The microscope made easy: or, I. The nature, uses, and magnifying powers of the best kinds of microscopes ... II. An account of what surprising discoveries have already been made by the microscope ... / By Henry Baker.

THE

MICROSCOPE Made Eaſy:

OR,

I. The *Nature*, *Uſes*, and *Magnifying Powers* of the beſt Kinds of MICROSCOPES *Deſcribed*, *Calculated*, and *Explained*:

FOR THE

Inſtruction of ſuch, particularly, as deſire to ſearch into the WONDERS of the *Minute Creation*, tho' they are not acquainted with *Optics*.

Together with

Full Directions how to *prepare*, *apply*, *examine*, and *preſerve* all Sorts of OBJECTS, and proper Cautions to be obſerved in viewing them.

II. An Account of what ſurprizing *Diſcoveries* have been already made by the MICROSCOPE: With uſeful Reflections on them.

AND ALSO

A great Variety of new *Experiments* and *Obſervations*, pointing out many uncommon Subjects for the Examination of the CURIOUS.

By *HENRY BAKER*, Fellow of the *Royal Society*, and Member of the Society of *Antiquaries*, in *London*.

Illuſtrated with COPPER PLATES.

The SECOND EDITION: With an additional *Plate* of the *Solar Microſcope*, and ſome farther Accounts of the POLYPE.

Rerum Natura nuſquam magis quàm in Minimis tota eſt.
PLIN. Hiſt. Nat. Lib. XI. c. 2.

LONDON:

Printed for R. DODSLEY, at *Tully's Head* in *Pall-Mall*; and ſold by M. COOPER, in *Pater-noſter-Row*, and J. CUFF, Optician, in *Fleetſtreet*. 1743.

At a Meeting of the *Royal Society*,
October 28. 1742.

IMPRIMATUR.

M. FOLKES, *Pr. R.S.*

TO

Martin Folkes, *Esq^r*;

PRESIDENT,

And to the

COUNCIL and FELLOWS

OF THE

ROYAL SOCIETY of LONDON.

GENTLEMEN,

AN Attempt to excite in Mankind a general Desire of searching into the Wonders of NATURE, will, I persuade myself, be accepted favourably by You, whose Endeavours for the Advancement of Natural Knowledge, according to the Purpose of your Institution, are esteemed by all the World.

It is ſomething more than an hundred and twenty Years ſince the MICROSCOPE was happily invented; and to the valuable Diſcoveries made thereby, we ſtand indebted, as the following Sheets will ſhew, for a great part of our preſent Philoſophy. In ſuch a Length of Time, it is however probable, many more Advantages might have been reaped from it, had not ſome Difficulties and Diſcouragements prevented its general Uſe.

At the Beginning it was confined to very few; who, making a Secret of it, endeavoured all they could to keep it to themſelves; and, when it became a little more publick, the Price was fixt ſo high, that the moſt curious and induſtrious, who have not always the greateſt Share of Money, could not conveniently get at it. Of late Years, indeed, the Expence has been much leſs; but then new Diſcouragements have ſtarted up from Miſtake and Prejudice.

For

For Many have been frighted from the Uſe of it, by imagining it required great Skill in Optics, and abundance of other Learning, to comprehend it to any Purpoſe: whereas nothing is really needful but good Glaſſes, good Eyes, a little Practice, and a common Underſtanding, to diſtinguiſh what is ſeen; and a Love of Truth, to give a faithful Account thereof. Others have conſidered it as a meer Play-thing, a Matter of Amuſement and Fancy only, that raiſes our Wonder for a Moment, but is of no farther Service: which Miſtake they have fallen into, from being unacquainted with any Principles whereby to form a right Judgment of what they ſee. Many, again, have laid the Microſcope aſide, after a little Uſe, for want of knowing what Objects to examine, where to find, how to prepare, and in what manner to ap-

ply them. The Trouble of managing it has alſo frighted ſome.

But we are now ſo fortunate to have this Inſtrument greatly improved amongſt ourſelves, the Apparatus made much eaſier as well as more uſeful, and the Price conſiderably reduced. The Solar or *Camera Obſcura* Microſcope, and the Microſcope for viewing Objects that have no Tranſparency, by throwing a ſtrong reflected Light upon them, are alſo new Inventions, from whence great Things may be expected.

Nothing therefore is now wanting, but a general Inclination to employ theſe Inſtruments, for a farther Diſcovery of the Minute Wonders of the Creation; which may not, perhaps, improve our Knowledge leſs than the grander Parts thereof. Bears, Tigers, Lions, Crocodiles and Whales, Oaks and Cedars, Seas and Mountains, Comets, Stars, Worlds and Suns, are the CAPITALS in Nature's

Nature's mighty Volume, and of them we ſhould not be ignorant: but whoever would read there with Underſtanding, muſt make himſelf Maſter of the *little Letters* likewiſe, which occur a thouſand times more frequently, and, if he does not know them, will ſtop him ſhort at every Syllable.

The likelieſt Method of diſcovering Truth, is, by the Experiments of Many upon the ſame Subject; and the moſt probable Way of engaging People in ſuch Experiments, is, by rendering them eaſy, intelligible and pleaſant. To effect this is my Endeavour in the following Treatiſe, which may ſerve as the Repreſentation of an Object for the Inſtrument I am recommending; ſmall, indeed, and ſeemingly of no Conſequence; but what, upon Examination, will be found, perhaps, to contain as many uſeful Parts as thoſe that are much bulkier: for, to drop the Allu-

ſion here, I am certain, that with half the Pains I could have made it twice as large.

Think me not ſo preſumptuous to dream of inſtructing you in Matters you are much better acquainted with than I can pretend to be; but give me leave to requeſt the Favour of your Concurrence, in my Deſire of explaining, to thoſe that are ignorant, a Science that may prove of the moſt eminent Service towards the Advancement of True Knowledge, and in which every body that has Inclination and Opportunity may be able to do ſomething.

Excuſe my Miſtakes, forgive my detaining you thus long, and permit me the Honour to be, with all poſſible Reſpect and Veneration,

GENTLEMEN,

Your moſt Obedient

and devoted Humble Servant,

Henry Baker.

Contents of the CHAPTERS.

PART the FIRST.

PART the SECOND.

Chap.

THE

THE INTRODUCTION.

IN this inquiſitive Age, when the Deſire of Knowledge has ſpread itſelf far and wide, and we ſit not down contented, as heretofore, with the Opinions of ancient Times, but reſolve to examine for Ourſelves, and judge from our own Experience; it may not, perhaps, prove unacceptable to point out ſome proper Subjects of Enquiry.

The Works of Nature are the only Source of true Knowledge, and the Study of them the moſt noble Employment of the Mind of Man. Every Part of the Creation demands his Attention, and proclaims the Power and Wiſdom of its Almighty Author. The ſmalleſt Seed, the minuteſt Inſect ſhews the Skill

Skill of Providence in the Aptneſs of its Contrivance for the Purpoſes it is to ſerve, and diſplays an Elegance of Beauty beyond the utmoſt Stretch of Art.

The Wiſe in all Ages have been ſenſible of this Truth; and, as far as they were able, have ſtudied and enquired into the Receſſes of Nature; but for want of proper Helps have frequently been miſtaken. As certain Principles muſt firſt be learned e'er we can become Maſters of any Science, ſo in the School of Nature, we muſt begin with the *Minutiæ*, the ſmalleſt and moſt uncompounded Parts, e'er we can underſtand the larger and more conſiderable.

The Ancients, having only their naked Eyes to truſt to, were uncapable of any great Diſcoveries of this Sort: but we are ſo happy, that, by the Help of Glaſſes, we can diſtinguiſh and examine Objects many thouſands of times leſs than what the ſharpeſt Eye, unaſſiſted, can diſcern. In ſhort, MICROSCOPES furniſh us as it were with a new Senſe, unfold the amazing Operations of Nature, and preſent us with Wonders unthought of by former Ages.

Who, a thouſand Years ago, would have imagined it poſſible, to diſtinguiſh Myriads of

of living Creatures in a ſingle Drop of Water? Or, that the purple Tide of Life, and even the Globules of the Blood ſhould be ſeen diſtinctly, rolling thro' Veins and Arteries ſmaller than the fineſt Hair? That Millions of Millions of Animalcules ſhould be diſcovered in the *Semen Maſculinum* of all Creatures? That not only the exterior Form, but even the internal Structure of the Bowels, and the Motion of the Fluids in a *Gnat* or *Louſe*, ſhould be rendered Objects of Sight? Or, that numberleſs Species of Creatures ſhould be made viſible, tho' ſo minute, that a Million of them are leſs than a Grain of Sand?

Theſe are noble *Diſcoveries*, whereon a new Philoſophy has been raiſed, that enlarges the Capacity of the human Soul, and furniſhes a more juſt and ſublime Idea than Mankind had before, of the Grandeur and Magnificence of Nature, and the infinite Power, Wiſdom, and Goodneſs of Nature's Almighty Parent.

