other Concretes, are either of a deep Red, or of a Colour between Red and Black; besides this, I say, 'tis very remarkable, that notwithstanding that great Variety of Colours to be met with in the Herbs, Flowers, and other Bodies wont to be Distill'd in *Balneo*: yet (as far at least as our common Distillers Experience reacheth) all the Waters and Spirits that first come over by that way of Distillation, leave the Colours of their Concretes behind them, though indeed there be one or two Vegetables not commonly taken notice of, whose distill'd Liquors I elsewhere observe to carry over

the Tincture of the Concrete with them. And as in Distillations, so in Sublimations, it were worth while to take notice of what comes up, in reference to our present scope, by purposely performing them (as I have in some cases done) in conveniently shap'd Glasses, that the Colour of the ascending Fumes may be discern'd; For it may afford a Naturalist good Information to observe the Congruities or the Differences betwixt the Colours of the ascending Fumes, and those of the *Flowers*, they compose by their Convention. For it is evident, that these *Flowers*, do many of them in point of Colour, much differ, not only from one another, but oft times from the Concretes that afforded them. Thus, (not here to repeat what I formerly noted of the Black Soots of very differingly Colour'd Bodies) though Camphire and Brimstone afford *Flowers* much of their own Colour, save that those of Brimstone are wont to be a little Paler, than the Lumps that yielded them; yet ev'n of Red *Benzoin*, that sublim'd Substance, which *Chymists* call its *Flowers*, is wont to be White or Whitish. And to omit other Instances, even one and the same Black Mineral, Antimony, may be made to afford *Flowers*, some of them Red, and some Grey, and, which is more strange, some

ſome of them purely White. And 'tis the Preſcription of ſome Glaſs-men by exquiſitely mingling a convenient proportion of Brimſtone, Sal-Armoniack, and Quick-ſilver, and Subliming them together, to make a Sublimate of an excellent Blew; and though having caus'd the Experiment to be made, we found the produc'd Sublimate to be far from being of a lovely Colour, (as was promis'd) that there and there, it ſeem'd Blewiſh, and at leaſt was of a Colour differing enough from either of the Ingredients, which is ſufficient for our preſent purpoſe. But a much finer Colour is promis'd by ſome of the Empiricks, that pretend to Secrets, who tell us, that Orpiment, being Sublim'd, will afford among the Parts of it that fly Upward, ſome little Maſſes, which, though the Mineral it ſelf be of a good Yellow, will be Red enough to emulate Rubies, both in Colour and Tranſlucency. And this Experiment may, for ought I know, ſometimes ſucceed; for I remember, that having in a ſmall Bolt-head purpoſely ſublim'd ſome powder'd Orpiment, we could in the Lower part of the Sublimate diſcern here and there ſome Reddiſh Lines, though much of the Upper part of the Sublimate conſiſted of a matter, which was not alone purely

Yellow, but transparent almoſt like a Powder. And we have alſo this way obtain'd a Sublimate, the Lower part whereof though it conſiſted not of Rubies, yet the ſmall pieces of it, which were Numerous enough, were of a pleaſant Reddiſh Colour, and Gliſter'd very prettily. But to inſiſt on ſuch kind of Trials and Obſervations, (where the aſcending Fumes of Bodies differ in Colour from the Bodies themſelves) though it might indeed Inrich the Hiſtory of Colours, would Rob me of too much of the little time I have to diſpatch what I have further to tell you concerning them.

EXPERIMENT XXXIX.

Take the dry'd Buds (or Bloſſoms) of the Pomegranate Tree, (which are commonly call'd in the Shops *Balauſtiums*) pull off the Reddiſh Leaves, and by a gentle Ebullition of them in fair Water, or by a competent Infuſion of them in like Water well heated extract a faint Reddiſh Tincture, which if the Liquor be turbid, you may Clarifie it by Filtrating it. Into this, if you pour a little good Spirit of Urine, or ſome other Spirit abounding in the like ſort of Volatile Salts, the Mixture will preſently

presently turn of a dark Greeniſh Colour, but if inſtead of the fore-mention'd Liquor, you drop into the ſimple Infuſion a little rectify'd Spirit of Sea-Salt, the Pale and almoſt Colourleſs Liquor will immediately not only grow more Tranſparent, but acquire a high Redneſs, like that of Rich Claret Wine, which ſo ſuddenly acquir'd Colour, may as quickly be deſtroy'd and turn'd into a dirty Blewiſh Green, by the affuſion of a competent quantity of the above-mention'd Spirit of Urine.

Annotation.

This Experiment may bring ſome Light to, and receive ſome from a couple of other Experiments, that I remember I have met with in the Ingenious *Gaſſendus*'s Animadverſions upon *Epicurus*'s Philoſophy, whilſt I was turning over the Leaves of thoſe Learned Commentaries; (my Eyes being too weak to let me read ſuch Voluminous Books quite through) And I the leſs ſcruple (notwithſtanding my contrary Cuſtom in this Treatiſe) to ſet down theſe Experiments of another, becauſe I ſhall a little improve the latter of them, and becauſe by comparing therewith that which I have laſt recited, we may be aſſiſted to con-

jecture upon what account it is, that Oyl of Vitriol heightens the Tincture of Red-rose Leaves, since Spirit of Salt, which is a highly Acid *Menstruum*, but otherwise differing enough from Oyl of Vitriol, does the same thing. Our Authors Experiments then, as we made them, are these; We took about a Glass-full of luke-warm Water, and in it immerg'd a quantity of the Leaves of *Senna*, and presently upon the Immersion there did not appear any Redness in the Water, but dropping into it a little Oyl of Tartar, the Liquor soon discover'd a Redness to the watchful Eye, whereas by a little of that Acid Liquor of Vitriol, which is like the former, undeservedly called Oyl, such a Colour would not be extracted from the infused *Senna*. On the other side we took some Red-rose Leaves dry'd, and having shaken them into a Glass of fair Water, they imparted to it no Redness, but upon the affusion of a little Oyl of Vitriol the Water was immediately turn'd Red, which it would not have been, if instead of Oyl of Vitriol, we had imployed Oyl of Tartar to produce that Colour: That these were *Gassendus* his Experiments, I partly remember, and was assur'd by a Friend, who lately Transcribed them out of *Gassendus* his Book, which I there-

therefore add, because I have not now that Book at hand. And the design of *Gassendus* in these Experiments our Friend affirms to be, to prove, that of things not Red a Redness may be made only by Mixture, and the Varied position of parts, wherein the Doctrine of that Subtil Philosopher doth not a little Authorize, what we have formerly deliver'd concerning the Emergency and Change of Colours. But the instances, that we have out of him set down, seem not to be the most eminent, that may be produc'd of this truth: For our next Experiment will shew the production of several Colours out of Liquors, which have not any of them any such Colour, nor indeed any discernable one at all; and whereas though our Author tells us, that there was no Redness either in the Water, or the Leaves of *Senna*, or the Oyl of Tartar; And though it be true, that the Predominant Colour of the Leaves of *Senna* be another than Red, yet we have try'd, that by steeping that Plant a Night even in Cold water, it would afford a very deep Yellow or Reddish Tincture without the help of the Oyl of Tartar, which seems to do little more than assist the Water to extract more nimbly a plenty of that Red Tincture, wherewith the Leaves of *Senna*

do

do of themſelves abound, and having taken off the Tincture of *Senna*, made only with fair Water, before it grew to be Reddiſh, and Decanted it from the Leaves, we could not perceive, that by dropping ſome Oyl of Tartar into it, that Colour was conſiderable, though it were a little heightned into a Redneſs, which might have been expected, if the particles of the Oyl did eminently Co-operate, otherwiſe than we have expreſſed, to the production of this Redneſs.

And as for the Experiment with Redroſe Leaves, the ſame thing may be alledged, for we found that ſuch Leaves by bare Infuſion for a Night and Day in fair Water, did afford us a Tincture bordering at leaſt upon Redneſs, and that Colour being conſpicuous in the Leaves themſelves, would not by ſome ſeem ſo much to be produc'd as to be extracted by the affuſion of Oyl of Vitriol. And the Experiment try'd with the dry'd Leaves of Damaskroſes ſucceeded but imperfectly, but that is indeed obſervable to our Authors purpoſe, that Oyl of Tartar will not perform in this Experiment what Oyl of Vitriol doth; but becauſe this laſt named Liquor is not ſo eaſily to be had, give me leave to Adverti ſe you, that the Experiment will ſucceed,

if

if instead of it you imploy *Aqua-fortis*. And though some Trials of our own formerly made, and others easily deducible from what we have already deliver'd, about the different Families and Operations of Salt, might enable us to present you an Experiment upon Red-rose Leaves, more accommodated to our Authors purpose, than that which he hath given us; yet our Reverence to so candid a Philosopher, invites us rather to improve his Experiment, than substitute another in its place. Take therefore of the Tincture of Red-rose Leaves, (for with Damask-rose Leaves the Experiment succeedeth not well) made as before hath been taught with a little Oyl of Vitriol, and a good quantity of fair Water, pour off this Liquor into a clear Vial half fill'd with Limpid water, till the Water held against the Light have acquir'd a competent Redness, without losing its Transparency, into this Tincture drop leisurely a little good Spirit of Urine, and shaking the Vial, which you must still hold against the Light, you shall see the Red Liquor immediately turn'd into a fine Greenish Blew, which Colour was not to be found in any of the Bodies, upon whose Mixture it emerg'd, and this Change is the more observable, because in many Bodies

dies the Degenerating of Blew into Red is usual enough, but the turning of Red into Blew is very unfrequent. If at every drop of Spirit of Urine you shake the Vial containing the Red Tincture, you may delightfully observe a pretty variety of Colours in the passage of that Tincture from a Red to a Blew, and sometimes we have this way hit upon such a Liquor, as being lookt upon against and from the Light, did seem faintly to emulate the above-mention'd Tincture of *Lignum Nephriticum*. And if you make the Tincture of Red-roses very high, and without diluting it with fair Water, pour on the Spirit of Urine, you may have a Blew so deep, as to make the Liquor Opacous, but being dropt upon White Paper the Colour will soon disclose it self. Also having made the Red, and consequently the Blew Tincture very Transparent, and suffer'd it to rest in a small open Vial for a Day or two, we found according to our Conjecture, that not only the Blew but the Red Colour also was Vanish'd; the clear Liquor being of a bright Amber Colour, at the bottom of which subsided a Light, but Copious feculency of almost the same Colour, which seems to be nothing but the Tincted parts of the Rose Leaves drawn out by the Acid

Spirits

Spirits of the Oyl of Vitriol, and Precipitated by the Volatile Salt of the Spirit of Urine, which makes it the more probable, that the Redneſs drawn by the Oyl of Vitriol, was at leaſt as well an extraction of the Tinging parts of the Roſes, as a production of Redneſs; and laſtly, if you be deſtitute of Spirit of Urine, you may change the Colour of the Tincture of Roſes with many other Sulphureous Salts, as a ſtrong Solution of Pot-aſhes, Oyl of Tartar, &c. which yet are ſeldom ſo free from Feculency, as the Spirituous parts of Urine becomes by repeated Diſtillation.

Annotation.

On this occaſion, I call to mind, that I found, a way of producing, though not the ſame kind of Blew, as I have been mentioning, yet a Colour near of Kin to it, namely, a fair Purple, by imploying a Liquor not made Red by Art, inſtead of the Tincture of Red-roſes, made with an Acid Spirit; And my way was only to take Log-wood, (a Wood very well known to Dyers) having by Infuſion the Powder of it a while in fair Water made that Liquor Red, I dropt into it a *Tantillum* of an Urinous Spirit, as that of Sal-Armoniack, (and

(and I have done the same thing with an *Alcali*) by which the Colour was in a moment turn'd into a rich, and lovely Purple. But care must be had, that you let not fall into a spoonful above two or three Drops, lest the Colour become so deep, as to make the Liquor too Opacous. And (to answer the other part of *Gassendus* his Experiment) if instead of fair Water, I infus'd the Log-wood in Water made somewhat sowr by the Acid Spirit of Salt, I should obtain neither a Purple Liquor, nor a Red, but only a Yellow one.

EXPERIMENT XL.

The Experiment I am now to mention to you, *Pyrophilus*, is that which both you, and all the other *Virtuosi* that have seen it, have been pleas'd to think very strange; and indeed of all the Experiments of Colours, I have yet met with, it seems to be the fittest to recommend the Doctrine propos'd in this Treatise, and to shew that we need not suppose, that all Colours must necessarily be Inherent Qualities, flowing from the Substantial Forms of the Bodies they are said to belong to, since by a bare Mechanical change of Texture in the Minute parts of Bodies, two Colours may in

a moment be Generated quite *De novo*, and utterly Destroy'd. For there is this difference betwixt the following Experiment, and most of the others deliver'd in these Papers, that in this, the Colour that a Body already had, is not chang'd into another, but betwixt two Bodies, each of them apart devoid of Colour, there is in a moment generated a very deep Colour, and which if it were let alone, would be permanent; and yet by a very small Parcel of a third Body, that has no Colour of its own, (lest some may pretend I know not what Antipathy betwixt Colours) this otherwise permanent Colour will be in another trice so quite destroy'd, that there will remain no foot-steps either of it or of any other Colour in the whole Mixture.

The Experiment is very easie, and it is thus performed: Take good common Sublimate, and fully satiate with it what quantity of Water you please, Filtre the Solution carefully through clean and close Paper, that it may drop down as Clear and Colourless as Fountain Water. Then when you'l shew the Experiment, put of it about a Spoonful into a small Wine-glass, or any other convenient Vessel made of clear Glass, and dropping in three or four drops

drops of good Oyl of Tartar, *per Deliquium*, well Filtred that it may likewise be without Colour, these two Limpid Liquors will in the twinkling of an Eye turn into an Opacous mixture of a deep Orange Colour, which by keeping the Glass continually shaking in your hand, you must preserve from setling too soon to the Bottom; And when the Spectators have a little beheld this first Change, then you must presently drop in about four or five drops of Oyl of Vitriol, and continuing to shake the Glass pretty strongly, that it may the Nimbler diffuse it self, the whole Colour, if you have gone Skilfully to work, will immediately disappear, and all the Liquor in the Glass will be Clear and Colourless as before, without so much as a Sediment at the Bottom. But for the more graceful Trial of this Experiment, 'twill not be amiss to observe, First, That there should not be taken too much of the Solution of Sublimate, nor too much of the Oyl of Tartar drop'd in, to avoid the necessity of putting in so much Oyl of Vitriol as may make an Ebullition, and perhaps run over the Glass. Secondly, That 'tis convenient to keep the Glass always a little shaking, both for the better mixing of the Liquors, and to keep the Yellow Substance from Subsiding, which else

else it would in a short time do, though when 'tis subsided it will retain its Colour, and also be capable of being deprived of it by the Oyl newly mentioned. Thirdly, That if any Yellow matter stick at the sides of the Glass, 'tis but inclining the Glass, till the clarify'd Liquor can wash alongst it, and the Liquor will presently imbibe it, and deprive it of its Colour.

Many have somewhat wondred, how I came to light upon this Experiment, but the Notions or Conjectures I have about the differing Natures of the several Tribes of Salts, having led me to devise the Experiment, it will not be difficult for me to give you the Chymical Reason, if I may so speak, of the *Phænomenon*. Having then observ'd, that *Mercury* being dissolv'd in some *Menstruums*, would yield a dark Yellow Precipitate, and supposing that, as to this, common Water, and the Salts that stick to the *Mercury* would be equivalent to those Acid *Menstruums*, which work upon the *Quick-silver*, upon the account of their saline Particles, I substituted a Solution of Sublimate in fair Water, instead of a Solution of *Mercury* in *Aqua-fortis*, or Spirit of *Nitre*, that simple Solution being both clearer and free from that very offensive smell, which accompanies the So-

lutions of *Mercury* made with those other corrosive Liquors; then I consider'd, that That which makes the Yellow Colour, is indeed but a Precipitate made by the means of the Oyl of Tartar, which we drop in, and which, as *Chymists* know, does generally precipitate Metalline Bodies corroded by Acid Salts; so that the Colour in our case results from the coalition of the Mercurial particles with the saline ones, wherewith they were formerly associated, and with the Alcalizate particles of the Salt of Tartar that swim up and down in the Oyl. Wherefore considering also, that very many of the effects of Lixiviate Liquors, upon the Solutions of other Bodies, may be destroyed by Acid *Menstruums*, as I elsewhere more particularly declare, I concluded, that if I chose a very potently Acid Liquor, which by its incisive power might undo the work of the Oyl of Tartar, and disperse again those Particles, which the other had by Precipitation associated, into such minute Corpuscles as were before singly Inconspicuous, they would become Inconspicuous again, and consequently leave the Liquor as Colourless as before the Precipitation was made.

This, as I said, *Pyrophilus*, seems to be the Chymical reason of this Experiment, that

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is such a reason, as, supposing the truth of those Chymical Notions I have elsewhere I hope evinc'd, may give such an account of the *Phænomena* as Chymical Notions can supply us with: but I both here and elsewhere make use of this way of speaking, to intimate that I am sufficiently aware of the difference betwixt a Chymical Explication of a *Phænomenon*, and one that is truly Philosophical or Mechanical; as in our present case, I tell you something, when I tell you that the Yellowness of the Mercurial Solution, and the Oyl of Tartar is produced by the Precipitation occasioned by the affusion of the latter of those Liquors, and that the destruction of the Colour proceeds from the Dissipation of that Curdl'd matter, whose Texture is destroy'd, and which is dissolv'd into Minute and Invisible particles by the potently Acid *Menstruum*, which is the reason, why there remains no sediment in the Bottom, because the infused Oyl takes it up, and resolves it into hidden or invisible Parts, as Water does Salt or Sugar. But when I have told you all this, I am far from thinking I have told all that such an Inquisitive Person as your self would know; for I presume you would desire as well as I to learn (at least) why the Particles of the

Mercury, of the Tartar, and of the Acid Salts convening together, ſhould make rather an Orange Colour than a Red, or a Blew, or a Green, for 'tis not enough to ſay what I related a little before, that divers Mercurial Solutions, though otherwiſe made, would yield a Yellow precipitate, becauſe the Queſtion will recur concerning them; and to give it a ſatisfactory anſwer, is, I freely acknowledge, more than I dare as yet pretend to.