That Man is certainly the happieſt, who is able to find out the greateſt Number of reaſonable and uſeful Amuſements, eaſily attainable and within his Power: and, if ſo, he that is delighted with the Works of Nature, and makes them his Study, muſt undoubtedly

doubtedly be happy; ſince every Animal, Flower, Fruit, or Inſect, nay, almoſt every Particle of Matter, affords him an Entertainment. Such a Man never can feel his Time hang heavy on his Hands, or be weary of himſelf, for want of knowing how to employ his Thoughts: each Garden or Field is to him a Cabinet of Curioſities, every one of which he longs to examine fully; and he conſiders the whole Univerſe as a Magazine of Wonders, which infinite Ages are ſcarce ſufficient to contemplate and admire enough.

The Invention of Glaſſes has brought under our Examination the two Extreams of the Creation, if I may be allowed to call them ſo, which were out of the Reach of former Ages: I mean, thoſe vaſt and diſtant Bodies of our Syſtem, the Sun and Planets; whoſe Dimenſions, Diſtances, Motions, Regularity and Order, we are become acquainted with by the Help of TELESCOPES, and thoſe exceedingly minute, and to them inviſible, and unknown, (though every where at hand) Species of Animals, Plants, *&c.* which the MICROSCOPE has diſcovered to us. I leave the TELESCOPE to others, who are better able to do it Juſtice: my Intent in this Diſcourſe is to treat of the MICROSCOPE, and encourage its more general Uſe,

by

by ſhewing the Pleaſure and Inſtruction it can afford us.

Mr. BOYLE ſays, in his Diſcourſe of the *Uſefulneſs of Experimental Philoſophy*, that his Wonder dwells not ſo much on Nature's *Clocks* as on her *Watches*; and, indeed, upon comparing the Structure of a *Mite* with that of an *Elephant*, I believe we ſhall concur in the ſame Opinion. The Largeneſs and Strength of the One may ſtrike us with Wonder and Terror, but we ſhall find ourſelves quite loſt in Amazement, if we attentively examine the ſeveral minute Parts of the Other. For the Mite has more Limbs than the Elephant, each of which is furniſhed with Veins and Arteries, Nerves, Muſcles, Tendons and Bones: it has Eyes, a Mouth, and a Proboſcis too (as well as the Elephant) to take in its Food; it has a Stomach to digeſt it, and Inteſtines to carry off what is not retained for Nouriſhment: it has an Heart to propel the Circulation of its Blood, a Brain to ſupply Nerves every where, and Parts of Generation as perfect as the largeſt Animal. Let us now ſtop, look back, and conſider, as far as our Abilities can reach, the exceſſive Minuteneſs of all theſe Parts; and if we find them ſo ſurprizing and beyond our Ideas, what ſhall we ſay of thoſe many Species of *Animalcules*, to whom a Mite

Mite itſelf, in Size, is as it were an Elephant?

All theſe, and numberleſs Wonders more, the MICROSCOPE can exhibit to us. I ſhall therefore proceed to deſcribe this noble Invention, ſhew how far it is improved at preſent, give a brief Account of what Diſcoveries have been made, and point out ſome Objects for the Curious to examine by it. In doing this I ſhall avoid as much as poſſible all Affectation of Learning, or Expreſſions that are not in common Speech, being deſirous that every body may underſtand me.

THE MICROSCOPE Made Easy, &c.

CHAP. I.

Of MICROSCOPES *in General.*

BY MICROSCOPES we are understood to mean, *Instruments of whatever Structure or Contrivance, that can make small Objects appear larger than they do to the naked Eye.*

This is effected by Glasses formed convex.

When only one ſuch convex Glaſs or **Lens* is uſed for this intent, the Inſtrument it is fixt in, however faſhioned, is called a *Single Microſcope:* but if two or more Glaſſes are imployed, conjointly, to magnify Objects more, it is then called a *Double* or *Compound Microſcope.*

One remarkable Difference in the Effect of theſe two Inſtruments is, that an Object view'd through a ſingle convex Glaſs, appears magnified, in the ſame Poſition exactly as when ſeen by the naked Eye; but when view'd through a Double Microſcope, compoſed of three convex Glaſſes, all Parts of it become inverted: that is, the Top of the Object appears at Bottom, the Right-ſide on the Left, and every Part in the Place moſt oppoſite to its natural and true Poſition: The Lights and Shades being alſo inverted, the ſinking parts appear to riſe, and the riſing parts to ſink in.

To what Accident, to what Country, or to whom we are obliged for the Invention

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* The Word *Lens* properly ſignifies a ſmall Glaſs in figure of a Lentil; but is extended to any Optic Glaſs not very thick, which either collects the Rays of Light into a Point in their Paſſage thro' it, or diſperſes them apart, according to the Laws of Refraction. If convex on both Sides, it is called a *Convex Lens*; but if one Side be flat, a *Plano-Convex:* If concave on both Sides, it is term'd a *Concave Lens*; if flat on one Side, a *Plano-Concave*; if convex on one Side and concave on the other, a *Convexo-Concave*, or *Concavo-Convex.*

of

of Microſcopes, is not in me to determine: the Honour has been given by ſome to DREBBEL a *Dutchman*, by others to FONTANA a *Neapolitan*, and by others ſtill to different People. The firſt Appearance of them however was about the Year 1621; ſince when they have been improving down to the preſent Time.

As my Deſire, is to make People ſenſible of the Pleaſure and Information the Microſcope can afford, and inſtruct them how to manage and underſtand it, rather than how to make it, I ſhall take up none of their Time with the Manner of melting, grinding, poliſhing, or ſetting of Glaſſes; a Work very few of my Readers will ever trouble themſelves about. But, inſtead thereof, I ſhall endeavour, with all the Brevity and Clearneſs I am able, to explain the Effects of Glaſſes on the Sight, and lead them gradually into the Nature, Uſes, and magnifying Powers of Microſcopes.

When Objects are ſeen through a perfectly flat Glaſs, the Rays of Light paſs through it from them to the Eye in a ſtrait Direction, and parallel to each other; and, conſequently, the Objects appear very little either diminiſhed, or enlarged, or nearer, or farther off, than to the naked Eye. But if the Glaſs they are ſeen through has any Degree of Convexity, the Rays of Light are directed from the Circumference towards

the Center, in an Angle proportionable to the Convexity of the Glaſs, and meet in a Point, at a greater or leſs Diſtance from the Glaſs, as it is leſs or more convex. This Point, where the Rays meet, is called the *Focus*; and this Focus is nearer or farther off, according to the Convexity of the Glaſs: for as a little Convexity throws it to a conſiderable Diſtance, when the Convexity is much, the Focus is very near. Its *magnifying Power* is alſo in the ſame Proportion to the Convexity: for as a flat Glaſs magnifies ſcarce at all, the leſs a Glaſs departs from Flatneſs, the leſs of courſe it magnifies; and the more it approaches towards a globular Figure, the nearer its Focus is, and the more its magnifying Power.

People's different Length of Sight depends on the ſame Principle, and ariſes from a more or leſs Convexity of the *Cornea* and *Cryſtalline Humour* of the Eye: the rounder theſe are, the nearer will the *Focus* or *Point of meeting Rays* be, and the nearer an Object muſt be brought to ſee it well. The Caſe of ſhort-ſighted People is only an over Roundneſs of the Eye, which makes a very near Focus; and that of old People is a ſinking or flattening of the Eye, whereby the Focus is thrown to a great Diſtance: ſo that the former may properly be called Eyes of too ſhort, and the latter Eyes of too long a Focus. Hence too, the Remedy for

the laſt is a convex Glaſs, to ſupply the want of Convexity in the Eye itſelf, and bring the Rays to a ſhorter Focus; whereas a concave Glaſs is needful for the firſt, to ſcatter the Rays, and prevent their coming to a Point too ſoon.

Nothing is more common than to obſerve old People holding Objects they would examine at a great Diſtance from them, for the Reaſon above-mentioned; and every body knows, ſhort-ſighted People cannot diſtinguiſh any thing without bringing it very near their Eyes. Both Extremes are inconvenient; but thoſe whoſe Eyes are flat by Age, ſhould remember with Satisfaction, that they have enjoy'd the Pleaſure of them for many Years; and the Short-ſighted may comfort themſelves, that they can diſtinguiſh much ſmaller Objects than long-ſighted People: for the Object is magnify'd in Proportion to the Roundneſs of the Eye and the Nearneſs of the Focus, and conſequently appears four times as big to an Eye whoſe Focus is but four Inches off, as it does to one whoſe focal Diſtance is at eight Inches. They have alſo this farther Advantage, that Age improves their Eyes, by the ſame Means it impairs other People's, that is, by making them more flat.

The nearer any Object can be brought to the Eye, the larger will be the Angle under which it appears, and the more it will be

magnified. Now, that Diſtance from the naked Eye, where the generality of People are ſuppoſed to ſee ſmall Objects beſt, is, at about eight Inches; conſequently, when ſuch Objects are brought nearer than eight Inches, (ſuppoſe to ſix) they'll become leſs diſtinct; and if nearer ſtill, on to four or three, they will ſcarce be ſeen at all. But by the help of convex Glaſſes we are enabled to view things, clearly, at much ſhorter Diſtances than theſe: for the Nature of a convex Lens is, to render an Object diſtinctly viſible to the Eye at the Diſtance of its Focus; wherefore the ſmaller a Lens is, and the more its Convexity, the nearer is its Focus, and the more its magnifying Power.

As it is an eaſy matter to melt a Glaſs Drop or Globule of a much ſmaller Diameter than any Lens can poſſibly be ground, and as the Focus of a Globule is no farther off than one quarter of its own Diameter, and conſequently it muſt magnify to a prodigious Degree, ſome Years ago People were extremely fond of ſuch Globules, and imagin'd no good Microſcope could be without them: but Experience has ſince taught, that they admit ſo little Light, can ſhew ſuch an exceedingly minute Part only of any Object, are ſo difficult to make uſe of, and ſtrain the Eyes ſo much, that their Power of magnifying, for want of due Diſtinctneſs, is rather apt to produce Error than diſcover Truth;

Truth: and therefore now they are very rarely employed.

CHAP. II.

Of the Kinds of MICROSCOPES.

MICROSCOPES are either Single or Double: the Single have but one Lens; the Double are a Combination of two or more. Each of these two Kinds has its particular Advantage: for a single Glass shews the Object nearer at hand, and rather more distinct; and a Combination of Glasses presents a larger Field, or, in other Words, exhibits more of an Object, equally magnified, at one View. It is difficult to determine which of these to recommend, since each affords a different Kind of Pleasure. Each of them too can produce considerable Authorities in its Favour; for Mr. LEEUWENHOEK never used any but * single

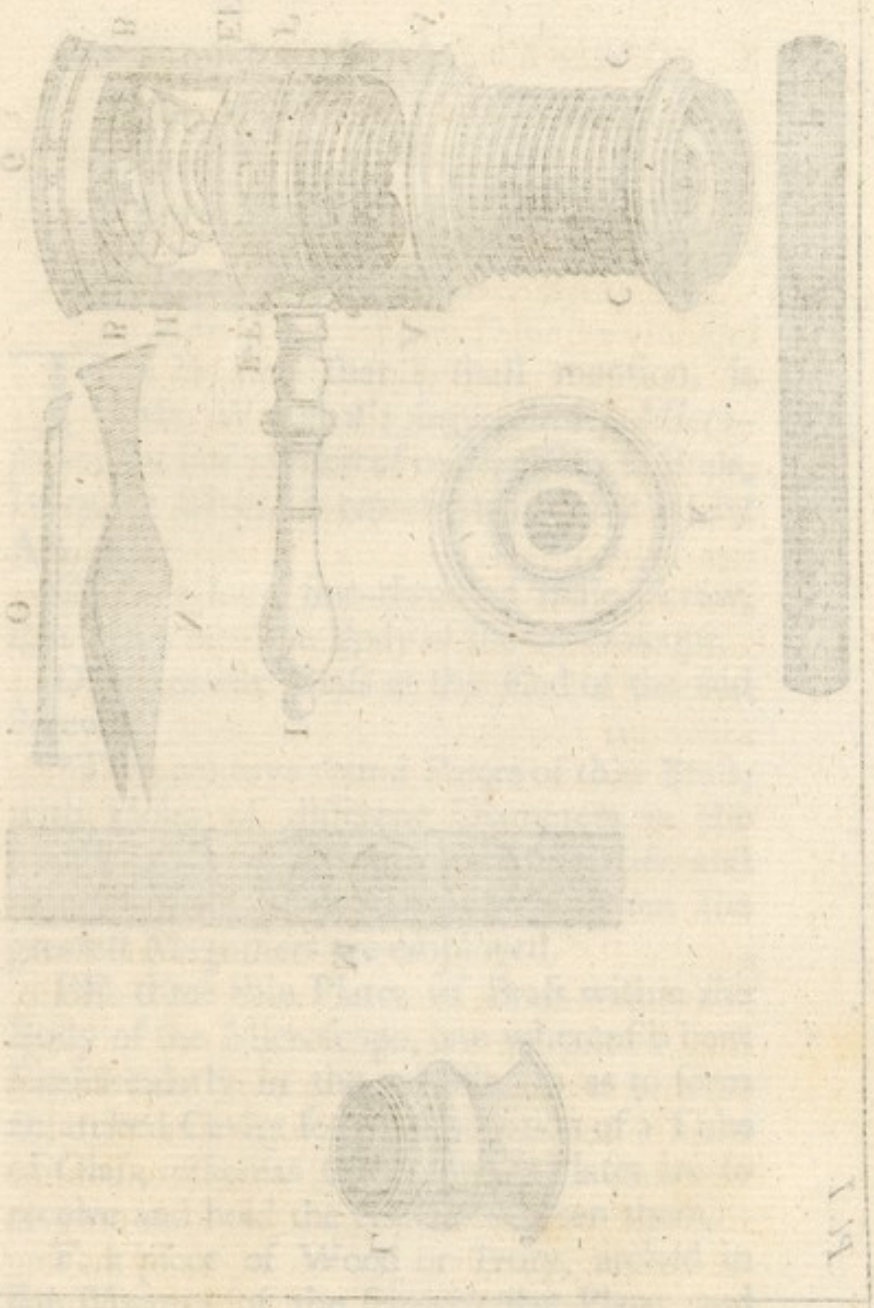
* Several Writers represent the Glasses Mr. LEEUWENHOEK made use of in his Microscopes to be little Globules or Spheres of Glass, which Mistake most probably arises from their undertaking to describe what they had never seen; for at the Time I am writing this, the Cabinet of Microscopes left by that famous Man, at his Death, to the *Royal Society*, as a Legacy, is standing upon my Table; and I can assure the World, that every one of the twenty-six Microscopes contained therein is a double convex Lens, and not a Sphere or Globule.

Microſcopes; and, on the contrary, Mr. HOOKE made all his Obſervations with double ones.

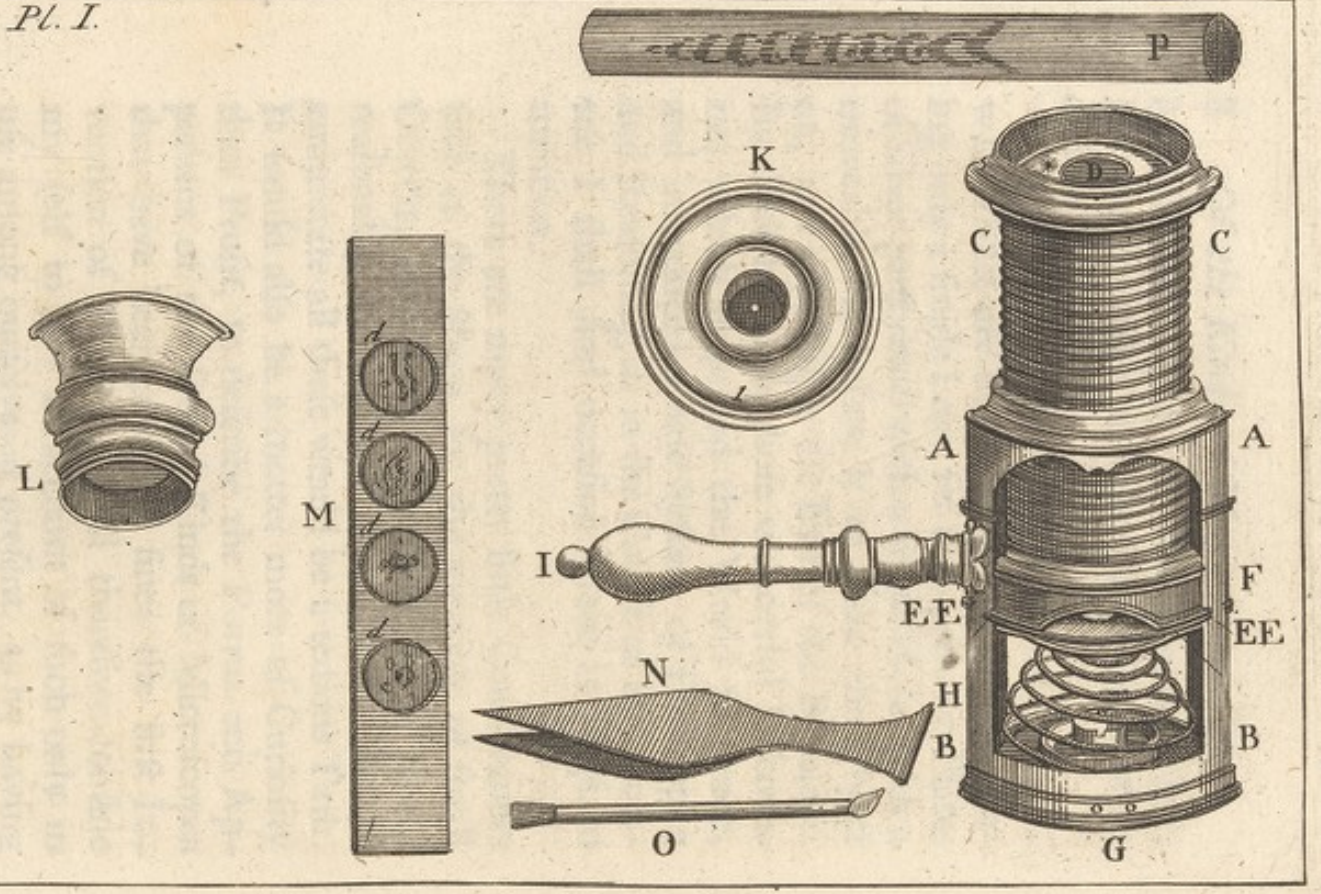
The famous Microſcopes of Mr. LEEUWENHOEK are the moſt ſimple poſſible, being only a ſingle Lens, ſet between two Plates of Silver perforated with a ſmall Hole, with a moveable Pin before it to place the Object on, and adjuſt it to the Eye of the Beholder. By theſe he made thoſe wonderful Diſcoveries which ſurprized the World ſo much, and introduced a new Syſtem of Philoſophy and Reaſoning, as in the Courſe of this Treatiſe I ſhall find occaſion more at large to mention.