But to confirm my conjecture about the Chymical reaſon of our Experiment, I may add, that as I have (*viz.* pag. 34. of this Treatiſe) elſewhere (on another occaſion) told you, with ſaline Liquors of another kind and nature than Salt of Tartar, (namely, with Spirit of Urine, and Liquors of kin to that) I can make the *Mercury* precipitate out of the firſt ſimple Solution quite of another Colour than that hitherto mention'd; Nay, if inſtead of altering the Precipitating Liquor, I alter'd the Texture of the Sublimate in ſuch a way as my Notions about Salt required, I could produce the ſame *Phænomenon*. For having purpoſely ſublim'd together Equal parts (or thereabout) of Sal Armoniack and Sublimate, firſt diligently Mix'd, the aſcending Flowers being diſſolv'd in fair Water,

and

and Filtred, gave a Solution Limpid and Colourless, like that of the other sublimates, and yet an *Alcaly* dropped into this Liquor did not turn it Yellow but White. And upon the same Grounds we may with *Quick-silver*, without the help of common Sublimate, prepare another sort of Flowers dissoluble in Water without Discolouring it, with which I could likewise do what I newly mention'd; to which I shall add, (what possibly you'l somewhat wonder at) That so much does the Colour depend upon the Texture resulting from the Convention of the several sorts of Corpuscles, that though in our Experiment, Oyl of Vitriol destroys the Yellow Colour, yet with *Quick-silver* and fair Water, by the help of Oyl of Vitriol alone, we may easily make a kind of Precipitate of a fair and permanent Yellow, as you will e're long (in the Forty second Experiment of this third Part) be taught. And I may further add, that I chose Oyl of Vitriol, not so much for any other or peculiar Quality, as for its being, when 'tis well rectify'd, (which 'tis somewhat hazardous to bring it to be) not only devoid of Colour and in smells, but extremely Strong and Incisive; For though common and undephlegmated *Aqua fortis* will not perform

the same thing well, yet that which is made exceeding Strong by being carefully Dephlegm'd, will do it pretty well, though not so well as Oyl of Vitriol which is so Strong, that even without Rectification it may for a need be made use of. I will not here tell you what I have try'd, that I may be able to deprive at pleasure the Precipitate that one of the Sulphureous Liquors had made, by the copious Affusion of the other: Because I found, though this Experiment is too tickliſh to let me give a full account of it in few words, I shall therefore tell you, that it is not only for once, that the other above-mention'd Experiment may be made, the same Numerical parcels of Liquor being still imploy'd in it; for after I have clarifi'd the Orange Colour'd Liquor, by the addition of as little of the Oyl of Vitriol as will suffice to perform the effect, I can again at pleasure reproduce the Opacous Colour, by the dropping in of fresh Oyl of Tartar, and destroy it again by the Re-affusion of more of the Acid *Menstruum*; and yet oftner if I please, can I with these two contrariant Liquors recall and disperse the Colour, though by reason of the addition of so much new Liquor, in reference to the Mercurial particles, the Colour will at length appear more dilute and faint.

An improvement of the fortieth Experiment.

And, *Pyrophilus*, to confirm yet further the Notions that led me to think on the propoſed Experiment, I ſhall acquaint you with another, which when I had conveniency I have ſometimes added to it, and which has to the Spectators appeared little leſs Odd than the firſt; And though becauſe the Liquor, requiſite to make the Trial ſucceed well, muſt be on purpoſe prepared anew a while before, becauſe it will not long retain its fitneſs for this work, I do but ſeldom annex this Experiment to the other, yet I ſhall tell you how I devis'd it, and how I make it. If you boyl Crude Antimony in a ſtrong and clear *Lixivium*, you ſhall ſeparate a ſubſtance from it, which ſome Modern *Chymiſts* are pleas'd to call its Sulphur, but how deſervedly I ſhall not here examine, having elſewhere done it in an Opportune place; wherefore I ſhall now but need to take notice, that when this ſuppos'd Sulphur (not now to call it rather a kind of *Crocus*) is let fall by the Liquor upon its Refrigeration, it often ſettles in Flakes, or ſuch like parcels of a Yellow Subſtance, (which being by the pre-

cedent dissolution reduc'd into Minute parts, may peradventure be made to take Fire much more easily than the Grosser Powder of unprepared Antimony would have done.) Considering therefore, that common Sulphur boyl'd in a *Lixivium*, may be Precipitated out of it by Rhenish-wine or White-wine, which are Sowrish Liquors, and have in them, as I elsewhere shew, an Acid Salt; and having found also by Trial, that with other Acid Liquors I could Precipitate out of Lixiviate Solvents some other Mineral concretions abounding with sulphureous parts, of which sort is crude Antimony, I concluded it to be easie to Precipitate the Antimony dissolv'd, as was lately mention'd, with the Acid Oyl of Vitriol; and though common Sulphur yields a White Precipitate, which the *Chymists* call *Lac Sulphuris*, yet I supposed the Precipitated Antimony would be of a deep Yellow Colour, as well, if made with Oyl of Vitriol, as if made only by Refrigeration and length of time. From this 'twas easie to deduce this Experiment, that if you put into one Glass some of the freshly Impregnated and Filtrated Solution of Antimony, and into another some of the Orange-Coloured Mixture, (which I formerly shewed you how to make with a Mer-

Mercurial Solution and Oyl of Tartar) a few drops of Oyl of Vitriol dropp'd into the last mention'd Glass, would, as I told you before, turn the Deep Yellow mixture into a Clear Liquor; whereas a little of the same Oyl dropped out of the same Vial into the other Glass would presently (but not without some ill sent) turn the moderately cleer Solution into a Deep Yellow substance. But this, as I said, succeeds not well, unless you employ a *Lixivium* that has but newly dissolv'd Antimony, and has not yet let it fall. But yet in Summer time, if your *Lixivium* have been duly Impregnated and well Filtred after it is quite cold, it will for some days (perhaps much longer than I had occasion to try) retain Antimony enough to exhibit, upon the Affusion of the Corrosive Oyl, as much of a good Yellow substance as is necessary to satisfie the Beholders of the Possibility of the Experiment.

Reflections upon the XL. Experiment Compared with the X. and XX.

The Knowledge of the Distinction of Salts which we have propos'd, whereby they are discriminated into *Acid*, *Volatile*, or

or *Salsuginous* (if I may for Distinction sake so call the Fugitive Salts of Animal Substances) and *fixed* or *Alcalizate*, may possibly (by that little part which we have already delivered, of what we could say of its Applicableness) appear of so much Use in Natural Philosophy (especially in the Practick part of it) that I doubt not but it will be no Unwelcome Corollary of the Preceding Experiment, if by the help of it I teach you to distinguish, which of those Salts is Predominant in Chymical Liquors, as well as whether any of them be so or not. For though in our Notes upon the X. and XX. Experiments I have shown you a way by means of the Tincture of *Lignum Nephriticum*, or of Syrrup of Violets, to discover whether a propounded Salt be Acid or not, yet you can thereby only find in general that such and such Salts belong not to the Tribe of Acids, but cannot determine whether they belong to the Tribe of Urinous Salts (under which for distinction sake I comprehend all those Volatile Salts of Animal or other Substances that are contrary to Acids) or to that of Alcalies. For as well the one as the other of these Salino-Sulphurous Salts will restore the Cæruleous Colour to the Tincture of *Lignum Nephriticum*, and turn that of Syrrup of Violets into

into Green. Wherefore this XL. Experiment does opportunely supply the deficiency of those. For being sollicitous to find out some ready ways of discriminating the Tribes of Chymical Salts, I found that all those I thought fit to make tryal of, would, if they were of a Lixiviate Nature, make with Sublimate dissolved in fair Water an *Orange Tawny* Precipitate; whereas if they were of an Urinous Nature the Precipitate would be *White* and Milky. So that having always by me some Syrrup of Violets and some solution of Sublimate, I can by the help of the first of those Liquors discover in a trice, whether the propounded Salt or Saline Body be of an Acid Nature or no, if it be I need (you know) inquire no further; but if it be not, I can very easily, and as readily distinguish between the other two kinds of Salts, by the White or Orange-Colour that is immediately produc'd, by letting fall a few Drops or Grains of the Salt to be examin'd, into a spoonful of the cleer solution of sublimate. For Example, it has been suppos'd by some eminently Learned, That when Sal Armoniack being mingled with an Alcaly is forc'd from it by the Fire in close Vessels, the volatile Salt that will thereby be obtain'd (if the Operation be skilfully performed,)

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is but a more fine and subtile sort of Sal-Armoniack, which, 'tis presum'd, this Operation do's but more exquisitely purifie, than common Solutions, Filtrations, and Coagulations. But this Opinion may be easily shown to be Erroneous, as by other Arguments, so particularly by the lately deliver'd Method of distinguishing the Tribes of Salts. For the Saline Spirit of Sal-Armoniack, as it is in many other manifest Qualities very like the Spirit of Urine, so like, that it will in a trice make Syrrup of Violets of a Lovely Green, turn a solution of good Verdigrease into an Excellent Azure, and make the solution of a Sublimate yield a White Precipitate, insomuch that in most (for I say not all of the Experiments) where I Aim only at producing a sudden change of Colour, I scruple not to use Spirit of Sal-Armoniack when it is at hand, instead of Spirit of Urine, as indeed it seems chiefly to consist (besides the flegm that helps to make it fluid) of the Volatile Urinous Salt (yet not excluding that of Soot) that abounds in the Sal Armoniack and is set at liberty from the Sea Salt wherewith it was formerly associated, and clogged, by the Operation of the Alcaly, that divides the Ingredients of Sal Armoniack, and retains that Sea Salt with it self. What use may be made

made of the like way of exploration in that inquiry which puzzles ſo many Modern Naturaliſts, whether the Rich Pigment (which we have often had occaſion to mention) belongs to the Vegetable or Animal Kingdom, you may find in another place where I give you ſome account of what I try'd about Cochinele. But I think it needleſs to exemplifie here our Method by any other Inſtances, many ſuch being to be met with in divers parts of this Treatiſe; but I will rather advertiſe you, that, by this way of examining Chymical Liquors, you may not only in moſt caſes conclude *Affirmatively*, but in ſome caſes *Negatively*. As ſince Spirit of Wine, and as far as I have try'd, thoſe Chymical Oyls which Artiſts call Eſſential, did not (when I us'd them as I had us'd the ſeveral Families of Salts upon that Syrrup) turn Syrrup of Violets Red or Green, nor the ſolution of Sublimate White or Yellow, I inferr'd it may thence be probably argued, that either they are deſtitute of Salt, or have ſuch as belongs not to either of the three Grand Families already often mention'd. When I went to examine the Spirit of Oak or of ſuch like Concretes forced over through a Retort, I found by this means amongſt others, that (as I elſewhere ſhow) thoſe Chymiſts are much

much miſtaken in it, that account it a ſimple Liquor, and one of their Hypoſtatical Principles: for not to mention what flegm it may have, I found that with a few drops of one of this ſort of ſpirits mix'd with a good proportion of Syrrup of Violets, I could change the Colour and make it Purpliſh, by the affinity of which Colour to Redneſs, I conjectured that this Spirit had ſome Acid Corpuſcles in it, and accordingly I found that as it would deſtroy the Blewneſs of a Tincture of *Lignum Nephriticum*, ſo being put upon Corals it would Corrode them, as common ſpirit of Vinegar, and other Acid Liquors are wont to do. And farther to examine whether there were not a great part of the Liquor that was not of an Acid nature, having ſeparated the Sour or Vinegar-like part from the reſt, which (if I miſtake not) is far the more Copious, we concluded as we had conjectured, the other or remaining part, though it had a ſtrong taſte as well as ſmell, to be of a nature differing from that of either of the three ſorts of Salts above-mention'd, ſince it did as little as ſpirit of Wine, and Chymical Oyls, alter the Colour either of Syrrup of Violets or Solution of ſublimate, whence we alſo inferred that the change that had been made of that Syrrup into a Purple Colour, was

effect-

effected by the Vinegar, that was one of the two Ingredients of the Liquor, which was wont to pass for a Simple or Uncompounded Spirit. And, upon this account, 'twas of the Spirit of Oak (and the like Concretes) freed from its Vinegar that I elsewhere told you, that I had not then observ'd it, (and I have repeated the Tryal but very lately) to destroy the cæruleous Tincture of *Lignum Nephriticum*. But this only, *en passant*; for the Chief thing I had to add was this, That by the same way may be examin'd and discover'd, divers changes that are produced in Bodies, either by Nature only, or by Art; either of them being able by changing the Texture of some Concretes I could name, to qualifie them to Operate after a new manner upon the above mention'd Syrrup, or Solution, or both. And by this means, to tell you that upon the by, I have been able to discover, that there may be made Bodies, which though they run *per Deliquium*, as readily as Salt of Tartar, belong in other respects, not to the family of Alcaliz, much less to that of Salsuginous, or that of Acid Salts. Perhaps too, I may know a way of making a highly operative saline Body that shall neither change the Colour of Syrrup of Violets, nor Precipitate the solution of Sublimate; And, I can likewise

likewiſe if I pleaſe conceal by what Liquors I perform ſuch changes of Colour, as I have been mentioning to you, by quite altering the Texture of ſome ordinary Chymical productions, the Exploration of which is the main uſe of the fortieth Experiment, which I think teaches not a little, if it teach us to diſcover the nature of thoſe things (in reference to Salt) that are obtained by the ordinary Chymical Analyſis of mix'd Bodies, though perhaps there may be other Bodies prepared by Chymiſtry which may have the ſame Effects in the change of Colours; and yet be produc'd not from what Chymiſts call the Reſolution of Bodies, but from their Compoſition. But the diſcourſing of things of this nature is more proper for another place. I ſhall now only add, what might perhaps have been more ſeaſonably told you before; That the Reaſon why the way of Exploration of Salts hitherto delivered, ſucceeds in the ſolution of ſublimate, depends upon the particular Texture of that ſolution, as well as upon the differing Natures of the ſaline Liquors imployed to Precipitate it. For Gold diſſolved in *Aqua Regia*, whether you Precipitate it with Oyl of Tartar which is an Alcaly, or with Spirit of Urine, or Sal Armoniack which belongs to the family of Volatile

Volatile Salts, will either way afford a Yellow ſubſtance: though with ſuch an Acid Liquor, as, I ſay not Spirit of Salt, the Body that yields it, being upon the matter an Ingredient of *Aqua Regis*, but Oyl of Vitriol it ſelf, I did not find that I could precipitate the Metal out of the Solution, or deſtroy the Colour of it, though the ſame Oyl of Vitriol would readily Precipitate Silver diſſolv'd in *Aqua-fortis*. And if you diſſolve pure Silver in *Aqua-fortis*, and ſuffer it to ſhoot into Chryſtals, the clear Solution of theſe made in fair Water, will afford a very White Precipitate, whether it be made with an Alcaly, or an Acid Spirit, as that of Salt; whereas, which may ſeem ſomewhat ſtrange, with Spirit of Sal Armoniack (that I us'd was made of Quick-lime) I could obtain no ſuch White Precipitate; that Volatile Spirit, nor (as I remember) that of Urine, ſcarce doing any more than ſtriking down a very ſmall quantity of matter, which was neither White nor Whitiſh, ſo that the remaining Liquor being ſuffer'd to evaporate till the ſuperfluous Moiſture was gone, the greateſt part of the Metalline Corpuſcles with the Saline ones that had imbib'd them, concoagulated into Salt, as is uſual in ſuch Solutions, wherein the Metal has not been Precipitated.

EXPERIMENT XLI.

Of Kin to the laſt or fortieth Experiment is another which I remember I have ſometimes ſhewn to *Virtuoſi* that were pleas'd not to diſlike it. I took Spirit of Urine made by Fermentation, and with a due proportion of Copper brought into ſmall parts, I obtain'd a very lovely Azure Solution, and when I ſaw the Colour was ſuch as was requiſite, pouring into a clean Glaſs, about a ſpoonful of this tincted Liquor, (of which I us'd to keep a Quantity by me,) I could by ſhaking into it ſome drops of Strong Oyl of Vitriol, deprive it in a trice of its Deep Colour, and make it look like Common-water.

Annotation.

This Experiment brings into my mind this other, which oftentimes ſucceeds well enough, though not quite ſo well as the former; Namely, that if into about a ſmall ſpoonful of a Solution of good French Verdigreaſe made in fair Water, I dropt and ſhak'd ſome ſtrong ſpirit of Salt, or rather deflegm'd *Aqua-Fortis*, the Greenneſs of the ſolution would be made in a trice almoſt

most totally to disappear, & the Liquor held against the Light would scarce seem other than Clear or Limpid, to any but an Attentive Eye, which is therefore remarkable, because we know that *Aqua-fortis* corroding Copper, which is it that gives the Colour to Verdigrease, is wont to reduce it to a Green Blew Solution. But if into the other altogether or almost Colourless Liquor I was speaking of, you drop a just quantity either of Oyl of Tartar or Spirit of Urine, you shall find that after the Ebullition is ceas'd, the mixture will disclose a lively Colour, though somewhat differing from that which the solution of Verdigrease had at first.

EXPERIMENT XLII.