There are many pretty little Contrivances ſold at the Shops for the viewing of ſmall Objects, which are entertaining as far as can reaſonably be expected from them: but to enumerate all theſe would be a tedious Taſk. It would alſo be a matter more of Curioſity than Profit, to deſcribe the Forms and Apparatus of the ſeveral Kinds of Microſcopes that have been contrived ſince the firſt Invention of them. I ſhall therefore confine my ſelf to give an account of ſuch only in uſe among ourſelves at preſent, as by having a proper Set of Glaſſes, gradually magnifying one above another, are fit to make Diſcoveries of Conſequence.

CHAP.



Pl. I.



CHAP. III.

Of Mr. WILSON's *Single Pocket-Microſcope.*

THE firſt that I ſhall mention, is Mr. WILSON's *ſingle Pocket Microſcope*; the Body whereof made either of Braſs, Ivory, or Silver, is repreſented (*Plate* I.) by AA. BB.

CC. is a long fine-threaded male Screw, that turns into the Body of the Microſcope.

D. a convex Glaſs at the End of the ſaid Screw.

*Two concave round Pieces of thin Braſs, with Holes of different Diameters in the middle of them, to cover the ſaid Glaſs, and thereby diminiſh the Aperture when the greateſt Magnifiers are employed.

EE. three thin Plates of Braſs within the Body of the Microſcope, one whereof is bent ſemicircularly in the middle, ſo as to form an arched Cavity for the Reception of a Tube of Glaſs, whereas the two flat Plates are to receive and hold the Sliders between them.

F. a piece of Wood or Ivory, arched in the Manner of the ſemicircular Plate, and cemented thereto.

G. the other End of the Body of the Microſcope, where a hollow female ſcrew is adapted to receive the different Magnifiers.

H. a ſpiral Spring of Steel, between the ſaid End G and the Plates of Braſs; intended to keep the Plates in a right Poſition, and counter-act againſt the long Screw CC.

I. a ſmall turn'd Handle, for the better holding of the Inſtrument, to ſcrew on or off at pleaſure.

To this Microſcope belong ſeven different magnifying Glaſſes: ſix of them are ſet in Silver, Braſs, or Ivory, as in the Figure K, and marked 1. 2. 3. 4. 5. 6. the loweſt Numbers being the greateſt Magnifiers.

L. is the ſeventh Magnifier, ſet in the Manner of a little Barrel, to be held in the Hand for the viewing any larger Object.

M. is a flat Slip of Ivory, called a Slider, with four round Holes through it, wherein to place Objects between two Glaſſes or Pieces of *Muſcovy* Talc, as they appear *d d d d.*

Eight ſuch Ivory Sliders, and one of Braſs, are uſually ſold with this Microſcope; ſome with Objects placed in them, and others empty, for viewing any thing that may offer: but whoever pleaſes to make a large Collection of Objects, may have as many as he deſires.

The Braſs Slider is to confine any ſmall Object, that it may be viewed without cruſhing or deſtroying it.

N. is a Forceps or Pair of Plyers, for the taking up of Inſects or other Objects, and adjuſting them to the Glaſſes.

O. is a little Hair-Bruſh or Pencil, where-with to wipe any Duſt from off the Glaſſes, or to take up any ſmall Drop of Liquid one would examine, and put it upon the Talcs or Iſinglaſs.

P. is a Tube of Glaſs, contrived to confine living Objects, ſuch as Frogs, Fiſhes, *&c.* in order to diſcover the Blood, as it ſtreams along the Veins and Arteries.

All theſe Particulars are contained in a little neat Box, very convenient for carrying in the Pocket.

When an Object is to be view'd, thruſt the Ivory Slider, in which the ſaid Object is placed, between the two flat Braſs Plates EE: obſerving always to put that ſide of the Slider where the Braſs Rings are, fartheſt from your Eye. Then ſcrew on the magnifying Glaſs you intend to uſe, at the End of the Inſtrument G; and looking through it againſt the Light, turn the long Screw CC, till your Object be brought to fit your Eye; which you will know by its appearing then perfectly diſtinct and clear.---'Tis beſt to look at it firſt through a Magnifier that can ſhew the Whole thereof at once, and afterwards to inſpect the ſeveral Parts more particularly with one of the greateſt Magnifiers: for thus you will gain a true Idea of the Whole, and of all its Parts. And tho' the greateſt Magnifiers can ſhew but a minute Portion of any Object at once, ſuch as

the Claw of a Flea, the Horn of a Louſe, or the like; yet by gently moving the Slider that contains your Object, the Eye will gradually overlook it all: and if any Part ſhould be out of Diſtance, the Screw CC will eaſily bring it to the true Focus.

As Objects muſt be brought very near the Glaſſes when the greateſt Magnifiers are uſed, be particularly careful not to ſcratch them, by rubbing the Slider againſt them, as you move it in or out. A few Turns of the Screw CC will eaſily prevent this Miſchief, by giving them Room enough.

You may change the Objects in your Sliders, for what others you think proper, by taking out the Braſs Rings with the Point of a Pen-knife; the Iſinglaſs will then fall out, if you but turn the Sliders; and after putting what you pleaſe between them, by replacing the Braſs Rings, you will faſten them as they were before. 'Tis proper to have ſome Sliders furniſhed with Talcs, but without any Objects between them, to be always in Readineſs for the Examination of Fluids, Salts, Sands, Powders, the *Farina* of Flowers, or any other caſual Objects of ſuch ſort as need only be apply'd to the Outſide of the Talc.

The Circulation of the Blood may eaſieſt be ſeen in the Tails or Fins of Fiſhes, in the fine Membrane between a Frog's Toes, or, beſt of all, in the Tail of a Water-Newt.

If

If your Object be a ſmall Fiſh, place it within the Tube, and ſpread its Tail or Fin againſt the Side thereof: if a Frog, chuſe ſuch an one as can but juſt be got into your Tube, and with a Pen or Stick expand the tranſparent Membrane between the Toes of the Frog's hind Foot as wide as you are able. When your Object is ſo adjuſted, that no Part thereof can intercept the Light from the Place you intend to view, unſcrew the long Screw CC, and thruſt your Tube into the arched Cavity, quite thro' the Body of the Microſcope; then ſcrew it to the true focal Diſtance, and you'll ſee the Blood paſſing along its Veſſels with a rapid Motion, and in a moſt ſurprizing Manner.

Make uſe of the third or fourth Magnifier for Frogs or Fiſhes; but for the Tails of Water-Newts, the fifth or ſixth will do; becauſe the Globules of their Blood are twice as large as thoſe of Frogs or Fiſh. The firſt or ſecond Magnifier cannot well be employed to this purpoſe; for the Thickneſs of the Tube wherein the Object lies, will ſcarce admit its being brought ſo near as the focal Diſtance of the Magnifier.

The *Single Microſcope* above deſcribed, may be formed into a *Double One*, by ſcrewing it to a Tube with an Eye-Glaſs at the End thereof: it is alſo made to anſwer nearly the Purpoſes of the large *Double Reflecting Microſcope*, by the Contrivance following.

CHAP.

CHAP. IV.

A New Invention for fixing the Pocket-Microſcope, *and giving Light to it by a* Speculum. *Plate* II.

IN this Plate, A is a Scroll of Braſs, fix'd upright on a round Pedeſtal of Wood, B, ſo as to ſtand perfectly firm and ſteady.

C. is a Braſs Screw, that paſſes through a Hole in the upper Limb of the Scroll, into the Side of the Microſcope D, and ſcrews it faſt to the ſaid Scroll.

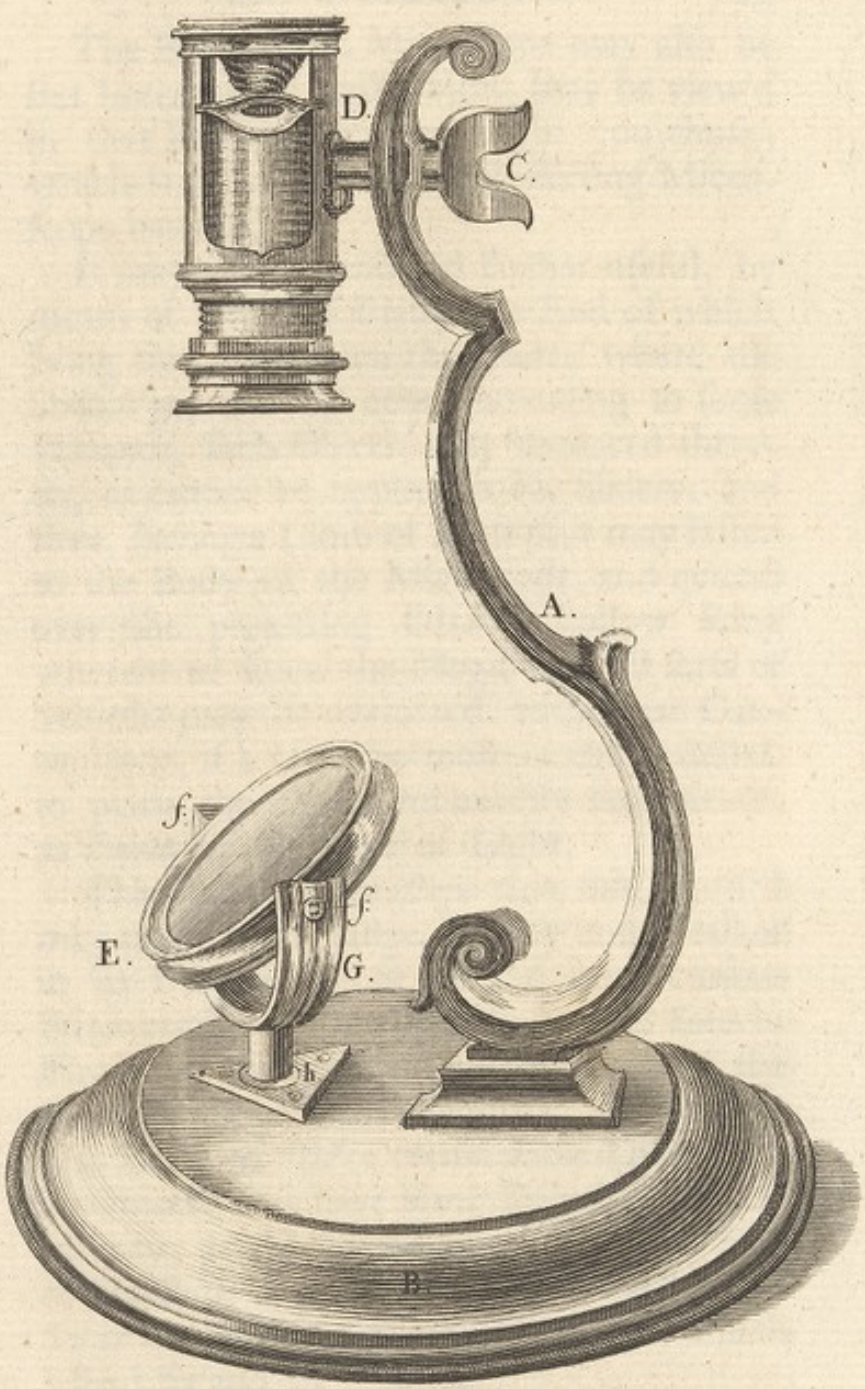
E. a concave Looking-glaſs or Speculum, ſet in a Box of Braſs, which hangs in the Arch G, by two ſmall Screws *f f*, that ſcrew into the oppoſite Sides thereof.

At the Bottom of the ſaid Arch is a Pin of the ſame Metal, exactly fitted to a Hole h, in the wooden Pedeſtal, made for the Reception of the ſaid Pin.

As the Arch turns on this Pin, and the Speculum turns on the Ends of the Arch, it may, by this twofold Motion, be eaſily adjuſted, in ſuch a manner, as to reflect the Light of the Sky, the Sun, or a Candle, directly upwards, thro' the Microſcope that is fixed perpendicularly over it; and by ſo doing, may be made to anſwer almoſt all the Ends of the large *Double Reflecting Microſcope*, which I ſhall preſently deſcribe.

The

Pl. II.



Partbury del.

J. Wigley Sculp.

CHAP. V.

Of the Double REFLECTING MICROSCOPE.

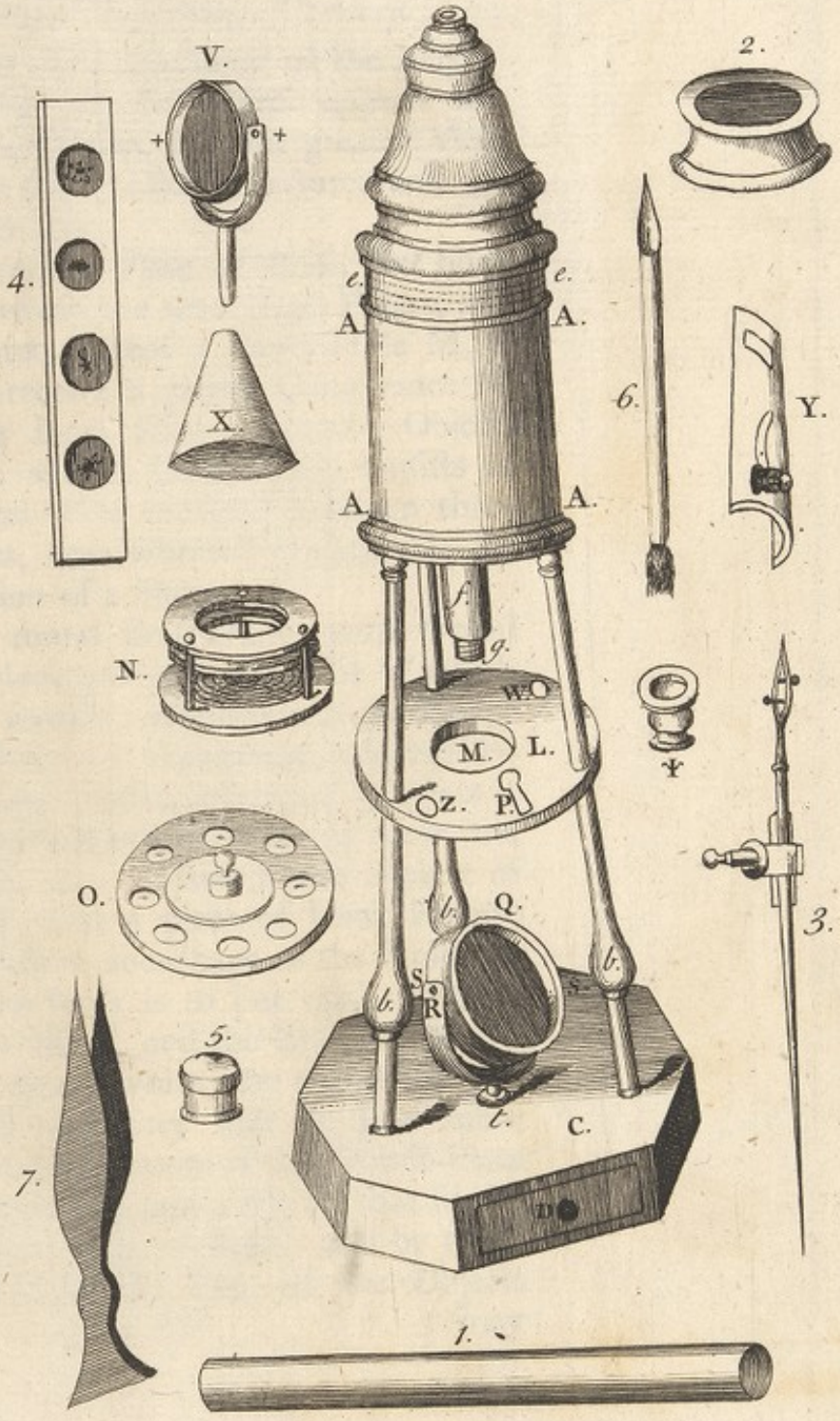
THE *Double Reflecting Microscope* in use at present, (whose Picture with its Apparatus is seen Plate III.) is an Alteration and Improvement by Mr. CULPEPER and Mr. SCARLET, of Mr. MARSHAL'S *large Double Microscope*; than which it is less cumbersome, may be managed with much more Ease, and by means of a reflected Light, is capable of shewing Objects in a clearer and more pleasing Manner.

The Body of this Microscope AAAA, being a large Tube, is supported by three Brass Pillars *b b b*, rising from a wooden Pedestal C; in which Pedestal is a Drawer D, to hold the Object-Glasses and other Parts of the Apparatus.

A lesser Tube *e e*, slides into the greater, and sends from its Bottom another Tube much smaller than itself, *f*, with a male Screw *g*, at the End thereof, whereon to screw the Object-Glass or Magnifier.