That the Colour (*Pyrophilus*) of a Body may be chang'd by a Liquor which of it self is of no Colour, provided it be saline, we have already manifested by a multitude of instances. Nor doth it seem so strange, because Saline Particles swimming up and down in Liquors, have been by many observ'd to be very operative in the Production and change of Colours. But divers of our Friends that are not acquainted with Chymical Operations have thought it very strange that a White Body, and a Dry one

too, ſhould immediately acquire a rich new colour upon the bare affuſion of Spring-Water deſtitute as well of adventitious Salt as of Tincture. And yet (*Pyrophilus*) the way of producing ſuch a change of Colours may be eaſily enough lighted on by thoſe that are converſant in the Solutions of Mercury. For we have try'd, that though by Evaporating a Solution of Quick-Silver in *Aqua-fortis*, and abſtracting the Liquor till the remaining matter began to be well, but not too ſtrongly dryed, fair Water pour'd on the remaining *Calx* made it but ſomewhat Yellowiſh; yet when we took good Quick-Silver, and three or four times its weight of Oyl of Vitriol, in caſe we in a Glaſs Retort placed in Sand drew off the Saline *Menſtruum* from the Metalline Liquor, till there remained a dry *Calx* at the bottom, though this Precipitate were a Snow White Body, yet upon pouring on it a large quantity of fair Water, we did almoſt in a moment perceive it to paſs from a Milky Colour to one of the loveliest Light Yellows that ever we had beheld. Nor is the Turbith Mineral, that Chymiſts extol for its power to Salivate, and for other virtues, of a Colour much inferiour to this, though it be often made with a differing proportion of the Ingredients,

gredients, a more troubleſome way. For *Beguinus*, who calls it *Mercurius præcipitatus optimus*, takes to one part of Quick-ſilver, but two of Liquor, and that is Rectified Oyl of Sulphur, which is (in *England* at leaſt) far more ſcarce and dear than Oyl of Vitriol; he alſo requires a previous Digeſtion, two or three Cohobations, and frequent Ablutions with hot Diſtill'd Water, with other preſcriptions, which though they may conduce to the Goodneſs of the Medicine, which is that he aims at, are troubleſome, and, our Tryals have inform'd you unneceſſary to the *obtaining the Lemmon Colour* which he regards not. But though we have very rarely ſeen either in Painters Shops, or elſewhere a finer Yellow than that which we have divers times this way produc'd (which is the more conſiderable, becauſe durable and pleaſant Yellows are very hard to be met with, as may appear by the great uſe which Painters are for its Colours ſake fain to make of that pernicious and heavy Mineral, Orpiment) yet I fear our Yellow is too coſtly, to be like to be imploy'd by Painters, unleſs about Choice pieces of Work, nor do I know how well it will agree with every Pigment, eſpecially, with Oyled Colours. And whether this

Beguinus Tyr. Chy. Lib. 2. Cap. 13.

Experiment, though it have seem'd somewhat strange to most we have shown it to, be really of another Nature than those wherein Saline Liquors are imploy'd, may, as we formerly also hinted, be so plausibly doubted, that whether the Water pour'd on the *Calx*, do barely by imbibing some of its Saline parts alter its Colour, by altering its Texture, or whether by dissolving the Concoagulated Salts, it does become a Saline *Menstruum*, and, as such, work upon the Mercury, I freely leave to you, *Pyrophilus*, to consider. And that I may give you some assistance in your Enquiry, I will not only tell you, that I have several times with fair Water wash'd from this *Calx*, good store of strongly tasted Corpuscles, which by the abstraction of the *Menstruum*, I could reduce into Salt; but I will also subjoyn an Experiment, which I devis'd, to shew among other things, how much a real and permanent Colour may be as it were drawn forth by a Liquor that has neither Colour, nor so much as Saline or other Active parts, provided it can but bring the parts of the Body it imbibes to convene into clusters dispos'd after the manner requisite to the exhibiting of the emergent Colour. The Experiment was this.

EXPERIMENT XLIII.

We took good common Vitriol, and having beaten it to Powder, and put it into a Crucible, we kept it melted in a gentle heat, till by the Evaporation of some parts, and the shuffling of the rest, it had quite lost its former Colour, what remained we took out, and found it to be a friable *Calx*, of a dirty Gray. On this we poured fair Water, which it did not Colour Green or Blew, but only seemed to make a muddy mixture with it, then stopping the Vial wherein the Ingredients were put, we let it stand in a quiet place for some days, and after many hours the water having dissolved a good part of the imperfectly calcin'd Body, the Vitriolate Corpuscles swiming to and fro in the Liquor, had time by their opportune Occursions to constitute many little Masses of Vitriol, which gave the water they impregnated a fair Vitriolate Colour; and this Liquor being poured off, the remaining dirty Powder did in process of time communicate the like Colour, but not so deep, to a second parcel of clear Water that we poured on it. But this Experiment, *Pyrophilus*, is, (to give you that hint by the way) of too Luciferous a Nature to be fit to be

fully profecuted, now that I am in haſte, and willing to diſpatch what remains. And we have already ſaid of it, as much as is requiſite to our preſent purpoſe.

EXPERIMENT XLIV.

It may (*Pyrophilus*) ſomewhat contribute towards the ſhewing how much ſome Colours depend upon the leſs or greater mixture, and (as it were) Contemperation of the Light with ſhades, to obſerve how that ſometimes the number of Particles, of the ſame Colour, received into the Pores of a Liquor, or ſwiming up and down in it, do ſeem much to vary the Colour of it. I could here preſent you with particular inſtances to ſhow, how in many (if not moſt) conſiſtent Bodies, if the Colour be not a Light one, as White, Yellow, or the like, the cloſeneſs of parts in the Pigments makes it look Blackiſh, though when it is diſplay'd and laid on thinly, it will perhaps appear to be either Blew, or Green, or Red. But the Colours of conſiſtent Pigments, not being thoſe which the Preamble of this Experiment has led you to expect Examples in, I ſhall take the inſtances I am now to give you, rather from Liquors than Dry Bodies. If then you put a little fair Water into a

clear

clear and ſlender Vial, (or rather into one of thoſe Pipes of Glaſs, which we ſhall by and by mention;) and let fall into it a few drops of a ſtrong Decoction or Infuſion of *Cochinele*, or (for want of that) of *Brazil*; you may ſee the tincted drops deſcend like little Clouds into the Liquor; through which, if, by ſhaking the Vial, you diffuſe them, they will turn the Water either of a Pinck Colour, or like that which is wont to be made by the waſhing of raw fleſh in fair Water; by dropping a little more of the Decoction, you may heighten the Colour into a fine Red, almoſt like that which ennobles Rubies; by continuing the affuſion, you may bring the Liquor to a kind of a Crimſon, and afterwards to a Dark and Opacous Redneſs, ſomewhat like that of Clotted Blood. And in the paſſage of the Liquor from one of theſe Colours to the other, you may obſerve, if you conſider it attentively, divers other leſs noted Colours belonging to Red, to which it is not eaſie to give Names; eſpecially conſidering how much the proportion of the Decoction to the fair Water, and the ſtrength of that Decoction, together with that of the trajected Light and other Circumſtances, may vary the Phænomena of this Experiment. For the conveniencer making whereof, we uſe inſtead

inſtead of a Vial, any ſlender Pipe of Glaſs of about a foot or more in length, and about the thickneſs of a mans little finger; For, if leaving one end of this Pipe open, you Seal up the other Hermetically, (or at leaſt ſtop it exquiſitely with a Cork well fitted to it, and over-laid with hard Sealing Wax melted, and rubbed upon it;) you ſhall have a Glaſs, wherein may be obſerved the Variations of the Colours of Liquors much better than in large Vials, and wherein Experiments of this Nature may be well made with very ſmall quantities of Liquor. And if you pleaſe, you may in this Pipe produce variety of Colours in the various parts of the Liquor, and keep them ſwimming upon one another unmix'd for a good while. And ſome have marvell'd to ſee, what variety of Colours we have ſometimes (but I confeſs rather by chance than skill) produced in thoſe Glaſſes, by the bare infuſion of Brazil, variouſly diluted with fair Water, and alter'd by the Infuſion of ſeveral Chymical Spirits and other Saline Liquors devoid themſelves of Colour, and when the whole Liquor is reduced to an Uniform degree of Colour, I have taken pleaſure to make that very Liquor ſeem to be of Colours gradually differing, by filling with it Glaſſes of a Conical figure, (whether the Glaſs have

its

its basis in the ordinary position, or turn'd upwards.) And yet you need not Glasses of an extraordinary shape to see an instance of what the varied mixture of Light and Shadow can do in the diversifying of the Colour. For if you take but a large round Vial, with a somewhat long and slender Neck, and filling it with our Red Infusion of Brazil, hold it against the Light, you will discern a notable Disparity betwixt the Colour of that part of the Liquor which is in the Body of the Vial, and that which is more pervious to the Light in the Neck. Nay, I remember, that I once had a Glass and a Blew Liquor (consisting chiefly (or only, if my memory deceive me not,) of a certain Solution of Verdigrease) so fitted for my purpose, that though in other Glasses the Experiment would not succeed, yet when that particular Glass was fill'd with that Solution, in the Body of the Vial it appear'd of a lovely Blew, and in the neck, (where the Light did more dilute the Colour,) of a manifest Green; and though I suspected there might be some latent Yellowness in the substance of the neck of the Glass, which might with the Blew compose that Green, yet was I not satisfied my self with my Conjecture, but the thing seem'd odd to me, as well as to divers curi-

ous

ous persons to whom it was shown. And I lately had a Broad piece of Glass, which being looked on against the Light seem'd clear enough, and held from the Light appear'd very lightly discoloured, and yet it was a piece knocked off from a great lump of Glass, to which if we rejoyn'd it, where it had been broken off, the whole Mass was as green as Grass. And I have several times us'd Bottles and Stopples that were both made (as those, I had them from, assured me) of the very same Metal, and yet whilst the bottle appeared but inclining towards a Green, the Stopple (by reason of its great thickness) was of so deep a Colour that you would hardly believe they could possibly be made of the same materials. But to satisfie some Ingenious Men, on another occasion, I provided my self of a flat Glass (which I yet have by me,) with which if I look against the Light with the Broad side obverted to the Eye, it appears like a good ordinary window Glass; but if I turn the Edge of it to my Eye, and place my Eye in a convenient posture in reference to the Light, it may contend for deepness of Colour with an Emerald. And this Greenness puts me in mind of a certain thickish, but not consistent Pigment I have sometimes made, and can show you when you please,

which

which being dropp'd on a piece of White Paper appears, where any quantity of it is fallen, of a somewhat Crimson Colour, but being with ones finger spread thinly on the Paper does presently exhibit a fair Green, which seems to proceed only from its disclosing its Colour upon the Extenuation of its Depth into Superficies, if the change be not somewhat help'd by the Colours degenerating upon one or other of the Accounts formerly mention'd. Let me add, that having made divers Trials with that Blew substance, which in Painters Shops is called *Litmase*, we have sometimes taken Pleasure to observe, that being dissolv'd in a due proportion of fair Water, the Solution either oppos'd to the Light, or dropp'd upon White Paper, did appear of a deep Colour betwixt Crimson and Purple; and yet that being spread very thin on the Paper and suffer'd to dry on there, the Paper was wont to appear Stain'd of a Fine Blew. And to satisfie my self, that the diversity came not from the Paper, which one might suspect capable of imbibing the Liquor, and altering the Colour, I made the Tryal upon a flat piece of purely White Glass'd Earth, (which I sometimes make use of about Experiments of Colours) with an Event not unlike the former.

And

And now I ſpeak of *Litmaſs*, I will add, that having this very day taken a piece of it, that I had kept by me theſe ſeveral years, to make Tryals about Colours, and having let fall a few drops of the ſtrong Infuſion of it in fair Water, into a fine Chryſtal Glaſs, ſhap'd like an inverted Cone, and almoſt full of fair Water, I had now (as formerly) the pleaſure to ſee, and to ſhow others, how theſe few tincted drops variouſly diſperſing themſelves through the Limpid Water, exhibited divers Colours, or varieties of Purple and Crimſon. And when the Corpuſcles of the Pigment ſeem'd to have equally diffuſed themſelves through the whole Liquor, I then by putting two or three drops of Spirit of Salt, firſt made an odd change in the Colour of the Liquor, as well as a viſible commotion among its ſmall parts, and in a ſhort time changed it wholly into a very Glorious Yellow, like that of a Topaz. After which if I let fall a few drops of the ſtrong and heavy Solution of Pot-aſhes, whoſe weight would quickly carry it to the ſharp bottom of the Glaſs, there would ſoon appear four very pleaſant and diſtinct Colours; Namely, a Bright, but Dilute Colour at the picked bottom of the Glaſs; a Purple, a little higher; a deep and glorious Crimſon, (which Crim-

ſon ſeem'd to terminate the operation of the Salt upward) in the confines betwixt the Purple and the Yellow; and an Excellent Yellow, the ſame that before enobled the whole Liquor, reaching from thence to the top of the Glaſs. And if I pleas'd to pour very gently a little Spirit of Sal Armoniack, upon the upper part of this Yellow, there would alſo be a Purple or a Crimſon, or both generated there, ſo that the unalter'd part of the Yellow Liquor appear'd intercepted betwixt the two Neighbouring Colours.

My ſcope in this 3. Experiment (*Pyrophilus*) is manifold, as firſt to invite you to be wary in judging of the Colour of Liquors in ſuch Glaſſes as are therein recommended to you, and conſequently as much if not more, when you imploy other Glaſſes. Secondly, That you may not think it ſtrange, that I often content my ſelf to rub upon a piece of White Paper, the Juice of Bodies I would examine, ſince not only I could not eaſily procure a ſufficient Quantity of the juices of divers of them; but in ſeveral Caſes the Tryals of the quantities of ſuch Juices in Glaſſes would make us more lyable to miſtakes, than the way that in thoſe caſes I have made uſe of. Thirdly, I hope you will by theſe and divers other

particu-

particulars deliver'd in this Treatise, be easily induced to think that I may have set down many Phænomena very faithfully, and just as they appear'd to me, and yet by reason of some unheeded circumstance in the conditions of the matter, and in the degree of Light, or the manner of trying the Experiment, you may find some things to vary from the Relations I make of them. Lastly, I design'd to give you an opportunity to free your self from the amazement which possesses most Men, at the Tricks of those Mountebanks that are commonly call'd Water-drinkers. For though not only the vulgar, but ev'n many persons that are far above that Rank, have so much admir'd to see, a man after having drunk a great deal of fair water, to spurt it out again in the form of Claret-wine, Sack, and Milk, that they have suspected the intervening of Magick, or some forbidden means to effect what they conceived above the power of Art; yet having once by chance had occasion to oblige a Wanderer that made profession of that and other Jugling Tricks, I was easily confirm'd by his Ingenious confession to me, That this so much admired Art, indeed consisted rather in a few Tricks, than in any great Skill, in altering the Nature and Colours of things. And I am easie

to

to be perſwaded, that there may be a great deal of Truth in a little Pamphlet Printed divers years ago in Engliſh, wherein the Author undertakes to diſcover, and that (if I miſtake not) by the confeſſion of ſome of the Complices themſelves, That a famous Water-drinker then much admired in *England*, perform'd his pretended Tranſmutations of Liquors by the help of two or three inconſiderable preparations and mixtures of not unobvious Liquors, and chiefly of an Infuſion of Brazil variouſly diluted and made Pale or Yellowiſh, (and otherwiſe alter'd) with Vinegar, the reſt of their work being perform'd by the ſhape of the Glaſſes, by Craft and Legerdemane. And for my part, that which I marvel at in this buſineſs, is, the Drinkers being able to take down ſo much Water, and ſpout it out with that violence; though Cuſtom and a Vomit ſeaſonably taken before hand, may in ſome of them much facilitate the work. But as for the changes made in the Liquors, they were but few and ſlight in compariſon of thoſe, that the being converſant in Chymical Experiments, and dextrous in applying them to the Tranſmuting of Colours, may eaſily enough enable a man to make, as ev'n what has been newly deliver'd in this, and the foregoing Experiment; eſpecially if we add

to it the things contained in the XX, the XXXIX, and the XL. Experiments, may perhaps have already perſwaded you.

EXPERIMENT XLV.

You may I preſume (*Pyrophilus*) have taken notice, that in this whole Treatiſe, I purpoſely decline (as far as I well can) the mentioning of Elaborate Chymical Experiments, for fear of frighting you by their tediouſneſs and difficulty; but yet in confirmation of what I have been newly telling you about the poſſibility of Varying the Colours of Liquors, better than the Water-drinkers are wont to do, I ſhall add, that *Helmont* uſed to make a preparation of Steel, which a very Ingenious Chymiſt, his Sons Friend, whom you know, ſometimes employes for a ſuccedaneum to the Spaw-Waters, by Diluting this *Eſſentia Martis Liquida* (as he calls it) with a due proportion of Water. Now that for which I mention to you this preparation, (which as he communicated to me, I know he will not refuſe to *Pyrophilus*) is this, that though the Liquor (as I can ſhew you when you pleaſe) be almoſt of the Colour of a German (not an Oriental) Amethiſt, and conſequently remote enough from Green,

yet

yet a very few drops being let fall into a Large proportion of good Rheniſh, or (in want of that) White Wine (which yet does not quite ſo well) immediately turned the Liquor into a lovely Green, as I have not without delight ſhown ſeveral curious Perſons. By which *Phænomenon* you may learn, among other things, how requiſite it is in Experiments about the changes of Colours heedfully to mind the Circumſtances of them; for Water will not, as I have purpoſely tryed, concur to the production of any ſuch Green, nor did it give that Colour to moderate Spirit of Wine, wherein I purpoſely diſſolv'd it, and Wine it ſelf is a Liquor that few would ſuſpect of being able to work ſuddenly any ſuch change in a Metalline preparation of this Nature; and to ſatisfie my ſelf that this new Colour proceeds rather from the peculiar Texture of the Wine, than from any greater Acidity, that Rheniſh or White-wine (for that may not abſurdly be ſuſpected) has in comparison of Water; I purpoſely ſharpen'd the Solution of this Eſſence in fair Water, with a good quantity of Spirit of Salt, notwithſtanding which, the mixture acquir'd no Greenneſs. And to vary the Experiment a little, I try'd, that if into a Glaſs of Rheniſh Wine made Green by this Eſſence,

I dropped an Alcalizate Solution, or Urinous Spirit, the Wine would presently grow Turbid, and of an odd Dirty Colour: But if instead of dissolving the Essence in Wine, I dissolved it in fair Water sharpened perhaps with a little Spirit of Salt, then either the Urinous Spirit of Sal Armoniack, or the Solution of the fixed Salt of Pot-ashes would immediately turn it of a Yellowish Colour, the fixed or Urinous Salt Precipitating the Vitriolate substance contain'd in the Essence. But here I must not forget to take notice of a circumstance that deserves to be compar'd with some part of the foregoing Experiment; for whereas our Essence imparts a Greenness to Wine, but not to Water, the Industrious *Olaus Wormius* in his late *Musæum* tells us of a rare kind of Turn-Sole which he calls *Bezetta Rubra* given him by an Apothecary that knew not how it was made, whose lovely Redness would be easily communicated to Water, if it were immers'd in it; but scarce to Wine, and not at all to Spirit of Wine, in which last circumstance it agrees with what I lately told you of our Essence, notwithstanding their disagreement in other particulars. Libr. 2. Cap. 34.