There are five of these Magnifiers, number'd 1, 2, 3, 4, 5, which Numbers are also marked on the inner Tube, to direct whereabout to place it according to the Magnifier made use of: but if then it fits not the Eye exactly, slide the inner Tube gently higher

or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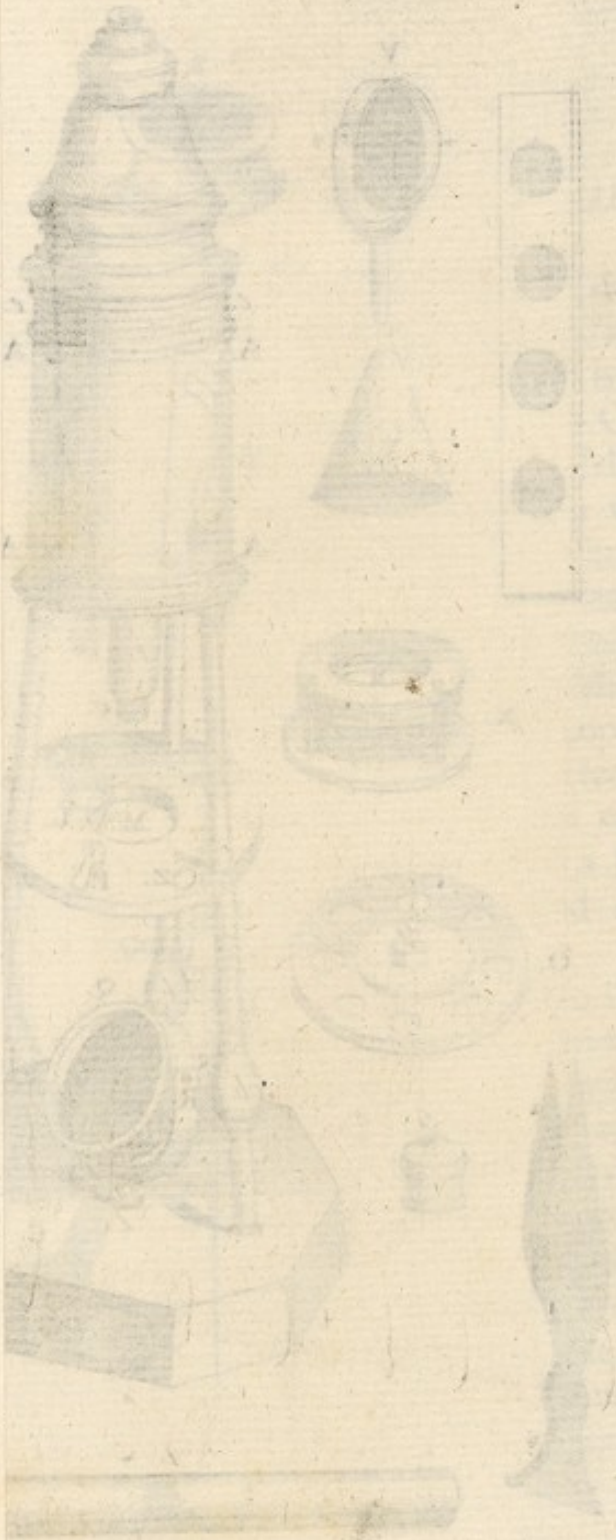


or lower, or turn the Screw of the Magnifier gradually, till the Object appears distinct.----Take notice, that the greatest Magnifiers have the smallest Apertures and the lowest Numbers.

L. is a circular Plate of Brass, fixt horizontally between the three Brass Pillars, and in the Center thereof a round Hole M. is adapted to receive a proper Contrivance N. for holding Ivory Sliders wherein Objects are placed: which Contrivance consists of a spiral Steel Wire confined between three Brass Circles, one whereof is moveable for the Admission of a Slider.

O. is a round Brass Plate, with several Holes for placing Objects in, some of which are usually furnish'd with them at the Shops: but two Holes are commonly reserved for small concave Glasses, whereon to place a Drop of any Liquid, in order to view the Animalcules, *&c.* There is also a piece of white Ivory, and a piece of black Ebony, of the same Size and Shape as the Holes for Objects: the Ivory is to put opake Objects on that are black, and the Ebony is to receive such as are white; by which Contrariety of Colours they will be seen more clearly.---At the Bottom of this Object-Plate is a Button to slip into a Slit P. that fits it, on the circular Plate of Brass: and by turning it round on this Pin, all the Objects

may be examin'd successively with very little Trouble.

Q. is a concave Looking-glass, set in a Box of Brass, and turning in an Arch R. upon two small Screws *s s*. From the Bottom of the Arch comes a Pin, which by letting down into a Hole *t*. in the Center of the Pedestal, enables it to turn vertically, or horizontally, and reflect the Light, either of a Candle, or the Sky, directly upwards on the Object to be viewed.

V. is a Plano-convex Lens, which by turning on two Screws **, when the Pin at the Bottom of it is placed in the Hole W. for its Reception in the circular Plate L. will transmit the Light of a Candle, to illuminate any opake Object that is put on the round piece of Ivory, or on the Ebony, for Examination: and it may be moved higher or lower as the Light requires. This Glass is of good service to point the Sunshine, or the Light of a Candle upon any opake Object; but in plain Day-light it is of no great use.

X. a Cone of black Ivory, to fasten on a Shank underneath the Brass circular Plate L. principally, when the first or second Magnifier is made use of, and the Object very transparent: for Experience teaches, that such Objects are render'd much more distinctly visible, by intercepting some part of the oblique Rays reflected from the concave Looking-glass.

The

The Brass Fish-pan Y. is, to fasten a Smelt, Gudgeon, or any such small Fish upon, to see the Blood circulate in its Tail. For which purpose, the Tail of the Fish must be spread across the oblong Hole at the smallest End of the Pan: then, by slipping the Button on the Backside of the Pan into the Slit P. through the circular Plate L. the Spring that comes from the Button will make it steady, and present it well to View.

But if it be a Frog, a Newt, or Eel, in which the Circulation is desired to be shewn, a Glass Tube 1. is fittest for the purpose. The Tail of a Newt, or Eel, or, in a Frog, the Web between the Toes of the Hind-Feet, are the Parts where it may be seen best. When the Object is well expanded on the Inside of the Tube, slide the Tube along under the circular Brass Plate L. (where there are two Springs and a Cavity made in the Shank to hold it) and bring your Object directly under the Magnifier.

There are three of these Glass Tubes, smaller one than another, and the Size of the Object must direct which to use; but in general, the less Room the Creature has to move about in, the easier it may be managed, and the quieter it will lye to be examined.

The Cell 2. with a concave and a plain Glass in it, is intended to confine Fleas, Lice, Mites, or any small living Objects,

during pleasure; and by placing it over the Hole M. in the middle of the circular Brass Plate, they may be viewed with much Conveniency.-----Three loose Glasses, *viz.* one plain, and two concave, belong also to this Microscope, and are designed to confine Objects, or place them upon occasionally.

The long steel Wire 3. with a pair of Plyers at one End, and a Point at the other, to hold fast, or stick Objects on, slips backwards or forwards in a Brass short Tube, whereto a Button is fastened, which fits into the little Hole *z*, near the Edge of the Brass Plate L: and, then, the Object may be readily brought to a right Position, and a Light be cast upon it, either by the Looking-glass underneath, or, if it be opake, by the Plano-convex Lens V.

4. is a flat Piece of Ivory called a Slider, with four round Holes through it, and Objects placed in them, between *Muscovy* Talcs or Isinglass, kept in by Brass Wires.

It is proper to have a Number of these Sliders filled with curious Objects, always ready, as well as some empty ones, for any new thing that offers. When made use of, thrust them between the Brass Rings of the Contrivance on purpose for them, N. which shoots into the round Hole M. in the Center of the Brass Plate L. This keeps them steady, and at the same time permits them to be moved to and fro for a thorough Examination.

A little Ivory round Box 5. to hold pieces of Iſinglaſs for the Sliders.

6. a ſmall Hair Bruſh, to wipe any Duſt off the Glaſſes, or to apply a Drop of any Liquid.

7. a pair of Nippers, to take up any Object to be examined.

The two Microſcopes I ſhall deſcribe next, *viz.* the *Solar*, or *Camera Obſcura Microſcope*, and the *Microſcope for Opake Objects*, are of a foreign Invention, and but lately known to us. We are, indeed obliged for them both to a Gentleman of *Pruſſia*, the ingenious Dr. LIBERKHUN, who when he was in *England*, about two Years ago, ſhewed an Apparatus for each of theſe Purpoſes, of his own Contrivance and Workmanſhip, to ſeveral Gentlemen of the *Royal Society*, and alſo to ſome Opticians; amongſt whom, Mr. CUFF, againſt *Serjeants-Inn* Gate, in *Fleetſtreet*, has taken great Pains to improve and bring them to Perfection: and therefore I ſhall give a Deſcription of them, as made and ſold by him.

CHAP. VI.

The Solar, or Camera Obſcura Microſcope.

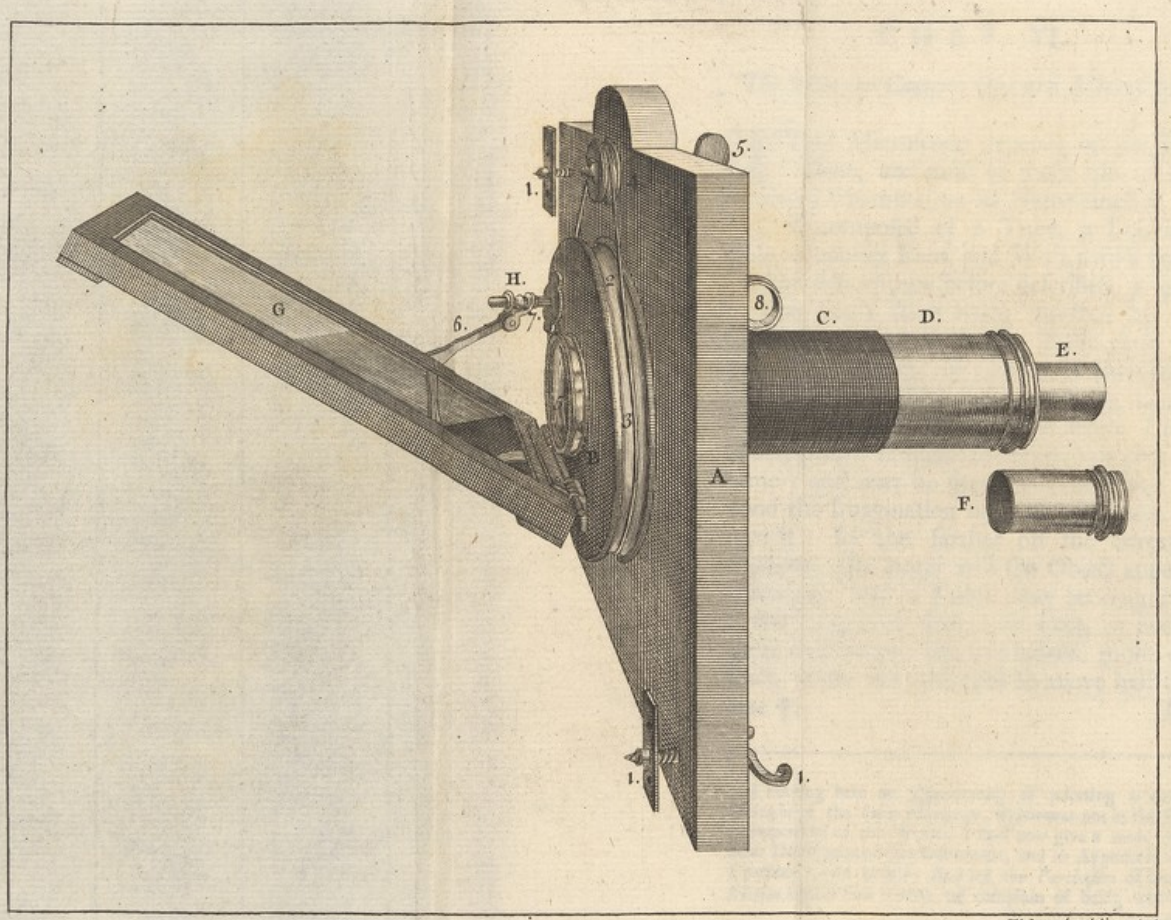
THIS Microſcope depends on the Sunſhine, and muſt be made uſe of in a darken'd Chamber, as its Name implies.

It is compoſed of a Tube, a Looking-glaſs, a convex Lens, and WILSON's ſingle Pocket Microſcope before deſcribed, p. 9.

The Sun's Rays being directed by the Looking-glaſs through the Tube upon the Object, the Image or Picture of the Object is thrown, diſtinctly and beautifully, upon a Screen of white Paper, or a white Linen Sheet, placed at ſome Diſtance to receive the ſame; and may be magnified, to a Size beyond the Imagination of thoſe who have not ſeen it: for the farther off the Screen is removed, the larger will the Object appear; inſomuch, that a Louſe may be magnified to the Length of five or ſix Feet, or even a great deal more: but it is indeed, more diſtinct, when not enlarged to above half that Size †.

The

† Having here an Opportunity of inſerting a curious Draught of the *Solar Microſcope*, which was not in the former Impreſſion of this Work; I ſhall now give a more particular Deſcription of that Inſtrument, and its Apparatus, than I poſſibly could before: And leſt the *Purchaſers* of the *firſt Edition* ſhould find Reaſon to complain of being unkindly uſed,



Th. Jefferys del. et Sculp.

F is another ſhort Braſs Tube, made to ſlide over the above-deſcribed Tube E. To the End hereof the Microſcope muſt be ſcrewed when we come to uſe it.

5, A convex Lens, whoſe Focus is about twelve Inches, deſigned to collect the Sun's Rays, and throw them more ſtrongly upon the Object.

G, a Looking-glaſs of an oblong Figure, ſet in a wooden Frame, faſten'd by Hinges to the circular Piece of Wood B, and turning about therewith, by means of the above-mention'd Cat-gut.

H, a jointed Wire, partly Braſs and partly Iron: the Braſs part whereof, which is flat 6, being faſten'd to the Looking-glaſs, and the Iron part, which is round 7, paſſing through the wooden Frame, enable the Obſerver (by putting it backwards or forwards) to elevate or decline the Glaſs according to the Sun's Altitude.

8, a Braſs Ring at the End of the jointed Wire, whereby to manage it with the greater Eaſe.

N. B. The Extremities of the Cat-gut are faſten'd to a Braſs Pin, by turning of which it may be braced up, if at any time it becomes too ſlack. This Pin lying behind could not be ſhewn in the Picture.

When this Microſcope is employed, the Room muſt be render'd as dark as poſſible; for on the Darkneſs of the Room, and the

the Brightneſs of the Sunſhine, depend the Sharpneſs and Perfection of your Image. Then putting the Looking-glaſs G through the Hole in your Window-ſhutter, faſten the ſquare Frame A to the ſaid Shutter by its two Screws and Nuts, 1. 1.

This done, adjuſt your Looking-glaſs to the Elevation and Situation of the Sun, by means of the jointed Wire H, together with the Cat-gut and Pulley 3. 4. For the firſt of theſe raiſing or lowering the Glaſs, and the other inclining it to either Side, there reſults a twofold Motion, which may eaſily be ſo managed as to bring the Glaſs to a right Poſition, that is, to make it reflect the Sun's Rays directly through the Lens 5, upon the Paper Screen, and form thereon a Spot of Light exactly round *.

As ſoon as this appears, ſcrew the Tube C into the Braſs Collar provided for it in the Middle of your Woodwork, taking care not to alter your Looking-glaſs: then ſcrewing the Magnifier you chuſe to employ to the End of your Microſcope, in the uſual Man-

* Though obtaining a perfectly circular Spot of Light upon the Screen before you apply the Microſcope, is a certain Proof that your Looking-glaſs is adjuſted right, that Proof muſt not always be expected: for the Sun is ſo low in Winter, that if it ſhines in a direct Line againſt the Window, it cannot then afford a Spot of Light exactly round. But if it be on either Side of you, a round Spot may be obtained even in *December*.

ner,

ner, take away the Lens at the other End thereof, and place a Slider, containing the Object to be examined, between the thin Braſs Plates, as in the other Ways of uſing the Microſcope.

Things being thus prepared, ſcrew the Body of your Microſcope to the ſhort Braſs Tube F, which ſlip over the ſmall End E of the Tube D, and pull out the ſaid Tube D leſs or more, as your Object is capable of enduring the Sun's Heat. Dead Objects may be brought within about an Inch of the Focus of the convex Lens, 5; but the Diſtance muſt be ſhorten'd for living Creatures, or they will ſoon be killed.

If the Light falls not exactly right, you may eaſily, by a gentle Motion of the jointed Wire and Pulley, direct it through the Axis of the microſcopic Lens.

The ſhort Tube F, which your Microſcope is ſcrewed to, enables you, by ſliding it backwards or forwards on the other Tube E, to bring your Objects to their true focal Diſtance; which will be known by the Sharpneſs and Clearneſs of their Appearance: they may alſo be turned round by the ſame Means, without being in the leaſt diſorder'd.

The Magnifiers moſt uſeful in the Solar Microſcope are, in general, the fourth, fifth, or ſixth.

Mention having been often made of a Screen to throw the Images of Objects on,

it

it is proper to inform the Reader, that ſuch a Screen is uſually compoſed of a Sheet of the largeſt Elephant Paper, ſtrained on a Frame which ſlides up, or down, or turns about at pleaſure on a round Wooden Pillar, in the manner of ſome Fire-ſcreens. Larger Skreens are likewiſe made ſometimes, with ſeveral Sheets of the ſame Paper paſted together on Cloth, and let down from the Ceiling with a Roller, like a large Map.

This Microſcope is the moſt entertaining of any, and, perhaps, the moſt capable of making Diſcoveries, in Objects that are not too opake: as it ſhews them much larger that can be done any other way. There are alſo ſeveral Conveniencies attending it, which no other Microſcope can have: for the weakeſt Eyes may uſe it without the leaſt Straining or Fatigue: Numbers of People may view any Object, together, at the ſame Time, and, by pointing to the particular Parts thereof, and diſcourſing on what lies before them, may be able better to underſtand one another, and more likely to find out the Truth, than when, in other Microſcopes, they muſt peep one after another, and perhaps ſee the Object neither in the ſame Light, nor the ſame Poſition. Such too as have no Skill in Drawing, may, by this Contrivance, eaſily ſketch out the exact Figure of any Object they have a mind to preſerve a Picture of; ſince they need only

faſten

faſten a Paper upon the Screen, and trace it out thereon either with a Pen or Pencil, as it appears before them.

It is worth their while, who are deſirous to take many Draughts this Way, to get a Frame, wherein a Sheet of Paper may be put or taken out at pleaſure; for if the Paper be ſingle, the Image of an Object will be ſeen as plainly almoſt on the back as on the fore Side, and by ſtanding behind the Screen, the Shade of the Hand will not obſtruct the Light in Drawing, as it muſt in ſome degree when one ſtands before it.