EXPE-

EXPERIMENT XLVI.

We have often taken notice, as of a remarkable thing, that Metals as they appear to the Eye, before they come to be farther altered by other Bodies, do exhibit Colours very different from those which the Fire and the *Menstruum*, either apart, or both together, do produce in them; especially considering that these Metalline Bodies are after all these disguises reducible not only to their former Metalline Consistence and other more radical properties, but to their Colour too, as if Nature had given divers Metals to each of them a double Colour, an *External*, and an *Internal*; But though upon a more attentive Consideration of this difference of Colours, it seem'd probable to me, that divers (for I say not all) of those Colours which we have just now called *Internal*, are rather produced by the Coalition of Metalline Particles with those of the Salts, or other Bodies employed to work on them, than by the bare alteration of the parts of the Metals themselves: and though therefore we may call the obvious Colours, Natural or Common, and the others Adventitious, yet becaufe such changes of Colours, from whatsoever cause they be resolved to

proceed may be properly enough taken in to illuſtrate our preſent ſubject, we ſhall not ſcruple to take notice of ſome of them, eſpecially becauſe there are among them ſuch as are produced without the intervention of Saline *Menſtruums*. Of the Adventitious Colours of Metalline Bodies the Chief ſorts ſeem to be theſe three. The firſt, ſuch Colours as are produc'd without other Additaments by the Action of the fire upon Metals. The next, ſuch as emerge from the Coalition of Metalline Particles with thoſe of ſome *Menſtruum* imploy'd to Corrode a Metal or Precipitate it; And the laſt, The Colours afforded by Metalline Bodies either Colliquated with, or otherwiſe Penetrating into, other Bodies, eſpecially fuſible ones. But theſe (*Pyrophilus*) are only as I told you, the *Chief* ſorts of the adventitious Colours of Metals, for there may others belong to them, of which I ſhall hereafter have occaſion to take notice of ſome, and of which alſo there poſſibly may be others that I never took notice of.

And to begin with the firſt ſort of Colours, 'tis well enough known to Chymiſts, that Tin being Calcin'd by fire alone is wont to afford a White *Calx*, and Lead Calcin'd by fire alone affords that moſt Common Red Powder we call *Minium*: Copper alſo

ſo Calcin'd *per ſe*, by a long or violent fire, is wont to yield (as far as I have had occaſion to take notice of it) a very Dark or Blackiſh Powder; That Iron likewiſe may by the Action of Reverberated flames be turn'd into a Colour almoſt like that of Saffron, may be eaſily deduc'd from the Preparation of that Powder, which by reaſon of its Colour and of the Metal 'tis made of, is by Chymiſts call'd, *Crocus Martis per ſe*. And that *Mercury* made by the ſtreſs of Fire, may be turn'd into a Red Powder, which Chymiſts call Precipitate *per ſe*, I elſewhere more particularly declare.

Annotation I.

It is not unworthy the Admoniſhing you, (*Pyrophilus*,) and it agrees very well with our Conjectures about the dependence of the change of a Body's Colour upon that of its Texture, that the ſame Metal may by the ſucceſſive operation of the fire receive divers Adventitious Colours, as is evident in Lead, which before it come to ſo deep a Colour as that of *Minium*, may paſs through divers others.

Annotation II.

Not only the *Calces*, but the Glasses of Metals, Vitrify'd *per se*, may be of Colours differing from the Natural or Obvious Colour of the Metal; as I have observ'd in the Glass of Lead, made by long exposing Crude Lead to a violent fire, and what I have observ'd about the Glass or Slagg of Copper, (of which I can show you some of an odd kind of Texture,) may be elsewhere more conveniently related. I have likewise seen a piece of very Dark Glass, which an Ingenious Artificer that show'd it me profess'd himself to have made of Silver alone by an extreme *Violence* (which seems to be no more than is needful) of the fire.

Annotation. III.

Minerals also by the Action of the Fire may be brought to afford Colours very differing from their own, as I not long since noted to you about the variously Colour'd Flowers of Antimony, to which we may add the Whitish Grey-Colour of its *Calx*, and the Yellow or Reddish Colour of the Glass, whereinto that *Calx* may be flux'd.

And I remember, that I elsewhere told you,

you, that Vitriol Calcin'd with a very gentle heat, and afterwards with higher and higher degrees of it, may be made to pass through several Colours before it descends to a Dark Purplish Colour, whereto a strong fire is wont at length to reduce it. But to insist on the Colours produced by the Operation of fire upon several Minerals would take up far more time than I have now to spare.

EXPERIMENT XLVII.

The Adventitious Colours produc'd upon Metals, or rather with them, by Saline Liquors, are many of them so well known to Chymists, that I would not here mention them, but that besides a not un-needed Testimony, I can add something of my own, to what I shall repeat about them, and divers Experiments which are familiar to Chymists, are as yet unknown to the greatest part of Ingenious Men.

That Gold dissolved in *Aqua Regia* ennobles the *Menstruum* with its own Colour, is a thing that you cannot (*Pyrophilus*) but have often seen. The Solutions of Mercury in *Aqua-fortis* are not generally taken notice of, to give any notable Tincture to the *Menstruum*; but sometimes when the Liquor

Liquor first falls upon the Quick-Silver, I have obſerv'd a very remarkable, though not durable, Greenneſs, or Blewneſs to be produc'd, which is a *Phænomenon* not unfit for you to conſider, though I have not now the leiſure to diſcourſe upon it. Tin Corroded by *Aqua-fortis* till the *Menſtruum* will work no farther on it, becomes exceeding White, but as we elſewhere note, does very eaſily of it ſelf acquire the conſiſtence, not of a Metalline *Calx*, but of a Coagulated matter, which we have obſerv'd with pleaſure to look ſo like, either to curdled Milk, or curdled Whites of Eggs, that a perſon unacquainted with ſuch Solutions may eaſily be miſtaken in it. But when I purpoſely prepared a *Menſtruum* that would diſſolve it as *Aqua-fortis* diſſolves Silver, and not barely Corrode it, and quickly let it fall again, I remember not that I took notice of any particular Colour in the Solution, as if the more Whitiſh Metals did not much Tinge their *Menſtruums*, though the conſpicuouſly Colour'd Metals as Gold, and Copper, do. For Lead diſſolv'd in Spirit of Vinegar or *Aqua-fortis* gives a Solution clear enough, and if the *Menſtruum* be abſtracted appears either Diaphanous or White. Of the colour of Iron we have elſewhere ſaid ſomething; And 'tis worth noting,

noting, that though if that Metal be diſſolv'd in oyl of Vitriol diluted with Water, it affords a Salt or Magiſtery ſo like in colour, as well as ſome other Qualities, to other green Vitriol, that Chymiſts do not improperly call it *Vitriolum Martis*; yet I have purpoſely try'd, that, by changing the *Menſtruum*, and pouring upon the filings of Steel, inſtead of Oyl of Vitriol, *Aqua Fortis*, (whereof as I remember, I us'd 4 parts to one of the Metal) I obtain'd not a Green, but a Saffron Colour Solution; or rather a thick Liquor of a deep but yellowiſh Red. Common Silver, ſuch as is to be met with in Coins, being diſſolved in *Aqua Fortis*, yields a Solution tincted like that of Copper, which is not to be wondred at, becauſe in the coining of Silver, they are wont (as we elſewhere particularly inform you) to give it an Allay of Copper, and that which is ſold in Shops for refined Silver, is not (ſo far as we have tryed) ſo perfectly free from that ignobler Metal, but that a Solution of it in *Aqua fortis*, will give a Venereal Tincture to the *Menſtruum*. But we could not obſerve upon the ſolution of ſome Silver, which was perfectly refined, (ſuch as ſome that we have, from which 8 or 10 times its weight of Lead has been blown off) that the *Menſtruum*

ſtruum though held againſt the Light in a Chryſtal Vial did manifeſtly diſcloſe any Tincture, only it ſeem'd ſometimes not to be quite deſtitute of a little, but very faint Blewiſhneſs.

But here I muſt take notice, that of all the Metals, there is not any which doth ſo eaſily and conſtantly diſcloſe its unobvious colour as Copper doth. For not only in acid *Menſtruums* as *Aqua Fortis* and Spirit of Vinegar, it gives a Blewiſh green ſolution, but if it be almoſt any way corroded, it *appears of one of thoſe* two colours, as may be obſerved in Verdigreaſe made ſeveral ways, in that odd preparation of *Venus*, which we elſewhere teach you to make with Sublimate, and in the common Vitriols of *Venus* deliver'd by Chymiſts; and ſo conſtant is the diſpoſition of Copper, notwithſtanding the diſguiſe Artiſts put upon it, to diſcloſe the colour we have been mentioning, that we have by forcing it up with *Sal Armoniack* obtained a Sublimate of a Blewiſh Colour. Nay a famous Spagyriſt affirms, that the very Mercury of it is green, but till he teach us an intelligible way of making ſuch a Mercury, we muſt content our ſelves to inform you, that we have had a Cupreous Body, that was Præcipitated out of a diſtill'd Liquor, that ſeem'd to be

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the Sulphur of *Venus*, and ſeem'd even when flaming, of a Greeniſh Colour. And indeed Copper is a Metal ſo eaſily wrought upon by Liquors of ſeveral kinds, that I ſhould tell you, I know not any Mineral, that will concur to the production of ſuch a variety of Colours as Copper diſſolv'd in ſeveral *Menſtruums*, as Spirit of Vinegar, *Aqua-fortis*, *Aqua-Regis*, Spirit of Nitre, of Urine, of Soot, Oyls of ſeveral kinds, and I know not how many other Liquors, if the variety of ſomewhat differing colours (that Copper will be made to aſſume, as it is wrought upon by ſeveral Liquors) were not comprehended within the Limits of Greeniſh Blew, or Blewiſh Green.

And yet I muſt advertiſe you (*Pyrophilus*) that being deſirous to try if I could not make with crude Copper a Green Solution without the Blewiſhneſs that is wont to accompany its Vulgar Solutions, I bethought my ſelf of uſing two *Menſtruums*, which I had not known imploy'd to work on this Metal, and which I had certain Reaſons to make tryal of, as I ſucceſsfully did. The one of theſe Liquors (if I much miſremember not) was Spirit of Sugar diſtilled in a Retort, which muſt be warily done, (if you will avoid breaking your glaſſes)

glaſſes) and the other, Oyl or Spirit of Turpentine, which affords a fine Green Solution that is uſeful to me on ſeveral occaſions. And yet to ſhew that the adventitious Colour may reſult, as well from the true and permanent Copper it ſelf, as the Salts wherewith 'tis corroded, I ſhall add, that if you take a piece of good *Dantzick* Copperis, or any other Vitriol wherein *Venus* is prædominant, and having moiſtned it in your Mouth, or with fair Water, rub it upon a whetted Knife, or any other bright piece of Steel or Iron, it will (as we have formerly told you) preſently ſtain the Steel with a Reddiſh Colour, like that of Copper: the reaſon of which, we muſt not now ſtay to enquire.

Annotation I.

I preſume you may have taken notice (*Pyrophilus*) that I have borrowed ſome of the Inſtances mentioned in this 47. Experiment, from the Laboratories of Chymiſts, and becauſe in ſome (though very few) other paſſages of this Eſſay, I have likewiſe made uſe of Experiments mentioned alſo by ſome Spagyrical Writers, I think it not amiſs to repreſent to you on this Occaſion once for all, ſome things beſides

those

thoſe which I intimated in the præamble of this preſent Experiment; For beſides, that 'tis very allowable for a Writer to repeat an Experiment which he invented not, in caſe he improve it; And beſides that many Experiments familiar to Chymiſts are unknown to the generality of Learned Men, who either never read Chymical proceſſes, or never underſtood their meaning, or never durſt believe them; beſides theſe things, I ſay, I ſhall repreſent, That, as to the few Experiments I have borrowed from the Chymiſts, if they be very Vulgar, 'twould perhaps be difficult to aſcribe each of them its own Author, and 'tis more than the generality of Chymiſts themſelves can do: and if they be not of very known and familiar practiſe among them, unleſs the Authors wherein I found them had given me cauſe to believe, themſelves had tryed them, I know not why I might not ſet them down, as a part of the *Phænomena* of Colours which I preſent you; Many things unanimouſly enough delivered as matters of fact by (I know not how many Chymical Writers) being not to be relyed on, upon the ſingle Authority of ſuch Authors: For inſtance, as ſome Spagyriſts deliver (perhaps amongſt ſeveral deceitful proceſſes) that *Saccarum Saturni*

turni with Spirit of Turpentine will afford a Balsom, so *Beguinus* and many more tell us, that the same Concrete (*Saccarum Saturni*) will yield an incomparably fragrant Spirit, and a pretty Quantity of two several Oyls, and yet since many have complained, as well as I have done, that they could find no such odoriferous, but rather an ill-scented Liquor, and scarce any Oyl in their Distillation of that sweet Vitriol, a wary person would as little build any thing on what they say of the former Experiment, as upon what they aver of the later, and therefore I scrupled not to mention this Red Balsom of which I have not seen any, (but what I made) among my other Experiments about redness.

Annot. II.

We have sometimes had the Curiosity to try what Colours Minerals, as Tinglass, Antimony, Spelter, &c. would yield in several *Menstruums*, nor have we forborn to try the Colours of Stones, of which that famous one, (which *Helmont* calls *Paracelsus*'s *Ludus*) though it be digged out of the Earth and seem a true stone, has yielded in *Menstruums* capable to dissolve solid a stone, sometimes a Yellowish, some-

sometimes a Red solution of both which I can show you. But though I have from Minerals obtained with several *Menstruums* very differing Colours, and some such as perhaps you would be surprized to see drawn from such Bodies: yet I must now pass by the particulars, being desirous to put an End to this Treatise, before I put an end to your Patience and my own.

Annotation III.

And yet before I pass to the next Experiment, I must put you in mind, that the Colours of Metals may in many cases be further altered by imploying, either precipitating Salts, or other convenient Substances to act upon their Solutions. Of this you may remember, that I have given you several Instances already, to which may be added such as these, That if Quick-Silver be dissolved in *Aqua-fortis*, and Precipitated out of the Solution, either with water impregnated with Sea-salt, or with the spirit of that Concrete, it falls to the Bottom in the form of a White-Powder, whereas if it be Precipitated with an Alcaly, it will afford a Yellowish or tawny Powder, and if there be no Precipitation made, and the *Menstruum* be drawn off with a convenient

fire, the corroded Mercury will remain in the Bottom, in the form of a ſubſtance that may be made to appear of differing Colours by differing degrees of Heat; As I remember that lately having purpoſely abſtracted *Aqua-fortis* from ſome Quick-ſilver that we had diſſolv'd in it, ſo that there remained a White *Calx*, expoſing that to ſeveral degrees of fire, and afterwards to a naked one, we obtained ſome new Colours, and at length the greateſt part of the *Calx*, lying at the Bottom of the Vial, and being brought partly to a Deep Yellow, and partly to a Red Colour, the reſt appeared elevated to the upper part and neck of the Vial, ſome in the form of a Reddiſh, and ſome of an Aſh-Colour Sublimate. But of the differing Colours which by differing ways and working of Quick-Silver with Fire, and Saline bodies, may be produced in Precipitates, I may elſewhere have occaſion to take further notice. I alſo told you not long ſince, that if you corrode Quick-ſilver with Oyl of Vitriol inſtead of *Aqua-fortis*, and abſtract the *Menſtruum*, there will remain a White *Calx* which by the Affuſion of Fair Water preſently turns into a Lemmon Colour. And even the *Succedaneum* to a *Menſtruum* may ſometimes ſerve the turn to change the Colours of a Metal. The love-

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ly Red which Painters call Vermillion, is made of Mercury, which is of the Colour of Silver, and of Brimstone which is of Kin to that of Gold, Sublimed up together in a certain proportion, as is vulgarly known to Spagyrists.

EXPERIMENT XLVIII.

The third chief sort of the Adventitious Colours of Metals, is, that which is produced by associating them (especially when Calcin'd) with other fusible Bodies, and Principally Venice, and other fine Glass devoid of Colour.

I have formerly given you an Example, whereby it may appear, that a Metal may impart to Glass a Colour much differing from its own, when I told you, how with Silver I had given Glass a lovely Golden Colour. And I shall now add, that I have Learned from one of the Chief Artificers that sells Painted Glass, that those of his Trade Colour it Yellow with a preparation of the *Calx* of Silver. Though having lately had occasion among other Tryals to mingle a few grains of Shell-silver (such as is imployed with the Pensil and Pen) with a convenient proportion of powder'd Crystal Glass, having kept them two or three

hours in fusion, I was surpriz'd to find the Colliquated Mass to appear upon breaking the Crucible of a lovely Saphirine Blew, which made me suspect my Servant might have brought me a wrong Crucible, but he constantly affirmed it to be the same wherein the Silver was put, and considerable Circumstances countenanced his Assertion, so that till I have opportunity to make farther Tryal, I cannot but suspect, either that Silver which is not (which is not very probable) brought to a perfect Fusion and Colliquation with Glass, may impart to it other Colours than when Neal'd upon it, or else (which is less unlikely) that though Silver-Beaters usually chuse the finest Coyn they can get, as that which is most extensive under the Hammer, yet the Silver-leaves of which this Shel-silver was made, might retain so much Copper as to enable it to give the predominant Tincture to the Glass.

For, I must proceed to tell you (*Pyrophilus*) as another instance of the Adventitious Colours of Metals, that which is something strange, Namely, That though Copper Calcin'd *per se* affords but a Dark and basely Coloured *Calx*, yet the Glass-men do with it, as themselves inform me, Tinge their Glass green. And I remember, that when once we took some crude Copper,

per, and by frequent Ignition quenching it in Water had reduced it to a Dark and Ill-coloured Powder, and afterwards kept it in Fusion in about 100 times its weight of fine Glass, we had, though not a Green, yet a Blew Coloured Mass, which would perhaps have been Green, if we had hit right upon the Proportion of the Materials, and the Degree of Fire, and the Time wherein it ought to be kept in Fusion, so plentifully does that Metal abound in a Venerial Tincture, as Artists call it, and in so many ways does it disclose that Richness. But though Copper do as we have said give somewhat near the like Colour to Glass, which it does to *Aqua-fortis*, yet it seems worth inquiry, whether those new Colours which Mineral Bodies disclose in melted Glass, proceed from the Coalition of the Corpuscles of the Mineral with the Particles of the Glass as such, or from the Action (excited or actuated by fire) of the Alcalizate Salt (which is a main Ingredient of Glass,) upon the Mineral Body, or from the concurrence of both these Causes, or else from any other. But to return to that which we were saying, we may observe that *Putty* made by calcining together a proportion of Tin and Lead, as it is it self a White *Calx*, so does it turn the *Pitta di Cryſtallo* (as the

Glaſs-men call the matter of the Purer ſort of Glaſs, wherewith it is Colliquated into a White Maſs, which if it be opacous enough is employ'd, as we elſewhere declare, for White Amel. But of the Colours which the other Metals may be made to produce in Colourleſs Glaſs, and other Vitrifiable Bodies, that have native Colours of their own, I muſt leave you to inform your ſelf upon Tryal, or at leaſt muſt forbear to do it till another time, conſidering how many Annotations are to follow, upon what has in this and the two former Experiments been ſaid already.

Annotation I.

When the Materials of Glaſs being melted with Calcin'd Tin, have compoſed a Maſs Undiaphanous and White, this White Amel is as it were the Baſis of all thoſe fine Concretes that Goldſmiths and ſeveral Artificers imploy in the curious Art of Enamelling. For this White and Fuſible ſubſtance will receive into it ſelf, without ſpoiling them, the Colours of divers other Mineral ſubſtances, which like it will indure the fire.

Annota-

Annotation II.

So that as by the preſent (XLVIII.) Experiment it appears, that divers Minerals will impart to fuſible Maſſes, Colours differing from their own; ſo by the making and compounding of Amels, it may appear, that divers Bodies will both retain their Colour in the fire, and impart the *ſame* to ſome others wherewith they were vitrified, and in ſuch Tryals as that mention'd in the 17. Experiment, where I told you, that even in Amels a Blew and Yellow will compound a Green. 'Tis pretty to behold, not only that ſome Colours are of ſo fix'd a Nature, as to be capable of mixture without receiving any detriment by the fire, that does ſo eaſily deſtroy or ſpoil thoſe of other Bodies; but Mineral Pigments may be mingled by fire little leſs regularly and ſucceſsfully, than in ordinary Dying Fatts, the vulgar Colours are wont to be mingled by the help of Water.

Annotation III.

'Tis not only Metalline, but other Mineral Bodies, that may be imployed, to give Tinctures unto Glaſs (and 'tis worth noting

how ſmall a quantity of ſome Mineral ſubſtances, will Tinge a Comparatively vaſt proportion of Glaſs, and we have ſometimes attempted to Colour Glaſs, even with Precious Stones, and had cauſe to think the Experiment not caſt away. And 'tis known by them that have look'd into the Art of Glaſs, that the Artificers uſe to tinge their Glaſs Blew, with that Dark Mineral *Zaffora*, (ſome of my Tryals on which I elſewhere acquaint you) which ſome would have to be a Mineral Earth, others a Stone, and others neither the one, nor the other, but which is confeſſedly of a Dark, but not a Blew Colour, though it be not agreed of what particular Colour it is. 'Tis likewiſe though a familiar yet a remarkable practiſe among thoſe that Deal in the making of Glaſs, to imploy (as ſome of themſelves have informed me) what they call Manganeſs, and ſome Authors call *Magneſia* (of which I make particular mention in another Treatiſe) to exhibit in Glaſs not only other Colours than its own, (which is ſo like in Darkneſs or Blackiſhneſs to the Load-ſtone, that 'tis given by Mineraliſts, for one of the Reaſons of its Latine Name) but Colours differing from one another. For though they uſe it, (which is ſomewhat ſtrange) to Clariſie their Glaſs, and free

it

it from that Blewish Greenish Colour, which else it would too often be subject to, yet they also imploy it in certain proportions, to tinge their Glass both with a Red Colour, and with a Purplish or Murry, and putting in a greater quantity, they also make with it that deep obscure Glass which is wont to pass for Black, which agrees very well with, and may serve to confirm what we noted near the beginning of the 44. Experiment, of the seeming Blackness of those Bodies that are overcharged with the Corpuscles of such Colours, as Red, or Blew, or Green, &c. And as by several Metals and other Minerals we can give various Colours to Glass, so on the other side, by the differing Colours that Mineral Oars, or other Mineral Powders being melted with Glass disclose in it, a good Conjecture may be oftentimes made of the Metal or known Mineral, that the Oar proposed, either holds, or is most of kin to. And this easie way of examining Oars, may be in some cases of good use, and is not ill delivered by *Glauber*, to whom I shall at present refer you, for a more particular account of it: unless your Curiosity command also what I have observed about these matters; only I must here advertise you, that great circumspection is

requi-

requisite to keep this way from proving fallacious, upon the account of the variations of Colour that may be produced by the differing proportions that may be used betwixt the Oar and the Glass, by the Richness or Poorness of the Oar it self, by the Degree of Fire, and (especially) by the Length of Time, during which the matter is kept in fusion; as you will easily gather from what you will quickly meet with in the following Annotation upon this present 48. Experiment.

Annotation VI.

There is another way and differing enough from those already mentioned, by which Metals may be brought to exhibit adventitious Colours: For by this, the Metal does not so much impart a Colour to another Body, as receive a Colour from it, or rather both Bodies do by the new Texture resulting from their mistion produce a new Colour. I will not insist to this purpose upon the Examples afforded us by yellow Orpiment, and common Sea Salt, from which, sublim'd together, Chymists unanimously affirm their White or Crystalline Arsenick to be made: But 'tis not unworthy our noting, That though Yellow

low Orpiment be acknowledged to be the Copiouſeſt by far of the two Ingredients of Arſenick, yet this laſt named Body being duly added to the higheſt Coloured Metal Copper, when 'tis in fuſion, gives it a whiteneſs both within and without. Thus *Lapis Calaminaris* changes and improves the Colour of Copper by turning it into Braſs. And I have ſometimes by the help of Zinck duly mixed after a certain manner, given Copper one of the Richeſt Golden Colours that ever I have ſeen the beſt true Gold Ennobled with. But pray have a care that ſuch Hints fall not into any hands that may miſ-employ them.

Annotation V.

Upon the Knowledge of the differing ways of making Minerals and Metals produce their adventitious Colours in Bodies capable of Vitrification, depends the pretty Art of making what Chymiſts by a Barbarous Word are pleaſed to call *Amanſes*, that is counterfeit, or factitious Gems, as Emeralds, Rubies, Saphires, Topazes, and the like. For in the making of theſe, though pure Sand or Calcin'd Cryſtal give the Body, yet 'tis for the moſt part ſome Metalline or Mineral *Calx*, mingled in a ſmall

ſmall proportion that gives the Colour. But though I have many years ſince taken delight, to divert my ſelf with this pleaſing Art, and have ſeen very pretty productions of it, yet beſides that I fear I have now forgot moſt of the little Skill I had in it, this is no place to entertain you with what would rather take up an intire Diſcourſe, than be comprehended in an Annotation; wherefore the few things which I ſhall here take notice of to you, are only what belong to the preſent Argument, Namely,

Firſt, That I have often obſerved that Calcin'd Lead Colliquated with fine White Sand or Cryſtal, reduced by Ignitions and ſubſequent extinctions in Water to a ſubtile Powder, will of it ſelf be brought by a due Decoction to give a clear Maſs Coloured like a *German* Amethyſt. For though this Glaſs of Lead, is looked upon by them that know no better way of making *Amanſes*, as the grand Work of them all, yet which is an inconvenience that much blemiſhes this way, the Calcin'd Lead it ſelf does not only afford matter to the *Amanſes*, but has alſo as well as other Metals a Colour of its own, which as I was ſaying, I have often found to be like that of *German* (as many call them) not Eaſtern Amethyſts.

Secondly, That nevertheleſs this Colour may

may be easily over-powred by those of divers other Mineral Pigments (if I may so call them) so that with a glass of Lead, you may Emulate (for Instance) the fresh and lovely Greenness of an Emerald, though in divers cases the Colour which the Lead it self upon Vitrification tends to, may vitiate that of the Pigment, which you would introduce into the Mass.

Thirdly, That so much ev'n these Colours depend upon Texture, that in the Glass of Lead it self made of about three parts of *Lytharge* or *Minium* Colliquated with one of very finely Powder'd Crystal or Sand, we have taken pleasure to make the mixture pass through differing Colours, as we kept it more or less in the Fusion. For it was not usually till after a pretty long Decoction that the Mass attain'd to the Amethystin Colour.

Fourthly and lastly, That the degrees of Coction and other Circumstances may so vary the Colour produced in the same Mass, that in a Crucible that was not great I have had fragments of the same Mass, in some of which perhaps not so big as a Hazel-Nut, you may discern four distinct Colours.

Anno-

Annotation VI.

You may remember (*Pyrophilus*) that when I mentioned the three ſorts of adventitious Colours of Metals, I mention'd them but as the chief, not the only. For there may be other ways, which though they do not in ſo ſtrict a ſenſe belong to the adventitious Colours of Metals, may not inconveniently be reduced to them. And of theſe I ſhall name now a couple, without denying that there may be more.

The firſt may be drawn from the practiſe of thoſe that Dye Scarlet. For the famouſeſt Maſter in that Art, either in *England* or *Holland*, has confeſs'd to me, that neither others, nor he can ſtrike that lovely Colour which is now wont to be called the *Bow-Dye*, without their Materials be Boyled in Veſſels, either made of, or lin'd with a particular Metal. But of what I have known attempted in this kind, I muſt not as yet for fear of prejudicing or diſpleaſing others give you any particular Account.

See the latter end of the fiftieth Expement.

The other way (*Pyrophilus*) of making Metals afford unobvious Colours, is by imbuing divers Bodies with Solutions of them made in their proper *Menſtruums*, As (for Inſtance,)

Instance) though Copper plentifully dissolv'd in *Aqua-fortis*, will imbue several Bodies with the Colour of the Solution; Yet some other Metals will not (as I elsewhere tell you) and have often tryed. Gold dissolv'd in *Aqua Regia*, will, (which is not commonly known) Dye the Nails and Skin, and Hafts of Knives, and other things made of Ivory, not with a Golden, but a Purple Colour, which though it manifest it self but slowly, is very durable, and scarce ever to be washed out. And if I misremember not, I have already told you in this Treatise, that the purer Crystals of fine Silver made with *Aqua-fortis*, though they appear White, will presently Dye the Skin and Nails, with a Black, or at least a very Dark Colour, which Water will not wash off, as it will ordinary Ink from the same parts. And divers other Bodies may the same way be Dy'd, some of a Black, and others of a Blackish Colour.

And as Metalline, so likewise Mineral Solutions may produce Colours differing enough from those of the Liquors themselves. I shall not fetch an Example of this, from what we daily see happen in the powdring of Beef, which by the Brine imployed about it (especially if the flesh be over

over ſalted) does oftentimes apppear at our Tables of a Green, and ſometimes of a Reddiſh Colour, (deep enough) nor ſhall I inſiſt on the practice of ſome that deal in Salt Petre, who, (as I ſuſpected, and as themſelves acknowledged to me) do, with the mixture of a certain proportion of that, and common Salt, give a fine Redneſs, not only to Neats Tongues, but which is more pretty as well as difficult, to ſuch fleſh, as would otherwiſe be purely White; Theſe Examples, I ſay, I ſhall decline inſiſting on, as chuſing rather to tell you, that I have ſeveral times tryed, that a Solution of the Sulphur of Vitriol, or even of common Sulphur, though the Liquor appeared clear enough, would immediately tinge a piece of new Coin, or other clean Silver, ſometimes with a Golden, ſometimes with a deeper, and more Reddiſh Colour, according to the ſtrength of the Solution, and the quantity of it, that chanced to adhere to the Metal, which may take off your wonder that the water of the hot Spring at *Bath*, abounding with diſſolved Subſtances of a very Sulphureous Nature, ſhould for a while, as it were gild, the new or clean pieces of Silver coyn, that are for a due time immerſed in it. And to theſe may be added thoſe formerly mention'd Examples

of

of the adventitious Colours of Mineral Bodies; which brings into my mind, that, even Vegetable Liquors, whether by degeneration, or by altering the Texture of the Body that imbibes them, may ſtain other Bodies with Colours differing enough from their own; of which very good Herbariſts have afforded us a notable Example, by affirming that the Juice of *Alcanna* being green (in which ſtate I could never here procure it) does yet Dye the Skin and Nails of a Laſting Red. But I ſee this Treatiſe is like to prove too bulky without the addition of further Inſtances of this Nature.

EXPERIMENT XLIX.

Meeting the other day, *Pyrophilus*, in an *Italian* Book, that treats of other matters, with a way of preparing what the Author calls a *Lacca* of Vegetables, by which the *Italians* mean a kind of Extract fit for Painting, like that rich *Lacca* in Engliſh commonly called *Lake*, which is employed by Painters as a glorious Red. And finding the Experiment not to be inconſiderable, and very defectively ſet down, it will not be amiſs to acquaint you with what ſome Tryals have informed us, in reference to this

Experiment, which both by our Italian Author, and by divers of his Countrymen, is look'd upon as no trifling Secret.

Take then the root call'd in Latin *Curcuma*, and in Engliſh Turmerick, (which I made uſe of, becauſe it was then at hand, and is among Vegetables fit for that purpoſe one of the moſt eaſieſt to be had) and when it is beaten, put what Quantity of it you pleaſe into fair Water, adding to every pound of Water about a ſpoonful or better of as ſtrong a *Lixivium* or Solution of Potaſhes as you can well make, Clarifying it by Filtration before you put it to the Decocting water. Let theſe things boyl, or rather ſimper over a ſoft Fire in a clean glaz'd Earthen Veſſel, till you find by the Immerſion of a ſheet of White Paper (or by ſome other way of Tryal) that the Liquor is ſufficiently impregnated with the Golden Tincture of the Turmerick; then take the Decoction off the Fire, and Filter or Strain it that it may be clean, and leiſurely droping into it a ſtrong Solution of Roch Alom, you ſhall find the Decoction as it were curdl'd, and the tincted part of it either to emerge, to ſubſide, or to ſwim up and down, like little Yellow flakes; and if you pour this mixture into a Tunnel lin'd with Cap paper, the Liquor that Filtred formerly

ly so Yellow, will now pass clean through the Filtre, leaving its tincted, and as it were curdled parts in the Filtre, upon which fair Water must be so often pour'd, till you have Dulcifi'd the matter therein contained, the sign of which Dulcification is (you know) when the Water that has pass'd through it, comes from it as tastless as it was poured on it. And if without Filtration you would gather together the flakes of this Vegetable Lake, you must pour a great Quantity of fair Water upon the Decoction after the affusion of the Alluminous Solution, and you shall find the Liquor to grow clearer, and the Lake to settle together at the bottom, or emerge to the top of the Water, though sometimes having not poured out a sufficient Quantity of fair Water, we have observed the Lake partly to subside, and partly to emerge, leaving all the middle of the Liquor clear. But to make this Lake fit for use, it must by repeated affusions of fresh Water, be Dulcified from the adhering Salts, as well as that separated by Filtration, and be spread and suffered to dry leisurely upon pieces of Cloth, with Brown Paper, or Chalk, or Bricks un-

der them to imbibe the Moisture *.

* *The Curious Reader that desires further Information concerning Lakes, may Resort to the 7th. Book of* Neri's *Art of Glass, Englished (6 or 7 years since the writing of this 49th. Experiment) and Illustrated with Learned Observations, by the Inquisitive and Experienced Dr.* Charles Merret.

Annotation I.

Whereas it is presumed that the Magistery of Vegetables obtained this way consists but of the more Soluble and Coloured parts of the Plants that afford it, I must take the liberty to Question the Supposition. And for my so doing, I shall give you this account.

According to the Notions (such as they were) that I had concerning Salts; Allom, though to sense a Homogeneous Body, ought not to be reckoned among true Salts, but to be it self looked upon as a kind of Magistery, in regard that as Native Vitriol (for such I have had) contains both a Saline substance and a Metal, whether Copper, or Iron, corroded by it, and associated with it; so Allom which may be of so near a kin to Vitriol, that in some places of *England* (as we are assured by good Authority the same stone will some-

ſometimes afford both) ſeems manifeſtly to contain a peculiar kind of Acid Spirit, generated in the Bowels of the Earth, and ſome kind of ſtony matter diſſolved by it. And though in making our ordinary Allom, the Workmen uſe the Aſhes of a Sea Weed (vulgarly called Kelp) and Urine: yet thoſe that ſhould know, inform us, that, here in *England*, there is beſides the factitious Allom, Allom made by Nature without the help of thoſe Additaments. Now (*Pyrophilus*) when I conſidered this compoſition of Allom, and that Alcalizate Salts are wont to Precipitate what acid Salts hace diſſolved, I could not but be prone to ſuſpect that the Curdled Matter, which is called the Magiſtery of Vegetables, may have in it no inconſiderable proportion of a ſtony ſubſtance Precipitated out of the Allom by the *Lixivium*, wherein the Vegetable had been decocted, and to ſhew you, that there is no neceſſity, that all the curdled ſubſtance muſt belong to the Vegetable, I ſhall add, that I took a ſtrong Solution of Allom, and having Filtred it, by pouring in a convenient Quantity of a ſtrong Solution of Potaſhes, I preſently, as I expected, turned the mixture into a kind of white Curds, which being put to Filtre, the Paper retain'd a ſto-

ny *Calx*, copious enough, very White, and which seem'd to be of a Mineral Nature, both by some other signs, and this, that little Bits of it being put upon a live Coal, which was Gently Blown whilst they were on it, they did neither melt nor fly away, and you may keep a Quantity of this White Substance for a good while, (nay for ought I can guess, for a very long one) in a red hot Crucible without losing or spoiling it; nor did hot Water wherein I purposely kept another parcel of such *Calx*, seem to do any more than wash away the looser adhering Salts from the stony Substance, which therefore seem'd unlikely to be separable by ablutions (though reiterated) from the Præcipitated parts of the Vegetable, whose Lake is intended. And to shew you, that there is likewise in Allom a Body, with which the fix'd Salt of the Alcalizate Solution will concoagulate into a Saline Substance differing from either of them, I shall add, that I have taken pleasure to recover out of the slowly exhal'd Liquor, that pass'd through the filtre, and left the forementionꝺ *Calx* behind, a Body that at least seem'd a Salt very pretty to look on, as being very White, and consisting of an innumerable company of exceeding slender, and shining Particles, which would

would in part easily melt at the flame of a Candle, and in part flye away with some little noise. But of this substance, and its odd Qualities more perhaps elsewhere; for now I shall only take notice to you, that I have likewise with Urinous Salts, such as the Spirit of Sal Armoniack, as well as with the Spirit of Urine it self, Nay, (if I much mistake not) even with Stale Urine undistill'd, easily Precipitated such a White *Calx*, as I was formerly speaking of, out of a Limpid Solution of Allom, so that there is need of Circumspection in judging of the Natures of Liquors by Precipitations wherein Allom intervenes, else we may sometimes mistakingly imagine that to be Precipitated out of a Liquor by Allom, which is rather Precipitated out of Allom by the Liquor: And this puts me in mind to tell you, that 'tis not unpleasant to behold how quickly the Solution of Allom (or injected lumps of Allom) does occasion the severing of the coloured parts of the Decoction from the Liquor that seem'd to have so perfectly imbib'd them.

Annotation II.

The above mentioned way of making Lakes we have tryed not only with Turmerick, but also with Madder, which yielded us a Red Lake; and with Rue, which afforded us an extract, of (almost if not altogether) the same Colour with that of the leaves.

But in regard that 'tis Principally the Alcalizate Salt of the Pot-ashes, which enables the water to Extract so powerfully the Tincture of the Decocted Vegetables, I fear that our Author may be mistaken by supposing that the Decoction will always be of the very same Colour with the Vegetable it is made of. For Lixiviate Salts, to which Pot-ashes eminently belong, though by piercing and opening the Bodies of Vegetables, they prepare and dispose them to part readily with their Tincture, yet some Tinctures they do not only draw out, but likewise alter them, as may be easily made appear by many of the Experiments already set down in this Treatise, and though Allom being of an Acid Nature, its Solutions may in some Cases destroy the Adventitious Colours produc'd by the Alcaly, and restore the former: yet

besides

beſides that Allom is not, as I have lately ſhown, a meer Acid Salt, but a mixt Body, and beſides, that its operations are languid in compariſon of the activity of Salts freed by Diſtillation, or by Incineration and Diſſolution, from the moſt of their Earthy parts, we have ſeen already Examples, that in divers Caſes an Acid Salt will not reſtore a Vegetable ſubſtance to the Colour of which an Alcalizate one had deprived it, but makes it aſſume a third very differing from both, as we formerly told you, that if Syrrup of Violets were by an Alcaly turned Green, (which Colour, as I have try'd, may be the ſame way produced in the Violet-leaves themſelves without any Relation to a Syrrup) an Acid Salt would not make it Blew again, but Red. And though I have by this way of making Lakes, made Magiſteries (for ſuch they ſeem to be) of Brazil, and as I remember of Cochinele it ſelf, and of other things, Red, Yellow or Green which Lakes were ennobled with a Rich Colour, and others had no bad one; yet in ſome the Colour of the Lake ſeemed rather inferiour than otherwiſe to that of the Plant, and in others it ſeemed both very differing, and much worſe; but Writing this in a time and place where I cannot provide my ſelf of Flowrs and other Vegetables to pro-

ſecute

secute such Tryals in a competent variety of Subjects, I am content not to be positive in delivering a judgment of this way of Lakes, till Experience, or You, *Pyrophilus*, shall have afforded me a fuller and more particular Information.

Annotation III.

And on this occasion (*Pyrophilus*) I must here (having forgot to do it sooner) advertise you once for all, that having written several of the foregoing Experiments, not only in haste but at seasons of the year, and in places wherein I could not furnish my self with such Instruments, and such a variety of Materials, as the design of giving you an Introduction into the History of Colours requir'd, it can scarce be otherwise but that divers of the Experiments, that I have set down, may afford you some matter of new Tryals, if you think fit to supply the deficiencies of some of them (especially the freshly mention'd about Lakes, and those that concern Emphatical Colours) which deficiencies for want of being befriended with accommodations I could better discern than avoid.

Annotation

Annotation IV.

The use of Allom is very great as well as familiar in the Dyers Trade, and I have not been ill pleased with the use I have been able to make of it in preparing other pigments than those they imploy with Vegetable Juices. But the Lucriferous practises of Dyers and other Tradesmen, I do, for Reasons that you may know when you please, purposely forbear in this Essay, though not strictly from pointing at, yet from making it a part of my present work explicitely and circumstantially to deliver, especially since I now find (though late and not without some Blushes at my prolixity) that what I intended but for a short Essay, is already swell'd into almost a Volume.

EXPERIMENT L.

Yet here, *Pyrophilus*, I must take leave to insert an Experiment, though perhaps you'l think its coming in here an Intrusion: For I confess its more proper place would have been among those Experiments, that were brought as proofs and applications of our Notions concerning the differences of Salts,

Salts; but not having remembred to insert it in its fittest place, I had rather take notice of it in this, than leave it quite unmentioned: partly because it doth somewhat differ from the rest of our Experiments about Colours, in the way whereby 'tis made; and partly because the grounds upon which I devised it, may hint to you somewhat of the Method I use in Designing and Varying Experiments about Colours, and upon this account I shall inform you, not only What I did, but Why I did it.

I considered then that the work of the former Experiments was either to change the Colour of a Body into another, or quite to destroy it, without giving it a successor; but I had a mind to give you also a way, whereby to turn a Body endued with one Colour into two Bodies, of Colours as well as consistencies, very distinct from each other, and that by the help of a Body that had it self no Colour at all. In order to this, I remembred, that finding the Acidity of Spirit of Vinegar to be wholly destroyed by its working upon *Minium* (or calcin'd Lead) whereby the Saline particles of the *Menstruum* have their Taste and Nature quite altered, I had, among other Conjectures I had built upon that change, rightly concluded, that the Solution of Lead

in

in Spirit of Vinegar would alter the Colour of the Juices and Infusions of several Plants, much after the like manner that I had found Oyl of Tartar to do; and accordingly I was quickly satisfied upon Tryal, that the Infusion of Rose-leaves would by a small quantity of this Solution well mingl'd with it, be immediately turn'd into a somewhat sad Green.

And further, I had often found, that Oyl of Vitriol, though a potently Acid *Menstruum*, will yet Precipitate many Bodies, both Mineral and others, dissolv'd not only in *Aqua-fortis* (as some Chymists have observed) but particularly in Spirit of Vinegar, and I have further found, that the *Calces* or Powders Precipitated by this Liquor were usually fair and White.

Laying these things together, 'twas not difficult to conclude, that if upon a good Tincture of Red Rose-leaves made with fair Water, I dropp'd a pretty quantity of a strong and sweet Solution of *Minium*, the Liquor would be turn'd into the like muddy Green Substance, as I have formerly intimated to you, that Oyl of Tartar would reduce it to, and that if then I added a convenient quantity of good Oyl of Vitriol, this last nam'd Liquor would have two distinct operations upon the Mixture, the one, that it

it would Precipitate that resolv'd Lead in the form of a White Powder; the other, that it would Clarifie the muddy Mixture, and both restore, and exceedingly heighten the Redness of the Infusion of Roses, which was the most copious Ingredient of the Green composition, and accordingly trying the Experiment in a Wine glass sharp at the bottom (like an inverted Cone) that the subsiding Powder might seem to take up the more room, and be the more conspicuous, I found that when I had shaken the Green Mixture, that the Coloured Liquor might be the more equally dispersed, a few drops of the rectified Oyl of Vitriol did presently turn the opacous Liquor into one that was cleer and Red, almost like a Rubie, and threw down good store of a Powder, which when 'twas settl'd, would have appear'd very White, if some interspersed Particles of the red Liquor had not a little Allay'd the Purity, though not blemished the Beauty of the Colour. And to shew you, *Pyrophilus*, that these Effects do not flow from the Oyl of Vitriol, as it is such, but as it is a strongly Acid *Menstruum*, that has the property both to Precipitate Lead, as well as some other Concretes out of Spirit of Vinegar, and to heighten the Colour of Red Rose-leaves, I add, that I have

have done the same thing, though perhaps not quite so well with Spirit of Salt, and that I could not do it with *Aqua-fortis*, because though that potent *Menstruum* does as well as the others heighten the Redness of Roses, yet it would not like them Precipitate Lead out of Spirit of Vinegar, but would rather have dissolv'd it, if it had not found it dissolv'd already.

And as by this way we have produc'd a Red Liquor, and a White Precipitate out of a Dirty Green magistery of Rose-leaves; so by the same Method, you may produce a fair Yellow, and sometimes a Red Liquor, and the like Precipitate, out of an Infusion of a curious Purple Colour. For you may call to mind, that in the Annotation upon the 39. Experiment I intimated to you, that I had with a few drops of an Alcaly turn'd the Infusion of Logg-wood into a lovely Purple. Now if instead of this Alcaly I substituted a very strong and well Filtrated Solution of *Minium*, made with Spirit of Vinegar, and put about half as much of this Liquor as there was of the Infusion of Logg-wood, (that the mixture might afford a pretty deal of Precipitate,) the affusion of a convenient proportion of Spirit of Salt, would (if the Liquors were well and nimbly stirr'd together) presently

strike

ſtrike down a Precipitate like that formerly mention'd, and turn the Liquor that ſwam above it, for the moſt part into a lovely Yellow.

But for the advancing of this Experiment a little further, I conſidered, that in caſe I firſt turned a ſpoonful of the infuſion of Logg-wood Purple, by a convenient proportion of the Solution of *Minium*, the Affuſion of Spirit of Sal Armoniack, would Precipitate the Corpuſcles of Lead conceal'd in the Solution of *Minium*, and yet not deſtroy the Purple Colour of the Liquor; whereupon I thus proceeded; I took about a ſpoonful of the *freſh* Tincture of Logg-wood, (for I found that if it were *ſtale* the Experiment would not always ſucceed.) and having put to it a convenient proportion of the Solution of *Minium* to turn it into a deep and almoſt opacous Purple, I then dropp'd in as much Spirit of Sal Armoniack, as I gueſs'd would Precipitate about half or more (but not all) of the Lead, and immediately ſtirring the mixture well together, I mingled the Precipitated parts with the others, ſo that they fell to the bottom, partly in the form of a Powder, and partly in the form of a Curdled Subſtance, that (by reaſon of the Predominancy of the Tinged Corpuſcles over the

the White) retain'd as well as the Supernatant Liquor, a Blewish Purple colour sufficiently Deep, and then instantly (but yet Warily,) pouring on a pretty Quantity of Spirit of Salt, the matter first Precipitated, was, by the above specifi'd figure of the bottom of the Glass preserved from being reach'd by the Spirituous Salt; which hastily precipitated upon it a new Bed (if I may so call it) of White Powder, being the remaining Corpuscles of the Lead, that the Urinous Spirit had not struck down: So that there appeared in the Glass three distinct and very differingly colour'd Substances; a Purple or Violet-colour'd Precipitate at the bottom, a White and Carnation (sometimes a Variously coloured) Precipitate over That, and at the Top of all a Transparent Liquor of a lovely Yellow, or Red.

Thus you see, *Pyrophilus*, that though to some I may have seem'd to have lighted on this (50.) Experiment by chance, and though others may imagine, that to have excogitated it, must have proceeded from some extraordinary insight into the nature of Colours, yet indeed, the devising of it need not be look'd upon as any great matter, especially to one that is a little versed in the notions, I have in these, and other Pa-

pers hinted concerning the differences of Salts. And perhaps I might add upon more than conjecture, that these very notions and some particulars scatteringly delivered in this Treatise, being skilfully put together, may suggest divers matters (at least) about Colours, that will not be altogether Despicable. But those hinted, *Pyrophilus*, I must now leave such as You to prosecute, having already spent far more time than I intended to allow my self in acquainting You with particular Experiments and Observations concerning the changes of Colour, to which I might have added many more, but that I hope I may have presented You with a competent number to make out in some measure what I have at the beginning of this Essay either propos'd as my Design in this Tract, or deliver'd as my Conjectures concerning these matters. And it not being my present Design, as I have more than once Declar'd, to deliver any Positive Hypothesis or solemn Theory of Colours, but only to furnish You with some Experiments towards the framing of such a Theory; I shall add nothing to what I have said already, but a request that you would not be forward to think I have been mistaken in any thing I have deliver'd as matter of Fact concerning the changes of Colours, in case you

should

ſhould not every time you try it, find it exactly to ſucceed. For beſides the Contingencies to which we have elſewhere ſhewn ſome other Experiments to be obnoxious, the omiſſion or variation of a ſeemingly unconſiderable circumſtance, may hinder the ſucceſs of an Experiment, wherein no other fault has been committed. Of which truth I ſhall only give you that ſingle and almoſt obvious, but yet illuſtrious inſtance of the Art of Dying Scarlets; for though you ſhould ſee every Ingredient that is us'd about it, though I ſhould particularly inform you of the weight of each, and though you ſhould be preſent at the kindling of the fire, and at the increaſing and remitting of it, when ever the degree of Heat is to be alter'd, and though (in a word) you ſhould ſee every thing done ſo particularly that you would ſcarce harbour the leaſt doubt of your comprehending the whole Art: Yet if I ſhould not diſcloſe to You, that the Veſſels, that immediately contain the Tinging Ingredients, are to be made of or to be lin'd with Tin, You would never be able by all that I could tell you elſe (at leaſt, if the Famouſeſt and Candideſt Artificers do not ſtrangely delude themſelves) to bring your Tincture of

Chochinele to Dye a perfect Scarlet. So much depends upon the very Veſſel, wherein the Tinging matters are boil'd, and ſo great an Influence may an unheeded Circumſtance have on the ſucceſs of Experiments concerning Colours.

FINIS.

A SHORT ACCOUNT OF SOME OBSERVATIONS

Made by Mr. *Boyle*.

About a *Diamond* that *Shines* in the Dark.

First enclosed in a Letter written to a Friend.

And now together with it annexed to the Foregoing Treatise, upon the score of the Affinity betwixt

Light and *Colours*.



LONDON,
Printed for *Henry Herringman*. 1670.

A COPY OF THE LETTER

That Mr. *Boyle* wrote to Sir *Robert Morray*, to accompany the *Observations* touching the *Shining Diamond*.

SIR,

THough Sir *Robert Morray*, and Monsieur *Zulichem* be Persons that have deserv'd so well of the Commonwealth of Learning, that I should think my self unworthy to be looked upon as a Member of it, if I declin'd to Obey them, or to serve them; yet I should not without Reluctancy send you the Notes, you desire for him, if I did not hope that you will transmit together with them, some Account why they are not less unworthy of his perusal: which, that you may do, I must inform you, how

the writing of them was Occasion'd, which in short was thus. As I was just going out of Town, hearing that an Ingenious Gentleman of my Acquaintance, lately return'd from *Italy*, had a Diamond, that being rubb'd, would shine in the Dark, and that he was not far off, I snatched time from my Occasions to make him a Visit, but finding him ready to go abroad, and having in vain try'd to make the Stone yield any Light in the Day time, I borrow'd it of him for that Night, upon condition to restore it him within a Day or two at furthest, at *Gresham* Colledge, where we appointed to attend the meeting of the Society, that was then to be at that place. And hereupon I hasted that Evening out of Town, and finding after Supper that the Stone which in the Day time would afford no discernable Light, was really Conspicuous in the Dark, I was so taken with the Novelty, and so desirous to make some use of an opportunity that was like to last so little a while, that though at that time I had no body to assist me but a Foot-Boy, yet sitting up late, I made a shift that Night to try a pretty number of such of the things that then came into my thoughts, as were not in that place and time unpracticable. And the next Day being otherwise imploy'd,

ploy'd, I was fain to make use of a drowsie part of the Night to set down hastily in Writing what I had observ'd, and without having the time in the Morning, to stay the transcribing of it, I order'd the Observations to be brought after me to *Gresham* Colledge, where you may remember, that they were together with the Stone it self shown to the Royal Society, by which they had the good Fortune not to be dislik'd, though several things were through hast omitted, some of which you will find in the Margin of the inclosed Paper. The substance of this short Narrative I hope you will let Monsieur *Zulichem* know, that he may be kept from expecting any thing of finish'd in the Observations, and be dispos'd to excuse the want of it. But such as they are, I hope they will prove (without a Clinch) Luciferous Experiments, by setting the Speculations of the Curious on work, in a diligent Inquiry after the Nature of Light, towards the discovery of which, perhaps they have not yet met with so considerable an Experiment, since here we see Light produc'd in a dead and opacous Body, and that not as in rotten Wood, or in Fishes, or as in the *Bolonian* Stone, by a Natural Corruption, or by a Vi-

Violent Deſtruction of the Texture of the Body, but by ſo ſlight a Mechanical operation upon its Texture, as we ſeem to know what it is, and as is immediately perform'd, and that ſeveral wayes without at all prejudicing the Body, or making any ſenſible alterations in its Manifeſt Qualities. And I am the more willing to expoſe my haſty Tryals to Monſieur *Zulichem*, and to You, becauſe, he being upon the Conſideration of Dioptricks, ſo odd a *Phænomenon* relateing to the Subject, as probably he treats of, Light will, I hope, excite a perſon to conſider it, that is wont to conſider things he treats of very well. And for you Sir, I hope you will both recrute and perfect the Obſervations you receive, For you know that I cannot add to them, having a good while ſince reſtor'd to Mr. *Clayton* the Stone, which though it be now in the hands of a Prince that ſo highly deſerves, by underſtanding them, the greateſt Curioſities; yet he vouchſafes you that acceſs to him as keeps me from doubting, you may eaſily obtain leave to make further Tryals with it, of ſuch a Monarch as ours, that is not more inquiſitive himſelf, than a favourer of them that are ſo. I doubt not but theſe Notes will put you in mind of the Motion you made to the Society, to impoſe upon me

me the Task of bringing in, what I had on other occasions observ'd concerning shining Bodies. But though I deny not, that I sometimes made observations about the *Bolonian* Stone, and try'd some Experiments about some other shining Bodies; Yet the same Reasons that reduc'd me then to be unwilling to receive ev'n their commands, must now be my Apology for not answering your Expectations, Namely the abstruse nature of Light, and my being already overburden'd, and but too much kept imploy'd by the Urgency of the Press, as well as by more concerning and distracting Occasions. But yet I will tell you some part of what I have met with in reference to the Stone, of which I send you an account. Because I find on the one side, that a great many think it no Rarity upon a mistaken perswasion, that not only there are store of Carbuncles, of which this is one; but that all Diamonds and other glistering Jewels shine in the Dark. Whereas on the other side there are very Learned Men, who (plausibly enough) deny that there are any Carbuncles or shining Stones at all.

And certainly, those Judicious men have much more to say for themselves, than the others commonly Plead, and therefore did deservedly look upon Mr. *Clayton*'s Dia-

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mond as a great Rarity. For not only *Boetius de Boot*, who is judg'd the beſt Author on this Subject, aſcribes no ſuch Virtue to Diamonds, but begins what he delivers of Carbuncles, with this paſſage, *Magna fama eſt Carbunculi. Is vulgo putatur in tenebris Carbonis inſtar lucere; fortaſſis quia Pyropus ſeu Anthrax appellatus à veteribus fuit. Verum hactenus nemo unquam verè aſſerere auſus fuit, ſe gemmam noctu lucentem vidiſſe. Garcias ab Horto proregis Indiæ Medicus, refert ſe allocutum fuiſſe, qui ſe vidiſſe affirmarent. Sed iis fidem non habuit.* And a later Author, the Diligent and Judicious *Johannes de Laet* in his Chapter of Carbuncles and of Rubies, has this paſſage. *Quia autem Carbunculi, Pyropi & Anthraces à veteribus nominantur, vulgo creditum fuit, Carbonis inſtar in tenebris lucere, quod tamen nullâ gemmâ hactenus deprehenſum, licet à quibuſdam temerè jactetur.* And the recenteſt Writer I have met with on this Subject, *Olaus Wormius*, in his Account of his well furniſhed *Muſæum*, does, where he treats of Rubies, concur with the former Writers by theſe Words. *Sunt qui Rubinum veterum Carbunculum eſſe exiſtimant, ſed deeſt una illa nota, quod*

Boetius de Boot. Gem. & Lapid. Hiſtor. Lib. 2. Cap. 8.

Muſæi Wormiani. Cap. 17.

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in tenebris instar Anthracis non luceat: Ast talem Carbunculum in rerum naturâ non inveniri major pars Authorum existimant. Licet unum aut alterum in India apud Magnates quosdam reperiri scribant, cum tamen ex aliorum relatione id habeant saltem, sed ipsi non viderint. In confirmation of which I shall only add, that hearing of a Ruby, so very Vivid, that the Jewellers themselves have several times begg'd leave of the fair Lady to whom it belong'd, that they might try their choicest Rubies by comparing them with That, I had the Opportunity by the Favour of this Lady and her Husband (both which I have the Honour to be acquainted with) to make a Trial of this famous Rubie in the Night, and in a Room well darken'd, but not only could not discern any thing of Light, by looking on the Stone before any thing had been done to it, but could not by all my Rubbing bring it to afford the least Glimmering of Light.

But, Sir, though I be very backward to admit strange things for truths, yet I am not very forward to reject them as impossibilities, and therefore I would not discourage any from making further Inquiry, whether or no there be Really in *Rerum natura*, any such thing as a true Carbuncle or Stone that without Rubbing will shine

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in the Dark. For if such a thing can be found, it may afford no small Assistance to the Curious in the Investigation of Light, besides the Nobleness and Rarity of the thing it self. And though *Vartomannus* was not an Eye-witness of what he relates, that the King of *Pegu*, one of the Chief Kings of the *East-Indies*, had a true Carbuncle of that Bigness and Splendour, that it shin'd very Gloriously in the Dark; and though *Garcias ab Horto*, the *Indian* Vice-Roys Physician, speaks of another Carbuncle, only upon the Report of one, that he Discours'd with, who affirmed himself to have seen it; yet as we are not sure that these Men that gave themselves out to be Eye-witnesses speak true, yet they may have done so for ought we know to the contrary. And I could present you with a much considerabler Testimony to the same purpose, if I had the permission of a Person concern'd, without whose leave I must not do it. I might tell you that *Marcus Paulus Venetus* (whose suppos'd Fables, divers of our later Travellers and Navigators have since found to be truths) speaking of the King of *Zeilan* that then was, tells us, that he was said to have the best Ruby in the World, a Palm long and as big

Purchas's Pilgrim. lib. 1. cap. 4 pag. 104.

big as a mans Arm, without spot, shining like a Fire, and he subjoins, that the Great *Cham*, under whom *Paulus* was a considerable Officer, sent and offer'd the value of a City for it; But the King answer'd, he would not give it for the treasure of the World, nor part with it, having been his Ancestors. And I could add, that in the Relation made by two *Russian* Cossacks of their Journey into *Catay*, written to their Emperour, *In the Year 1619.* they mention'd their having been told by the people of those parts, that their King had a Stone, which Lights as the Sun both Day and Night, call'd in their Language *Sarra*, which those Cossacks interpret a Ruby. But these Relations are too uncertain for me to build any thing upon, and therefore I shall proceed to tell you, that there came hither about two years since out of *America*, the Governour of one of the Principal Colonies there, an Ancient *Virtuoso*, and one that has the Honour to be a member of the Royal Society; this Gentleman finding some of the chief Affairs of his Country committed to another and me, made me divers Visits, and in one of them when I enquir'd what Rare Stones they had in those parts of the *Indies* he belonged to, he told me, that the *Indians* had a Tradition

that

that in a certain hardly acceſſible Hill, a pretty way up in the Country, there was a Stone which in the Night time ſhin'd very vividly, and to a great diſtance; and he aſſured me, that though he thought it not fit to venture himſelf ſo far among thoſe Savages, yet he purpoſely ſent thither a bold *Engliſhman*, with ſome Natives to be his Guides, and that this Meſſenger brought him back word, that at a diſtance from the Hillock he had plainly perceived ſuch a ſhining ſubſtance as the *Indians* Tradition mention'd, and being ſtimulated by Curioſity, had ſlighted thoſe ſuperſtitious Fears of the Inhabitants, and with much ado by reaſon of the difficulty of the way, had made a ſhift to clamber up to that part of the Hill, where, by a very heedful Obſervation, he ſuppos'd himſelf to have ſeen the Light: but whether 'twere that he had miſtaken the place, or for ſome other Reaſon, he could not find it there, though when he was returned to his former Station, he did again ſee the Light ſhining in the ſame place where it ſhone before. A further Account of this Light I expect from the Gentleman that gave me this, who lately ſent me the news of his being landed in that Country. And though I reſerve to my ſelf a full Liberty of believing no more than

than I see cause; yet I do the less scruple to relate this, because a good part of it agrees well enough with another Story that I shall in the next place have occasion to subjoin, in order whereunto I shall tell you, that though the Learned Authors I formerly mentioned, tell us, that no Writer has affirm'd his having himself seen a real Carbuncle, yet, considering the Light of Mr. *Clayton*'s Diamond, it recalled into my mind, that some years before, when I was Inquisitive about Stones, I had met with an old *Italian* Book highly extolled to me by very competent Judges, and that though the Book were very scarce, I had purchased it at a dear Rate, for the sake of a few considerable passages I met with in it, and particularly one, which being very remarkable in it self, and pertinent to our present Argument, I shall put it for you, though not word for word, which I fear I have forgot to do, yet as to the Sense, into *English*.

Having promis'd (says our Author) *to say something of that most precious sort of Jewels*, Carbuncles, *because they are very rarely to be met with, we shall briefly deliver what we know of them. In* Clement *the seventh's time I happen'd to see one of*

Benvonuto Cellini *nell Arte del* Gioiellare, *Lib.* 1. *Pag.* 10.

them at a certain Ragusian *Merchants, nam'd* Beigoio di Bona: *This was a Carbuncle white, of that kind of Whiteness which we said was to be found in those Rubies of which we made mention a little above,* (where he had said that those Rubies had a kind of Livid Whiteness or Paleness like that of a Calcidonian) *but it had in it a Lustre so pleasing and so marvellous, that it shin'd in the Dark, but not as much as coloured Carbuncles, though it be true, that in an exceeding Dark place I saw it shine in the manner of fire almost gone out. But as for coloured Carbuncles, it has not been my Fortune to have seen any, wherefore I will only set down what I Learned about them Discoursing in my Youth with a* Roman *Gentleman of antient Experience in matters of Jewels, who told me, That one* Jacopo Cola *being by Night in a Vineyard of his, and espying something in the midst of it, that shin'd like a little* glowing Coal, at the foot of a Vine, went near towards the place where he thought himself to have seen that fire, but not finding it, he said, that being returned to the same place, whence he had first descry'd it, and perceiving there the same splendor as before, he marked it so heedfully, that he came at length to it, where he took up a very little Stone, which he carryed away with Transports and Joy. And the next day

day carrying it about to shew it divers of his Friends, whilst he was relating after what manner he found it; there casually interven'd a *Venetian* Embassadour, exceedingly expert in Jewels, who presently knowing it to be a Carbuncle, did craftily before he and the said *Jacopo* parted (so that there was no Body present that understood the Worth of so Precious a Gem) purchase it for the Value of 10 Crowns; and the next day left *Rome* to shun the being necessitated to restore it, (and as he affirmed) it was known within some while after that the said *Venetian* Gentleman did in *Constantinople* sell that Carbuncle to the then Grand Signior, newly come to the Empire, for a hundred thousand Crowns. *And this is what I can say* concerning *Carbuncles*, and this is not a little at least as to the first part of this account, where our *Cellini* affirms himself to have seen a Real Carbuncle with his own Eyes, especially since this Author appears wary in what he delivers, and is inclined rather to lessen, than increase the wonder of it. And his Testimony is the more considerable, because though he were born a Subject neither to the Pope nor the then King of *France* (that Royal *Virtuoso Francis* the first) yet both the one and the other of those Princes imploy'd him much

about making of their Noblest Jewels. What is now reported concerning a Shining Substance to be seen in one of the Islands about *Scotland*, were very improper for me to mention to Sir *Robert Morray*, to whom the first Information was Originally brought, and from whom I expect a farther (for I scarce dare expect a convincing) account of it. But I must not omit that some *Virtuoso* questioning me the other day at *White-Hall* about Mr. *Clayton*'s Diamond, and meeting amongst them an Ingenious *Dutch* Gentleman, whose Father was long Embassador for the Netherlands in *England*, I Learn'd of him, that, he is acquainted with a person, whose Name he told (but I do not well remember it) who was Admiral of the *Dutch* in the *East-Indies*, and who assur'd this Gentleman *Monsieur Boreel*, that at his return from thence he brought back with him into *Holland* a Stone, which though it look'd but like a Pale Dull Diamond, such as he saw Mr. *Clayton*'s to be, yet was it a Real Carbuncle, and did without rubbing shine so much, that when the Admiral had occasion to open a Chest which he kept under Deck in a Dark place, where 'twas forbidden to bring Candles for fear of Mischances, as soon as he opened the Trunck, the Stone would

would by its Native Light, ſhine ſo as to Illuſtrate a great part of it; and this Gentleman having very civilly and readily granted me the requeſt I made him, to Write to the Admiral, who is yet alive in *Holland*, (and probably may ſtill have the Jewel by him,) for a particular account of this Stone, I hope e're long to receive it, which will be the more welcome to me, not only becauſe ſo unlikely a thing needs a clear evidence, but becauſe I have had ſome ſuſpition of that (ſuppoſing the truth of the thing) what may be a ſhining Stone in a very hot Country as the *Eaſt-Indies*, may perhaps ceaſe to be ſo (at leaſt in certain ſeaſons,) in one as cold as *Holland*. For I obſerv'd in the Diamond I ſend you an account of, that not only rubbing but a very moderate degree of warmth, though excited by other ways, would make it ſhine a little. And 'tis not impoſſible that there may be Stones as much more ſuſceptible than that, of the Alterations requiſite to make a Diamond ſhine, as that appears to be more ſuſceptible of them, than ordinary Diamonds. And I confeſs to you, that this is not the only odd ſuſpition (for they are not ſo much as conjectures) that what I try'd upon this Diamond ſuggeſted to me. For not here to entertain you with the

changes I think may be effected even in harder sorts of Stones, by ways not vulgar, nor very promising, because I may elsewhere have occasion to speak of them, and this Letter is but too Prolix already; that which I shall now acknowledge to you is, That I began to doubt whether there may not in some Cases be some Truth in what is said of the right Turquois, that it often changes Colour as the Wearer is Sick or Well, and manifestly loses its splendour at his Death. For when I found that even the warmth of an Affriction that lasted not above a quarter of a minute, Nay, that of my Body, (whose Constitution you know is none of the hottest) would make a manifest change in the solidest of Stones a Diamond, it seem'd not impossible, that certain warm and Saline steams issuing from the Body of a living man, may by their plenty or paucity, or by their peculiar Nature, or by the total absence of them, diversifie the Colour, and the splendor of so soft a Stone as the Turquois. And though I admir'd to see, that I know not how many Men otherwise Learned, should confidently ascribe to Jewels such Virtues as seem no way competible to Inanimate Agents, if to any Corporeal ones at all, yet as to what is affirm'd concerning the Turquois's

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changing Colour, I know not well how to reject the Affirmation of so Learned (and which in this case is much more considerable) so Judicious a Lapidary as *Boetius de Boot* *, who upon his own particular and repeated Experience delivers so memorable

* The Narrative in the Authors own words, is this: *Ego* (says he) *sanctè affirmare possum me unam aureo Annulo inclusam perpetuo gestare, cujus facultatem (si gemmæ est) nunquam satis admirari potui. Gestaverat enim ante Triginta annos Hispanus quidem non procul à paternis ædibus habitans. Is cum vitâ functus esset, & ipsius suppellex (ut moris apud nos est) venum exposita esset, inter cætera etiam Turcois exponebatur. Verum nemo (licet complures eo concurrissent, ut eam propter Coloris Elegantiam, quam vivo Domino habuerat emerent) sibi emptam voluit; pristinum enim nitorem & Colorem prorsus amiserat, ut potius Malachites, quam Turcois videretur. Aderat tum temporis gemmæ habendæ desiderio etiam parens & frater meus, qui antea sæpius gratiam & elegantiam ipsius viderant, mirabundi eam nunc tam esse deformem, emit eam nihilominus pater, satisq; vili pretio, qua omnibus contemptui erat, ac præsentes non eam esse quam Hispanus gestarat, arbitrarentur. Domum reversus Pater, qui tam turpem Gemmam gestare sibi indecorum putabat, eam mihi dono dat, inquiens; Quandoquidem, fili mi, vulgi fama est, Turcoidem, ut facultates suas exercere possit, dono dari debere tibi eam devoveo, ego acceptam Gemmam Sculptori trado, ut gentilitia mea insignia illi, quemadmodum fieri solet, in Jaspide Chalcedonio, aliisq; Ignobilioribus Gemmis, insculperet. Turpe enim existimabam, hujusmodi Gemmâ ornatus gratia, dum gratiam nullam haberet, uti. Paret Sculptor redditque Gemmam, quam gesto pro annulo Signatorio. Vix per mensem gestaram, redit illi pristinus color, sed non ita nitens propter Sculpturam, ac inæqualem superficiem. Miramur omnes gemmam, atque id præcipuè quod color indies pulchrior fieret. Id quià observabam, nunquam fere eam à manu deposui, ita ut nunc adhuc eandem gestem.*

morable a Narrative of the Turquois's changing Colour, that I cannot but think it worth your Perusal, especially since a much later and very Experienced Author, *Olaus Wormius*, where he treats of that Stone, Confirms it with this Testimony. *Imprimis memorandum exemplum quod Anshelmus Boëtius de seipso refert, tam mutati Coloris quam à casu preservationis. Cui & ipse haud dissimile adferre possum, nisi ex Anshelmo petitum quis putaret.* I remember that I saw two or three years since a *Turquois* (worn in a Ring) wherein there were some small spots, which the *Virtuoso* whose it was assur'd me he had observ'd to grow sometimes greater, sometimes less, and to be sometimes in one part of the Stone, sometimes in another. And I having encouraged to make Pictures from time to time of the Stone, and of the Situation of the cloudy parts, that so their Motion may be more indisputable, and better observed, he came to me about the middle of this very week, and assur'd me that he had, as I wish'd, made from time to time Schemes or Pictures of the differing parts of the Stone, whereby the several Removes and motions of the above mentioned Clouds are very manifest, though the cause seem'd to him very occult: these Pictures

Olaus Wormius in Musæ. 18. pag. 186.

ctures he has promis'd to show me, and is very ready to put the Stone it self into my hands. But the Ring having been the other day casually broken upon his finger, unless it can be taken out, and set again without any considerable heat, he is loth to have it medled with, for fear its peculiarity should be thereby destroyed. And possibly his apprehension would have been strengthen'd, if I had had opportunity to tell him what is related by the Learned *Wormius* of an acquaintance of his, that had a *Nephritick* stone, of whose eminent Virtues he had often Experience even in himself, and for that cause wore it still about his Wrist; and yet going upon a time into a Bath of fair Water only, wherein certain Herbs had been boyled, the Stone by being wetted with this decoction, was depriv'd of all his Virtue, whence *Wormius* takes Occasion to advertise the sick, to lay by such stones whensoever they make use of a Bath. And we might expect to find *Turquois* likewise, easily to be wrought upon in point of Colour, if that were true, which the curious *Antonio Neri*, in his ingenious *Arte Vetraria* teaches of it, namely, That *Turquois's discoloured* and grown white, will regain and acquire

Musæ. Worm. pag. 99.

Arte Vetraria, lib. 7. cap. 102.

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an excellent Colour, if you but keep them two or three days at moſt covered with Oyl of ſweet Almonds kept in a temperate heat by warm aſhes, I ſay if it were true, becauſe I doubt whether it be ſo, and have not as yet had opportunity to ſatisfie my ſelf by Tryals, becauſe I find by the confeſſion of the moſt Skilful Perſons among whom I have laid out for *Turquoiſes*, that the true ones are great rarities, though others be not at all ſo. And therefore I ſhall now only mind you of one thing that you know as well as I, namely, that the rare Stone which is called *Oculus Mundi*, if it be good in its Kind, will have ſo great a change made in its Texture by being barely left a while in the Languideſt of Liquors, common Waters, that from Opacous it will become Tranſparent, and acquire a Luſtre of which it will again be deprived, without uſing any other Art or Violence, by leaving it a while in the Air. And before experience had ſatisfied us of the truth of this, it ſeem'd as unlikely that common Water or Air, ſhould work ſuch great changes in that Gem, as it now ſeems that the Effluviums of a humane Body ſhould effect leſſer changes in a *Turquois*, eſpecially if more ſuſceptible of them, than other Stones of the ſame kind. But both my Watch and my Eyes tell me that

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'tis now high time to think of going to ſleep, matters of this Nature, will be better, as well as more eaſily, clear'd by Conference, than Writing. And therefore ſince I think you know me too well to make it needful for me to diſclaim Credulity, notwithſtanding my having entertain'd you with all theſe Extravagancies; for you know well, how wide a difference I am wont to put betwixt things that barely *may be*, and things that *are*, and between thoſe Relations that are but not unworthy to be inquir'd into, and thoſe that are not worthy to be actually believed; without making Apologies for my Ravings, I ſhall readily comply with the drowſineſs that calls upon me to releaſe You, and the rather, becauſe Monſieur *Zulichem* being concern'd in your deſire to know the few things I have obſerved about the ſhining Stone. To entertain thoſe with Suſpicions that are accuſtomed not to acquieſce but in Demonſtrations, were a thing that cannot be looked upon as other than very improper by,

SIR,

Your moſt Affectionate
and
moſt Faithful Servant,

R. BOYLE.

OBSERVATIONS Made this *27. of *October* 1663. about Mr. *Clayton*'s Diamond.

* These were brought in and read before the Royal Society, (the Day following) *Oct.* 28. 1663.

The Stone it self being to be shown to the Royal Society, when the Observations were delivered, I was willing (being in haste) to omit the Description of it, which is in short, That it was a Flat or Table Diamond, of about a third part of an Inch in length, and somewhat less in breadth, that it was a Dull Stone, and of a very bad Water, having in the Day time very little of the Vividness of even ordinary Diamonds, and being Blemished with a whitish Cloud about the middle of it, which covered near a third part of the Stone.

BEing look'd on in the Day time, though in a Bed, whose Curtains were carefully drawn, I could not discern it to Shine at all, though well Rubb'd, but about a little after Sun-set, whilst the Twilight yet lasted, Nay, this Morning a pretty while after Sun-rising, (but before I had been abroad in the more freely inlightned Air of the Chamber) I could upon a light Affriction easily perceive the Stone to Shine.

Haste made me forget to take notice that I went abroad the same Morning, the Sun shining forth clear enough, to look upon the Diamond through a Micro-scope, *that I might try whether by that Magnifying Glass any thing of peculiar could be discerned in the Texture of the Stone, and especially of the whitish Cloud that possest a good part of it. But for all my attention I could not discover any peculiarity worth mentioning.*

Secondly,

Secondly, The Candles being removed, I could not in a Dark place discern the Stone to have any Light, when I looked on it, without having Rubb'd or otherwise prepar'd it.

Thirdly, By two white Pibbles though Hard Rubb'd one against another, nor by the long and vehement Affriction of Rock Crystal against a piece of Red cloath, nor yet by Rubbing two Diamonds set in Ring, as I had Rubb'd this Stone, I could produce any sensible degree of Light.

Fourthly, I found this Diamond hard enough, not only to enable me to write readily with it upon Glass, but to Grave on Rock Crystal it self.

V. For it drew light Bodies like Amber,

Fifthly, I found this to have like other Diamonds, an Electrical faculty.

Jet, and other Concretes that are noted to do so; But its attractive power seem'd inferior to theirs.

Sixthly, Being rubb'd upon my Cloaths, as is usual for the exciting of Amber, Wax, and other Electrical Bodies, it did in the Dark manifestly shine like Rotten Wood, or the Scales of Whitings, or other putrified Fish.

Seventhly, But this Conspicuousness was Fainter than that of the Scales, and Slabber (if I may so call it) of Whitings, and much Fainter than the Light of a Glow-worm, by which

which I have been ſometimes able to Read a ſhort Word, whereas after an ordinary Affriction of this Diamond I was not able to diſcern diſtinctly by the Light of it any of the neareſt Bodies: And this Glimmering alſo did very manifeſtly and conſiderably Decay preſently upon the ceaſing of the Affriction, though the Stone continued Viſible ſome while after.

Eighthly, But if it were Rubb'd upon a convenient Body for a pretty while, and Briskly enough, I found the Light would be for ſome moments much more conſiderable, almoſt like the Light of a Glow-worm, inſomuch after I ceaſed Rubbing, I could with the Chaf'd ſtone exhibit a little Luminous Circle, like that, but not ſo bright as that which Children make by moving a ſtick Fir'd at the end, and in this caſe it would continue Viſible about ſeven or eight times as long as I had been in Rubbing it.

Ninthly, I found that holding it a while near the Flame of a Candle, (from which yet I was careful to avert my Eyes) and being

IX. *We durſt not hold it in the Flame of a Candle, no more than put it into a naked Fire; For fear too Violent a Heat (which has been obſerved to ſpoil many other precious Stones) ſhould vitiate and impair a Jewel, that was but borrowed, and was ſuppoſed to be the only one of its Kind.*

being immediately removed into the Dark, it disclosed some faint Glimmering, but inferiour to that, it was wont to acquire by Rubbing. And afterward holding it near a Fire that had but little Flame, I found the Stone to be rather less than more excited, than it had been by the Candle.

Tenthly, I likewise indeavoured to make it Shine, by holding it a pretty while in a very Dark place, over a thick piece of Iron, that was well Heated, but not to that Degree as to be Visibly so. And though at length I found, that by this way also, the Stone acquired some Glimmering, yet it was less than by either of the other ways above mention'd.

Eleventhly, I also brought it to some kind of Glimmering Light, by taking it into Bed with me, and holding it a good while upon a warm part of my Naked Body.

Twelfthly, To satisfie my self, whether the Motion introduced into the Stone did generate the Light upon the account of its producing Heat there, I held it near the Flame of a Candle, till it was qualify'd to shine pretty well in the Dark, and then immediately I apply'd a slender Hair to try whether it would attract it, but found not that it did so; though if it were made to

shine

ſhine by Rubbing, it was as I formerly noted Electrical. And for further Confirmation, though I once purpoſely kept it ſo near the hot Iron I juſt now mention'd, as to make it ſenſibly Warm, yet it ſhin'd more Dimly than it had done by Affriction or the Flame of a Candle, though by both thoſe ways it had not acquir'd any warmth that was ſenſible.

Thirteenthly, having purpoſely rubb'd it upon ſeveral Bodies differing as to Colour, and as to Texture, there ſeem'd to be ſome little Diſparity in the excitation (if I may ſo call it) of Light. Upon White and Red Cloaths it ſeem'd to ſucceed beſt, eſpecially in compariſon of Black ones.

Fourteenthly, But to try what it would do rubb'd upon Bodies more hard, and leſs apt to yield Heat upon a light Affriction, than Cloath, I firſt rubb'd it upon a white wooden Box, by which it was excited, and afterwards upon a piece of purely Glazed Earth, which ſeem'd during the Attrition to make it ſhine better than any of the other Bodies had done, without excepting the White ones, which I add, leſt the Effect ſhould be wholly aſcrib'd to the diſpoſition White Bodies are wont to have to Reflect much Light.

Fifteenthly, Having well excited the Stone, I nimbly plung'd it under Water, that I had provided for that purpose, and perceiv'd it to Shine whilst it was beneath the Surface of that Liquor, and this I did divers times. But when I endeavour'd to produce a Light by rubbing it upon the lately mentioned Cover of the Box, the Stone and it being both held beneath the Surface of the Water, I did not well satisfie my self in the Event of the Trial; But this I found, if I took the Stone out, and Rubb'd it upon a piece of Cloath, it would not as else it was wont to do, presently acquire a Luminousness, but needed to be rubb'd manifestly much longer before the desired Effect was found.

XV. *We likewise Plunged it as soon as we had excited it, under Liquors of several sorts, as Spirit of Wine, Oyl, both Chymical and expres'd, an Acid Spirit, and as I remember an Alcalizate Solution, and found not any of those various Liquors to destroy its Shining property.*

Sixteenthly, I also try'd several times, that by covering it with my

XVI. *Having found by this Observation, that a warm Liquor would not extinguish Light in the Diamond, I thought fit to try, whether by reason of its warmth it would not excite it, and divers times I found, that if it were kept therein, till the Water had leisure to communicate some of its Heat to it, it would often shine as soon as it was taken out, and probably we should have seen it Shine more, whilst it was in the Water, if some degree of Opacity which heated Water is wont to acquire, upon the score of the Numerous little Bubbles generated in it, had not kept us from discerning the Lustre of the Stone.*

warm Spittle (having no warm Water at hand) it did not lose his Light.

Seventeenthly, Finding that by Rubbing the Stone with the Flat side downwards, I did by reason of the Opacity of the Ring, and the sudden Decay of Light upon the ceasing of the Attrition, probably lose the sight of the Stones greatest Vividness; and supposing that the Commotion made in one part of the Stone will be easily propagated all over, I sometimes held the piece of Cloath upon which I rubbed it, so, that one side of the Stone was exposed to my Eye, whilst I was rubbing the other, whereby it appeared more Vivid than formerly, and to make Luminous Tracts by its Motions to and fro. And sometimes holding the Stone upwards, I rubbed its Broad side with a fine smooth piece of Transparent Horn, by which means the Light through that Diaphanous Substance, did whilst I was actually rubbing the Stone, appear so Brisk, that sometimes and in some places it seem'd to have little Sparks of Fire.

Eighteenthly, I took also a piece of flat Blew Glass, and having rubbed the Diamond well upon a Cloath, and nimbly clapt the Glass upon it, to try whether in case the Light could pierce it, it would by

appearing Green, or of ſome other Colour than Blew, aſſiſt me to gueſs whether it ſelf were ſincere or no. But finding the Glaſs impervious to ſo faint a Light, I then thought it fit to try whether that hard Bodies would not by Attrition increaſe the Diamonds Light ſo as to become penetrable thereby; and accordingly when I rubb'd the Glaſs briskly upon the Stone, I found the Light to be Conſpicuous enough, and ſomewhat Dy'd in its paſſage, but found it not eaſie to give a Name to the Colour it exhibited.

Laſtly, To comply with the Suſpition I had upon the whole Matter, that the chief manifeſt Change wrought in the Stone, was by Compreſſion of its parts, rather than Incaleſcence, I took a piece of white Tile well Glaz'd, and if I preſs'd the Stone hard againſt it, it ſeem'd though I did not rub it to and fro, to ſhine at the Sides: And however it did both very manifeſtly and vigorouſly Shine, if whilſt I ſo preſs'd it, I mov'd it any way upon the Surface of the Tile, though I did not make it draw a Line of above a quarter of an Inch long, or thereabouts. And though I made it not move to and fro, but only from one end of the ſhort Line to the other, without any return or Lateral motion. Nay, after it had been

often

often rubb'd, and suffer'd to lose its Light again, not only it seem'd more easie to be excited than at the beginning of the Night; but if I did press hard upon it with my Finger, at the very instant that I drew it briskly off, it would disclose a very Vivid but exceeding short Liv'd Splendour, not to call it a little Coruscation. * So that a *Cartesian* would scarce scruple to think he had found in this Stone no slight Confirmation of his Ingenious Masters *Hypotheſis*, touching the Generation of Light in Sublunary Bodies, not sensibly Hot.

* *I after bethought my self of imploying a way, which produc'd the desir'd Effect both sooner and better. For holding betwixt my Fingers a Steel Bodkin, near the Lower part of it, I press'd the point hard against the Surface of the Diamond, and much more if I struck the point against it, the Coruscation would be extreamly sudden, and very Vivid, though very Vanishing too, and this way which commonly much surpris'd and pleas'd the Spectators, seem'd far more proper than the other, to show that pressure alone, if forcible enough, though it were so sudden and short, that it could not well be suppos'd to give the Stone any thing near a sensible degree of Warmth, as may be suspected of Rubbing, yet 'tis sufficient to generate a very Vivid Light.*

A Postscript.

Annexed some Hours after the Observations were Written.

So many particulars taken notice of in one Night, may make this Stone appear a kind of Prodigie, and the rather, because having try'd as I formerly noted, not only a fine Artificial Crystal, and some also that is Natural, but a Ruby and two Diamonds, I did not find that any of these disclos'd the like Glimmering of

We afterwards try'd precious Stones, as Diamonds, Rubies, Sapphires, and Emeralls, &c. but found not any of them to Shine except some Diamonds, and of these we were not upon so little practice, able to fore-tell before hand, which would be brought to Shine, and which would not; For several very good Diamonds either would not Shine at all, or much less than others that were far inferior to them. And yet those Ingenious Men are mistaken, that think a Diamond must be foul and cloudy, as Mr. *Claytons* was, to be fit for Shining; for as we could bring some such to afford a Glimmering Light, so with some clear and excellent Diamonds, we could do the like. But none of those many that we try'd of all Kinds, were equal to the Diamond on which the Observations were made, not only considering the degree of Light it afforded, but the easiness wherewith it was excited, and the Comparatively great duration of its Shining.

Light;

Light; yet after all, perceiving by the Hardneſs, and the Teſtimony of a Skilful Goldſmith, that this was rather a Natural than Artificial Stone; for fear leſt there might be ſome difference in the way of Setting, or in the ſhape of the Diamonds I made uſe of, neither of which was like this, a flat Table-ſtone, I thought fit to make a farther Tryal of my own Diamonds, by ſuch a brisk and aſſiduous Affriction as might make amends for the Diſadvantages above-mentioned, in caſe they were the cauſe of the unſucceſsfulneſs of the former Attempts: And accordingly I found, that by this way I could eaſily bring a Diamond I wore on my Finger to diſcloſe a Light, that was ſenſible enough, and continued ſo though I cover'd it with Spittle, and us'd ſome other Trials about it. And this will much leſſen the wonder of all the formerly mention'd Obſervations, by ſhewing that the properties that are ſo ſtrange are not peculiar to one Diamond, but may be found in others alſo, and perhaps in divers other hard and Diaphanous *Stones. Yet I hope that what this Diſcovery takes away from the Wonder of theſe Obſervations, it will add to the Inſtructiveneſs of them, by affording pregnant Hints, towards the Inveſtigation of the Nature of Light.*

FINIS.