I muſt obſerve, that Dr. LIBERKHUN's Solar Microſcope had no Looking-glaſs belonging to it, and therefore was of uſe a few Hours only in a Day, when the Tube could be placed directly againſt the Body of the Sun, and even then not without a good deal of Trouble; but by this lucky Contrivance of a Looking-glaſs, the Sun's Rays may be reflected thro' the Tube, whatever its Height or Situation be, provided it ſhines at all upon the Window, and that too with much Eaſe and Advantage.

CHAP.

CHAP. VII.

Of the Microſcope for Opake Objects.

THIS Microſcope remedies the Inconvenience of having the dark Side of an Object next the Eye, which has hitherto been an unſurmountable Obſtruction to the making Obſervations on opake Objects with any conſiderable Degree of Exactneſs or Satisfaction: for in all other Contrivances commonly known, the Nearneſs of the Inſtrument to the Object (when Glaſſes that magnify much are uſed) unavoidably overſhadows it ſo much, as to render its Appearance obſcure and undiſtinct. And, notwithſtanding Ways have been tried to point Light upon an Object, from the Sun, or a Candle, by a convex Glaſs placed on the ſide thereof: the Rays from either can be thrown upon it in ſuch an acute Angle only, that they ſerve to give a confuſed Glare, but are inſufficient to afford a clear and perfect View of the Object.

But in this new Microſcope, by means of a concave *Speculum* of Silver, highly poliſhed, in whoſe Center a magnifying Lens is placed, ſo direct and ſtrong a Light is reflected upon the Object, that it may be examined with all imaginable Eaſe and Pleaſure.

The

The Apparatus for this Purpoſe (as in the Plate, Numb. IV.) has afforded me more Delight and Satisfaction than I am able to deſcribe; and whoever trys it, will I believe join in my Opinion, that he never before ſaw an opake Object with ſo much Clearneſs, and in ſo perfect and true a manner.

The ſeveral Parts of this Inſtrument made either of Braſs or Silver, are as follows.

Through the firſt ſide, A. paſſes a fine Screw B. the other End whereof is faſtened to the moveable ſide C.

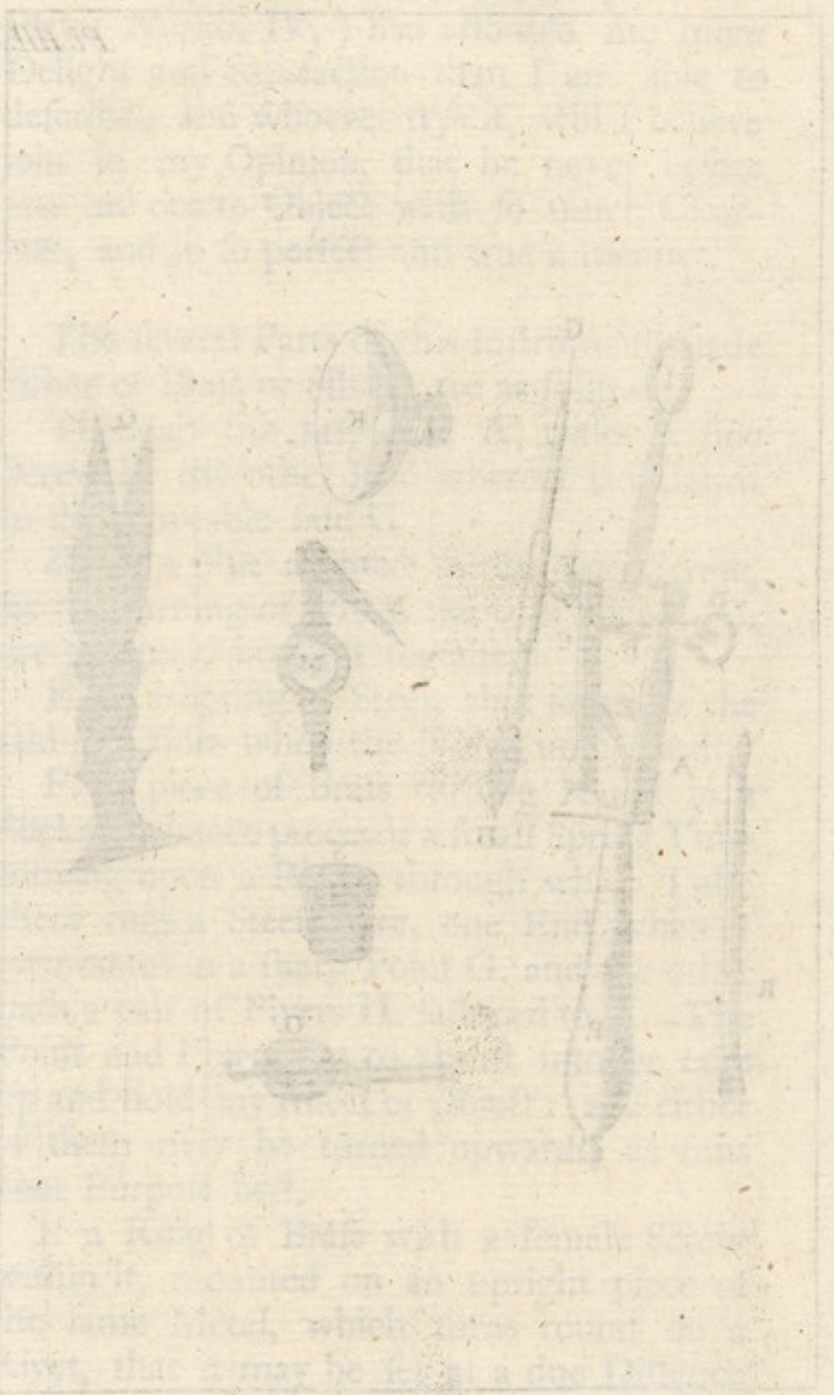
D. is a Nut adapted to the ſaid Screw, by the turning of which the two ſides A. C. are gradually brought together.

E. is a Spring of Steel, that ſeparates the ſaid two ſides when the Nut is unſcrewed.

F. a piece of Braſs turning round in a Socket, whence proceeds a ſmall Spring Tube moving upon a Rivet, through which Tube there runs a Steel Wire, one End whereof terminates in a ſharp Point G. and the other hath a pair of Plyers H. faſtened to it.—The Point and Plyers are to thruſt into or take up and hold any Inſect or Object: and either of them may be turned upwards, as ſuits your Purpoſe beſt.

I. a Ring of Braſs with a female Screw within it, mounted on an upright piece of the ſame Metal, which turns round on a Rivet, that it may be ſet at a due Diſtance

Pl. IIII.



when the leaſt Magnifiers are employed. ----This Ring receives the Screws of all the Magnifiers.

K. a concave Speculum of Silver, poliſhed as bright as poſſible, in the Center of which a double convex Lens is placed, with a proper Aperture to look through it. On the Back of this Speculum a male Screw L. is made fit to the Braſs Ring I. to ſcrew into the ſaid Ring at pleaſure.

There are four of theſe concave Specula, of different Depths, adapted to four Glaſſes of different magnifying Powers, to be uſed as Objects to be examined may require. The greateſt Magnifiers are known by having the leaſt Apertures.

M. a round Object-Plate, one ſide white and the other black, intended to render Objects the more viſible, by placing them, if black on the white, and if white on the black ſide. A Steel Spring N. turns down on each ſide to make any Object faſt: and iſſuing from the Object-Plate is a hollow Pipe to ſcrew it on the Needle's Point G.

O. a ſmall Box of Braſs, with a Glaſs on each ſide, contrived to confine any living Object, in order to examine it: this alſo has a Pipe to ſcrew upon the End of the Needle G.

P. a turned Handle of Wood, to ſcrew into the Inſtrument when it is made uſe of.

Q. a pair of Braſs Plyers, to take up any Object, or manage it with Conveniency.

R. a ſoft Hair Bruſh, to clean the Glaſſes or Specula, or apply a Drop of any Liquid to the Iſinglaſs of the Box O. in order to view the Animalcula.

S. a ſmall Ivory Box for Iſinglaſſes, to be placed when wanted in the ſmall Braſs Box O.

When you would view any Object, ſcrew the Speculum, with the Magnifier you think beſt to uſe, into the Braſs Ring I. Place your Object either on the Needle G. in the Plyers H. on the Object-Plate M. or in the Braſs hollow Box O. as may be moſt convenient, according to the Nature and Condition of it: then holding up your Inſtrument by the Handle P. look againſt the Light, through the magnifying Lens, and by means of the Nut D. together with the Motion of the Needle, by managing its lower End, the Object may be turn'd about, raiſed, or depreſſed, brought nearer the Glaſs, or put farther from it, till you hit the true focal Diſtance, and the Light be ſeen reflected from the Speculum ſtrongly upon the Object: by which means, it will be ſhewn in a manner ſurprizingly diſtinct and clear. And for this purpoſe, the Light of the Sky, or of a Candle, will anſwer to your Satisfaction.

This Microſcope is principally intended for opake Objects, but tranſparent ones may alſo be viewed by it: obſerving only, that when

when ſuch come under Examination, it will not always be proper to throw on them the Light reflected from the Speculum: for the Light tranſmitted through them meeting the reflected Light, may, together, produce too great a Glare. A little Practice will teach how to regulate both theſe Lights to good Advantage.

There is Reaſon to expect great Diſcoveries may be made by the *Apparatus* above deſcribed, as Opake Objects are a large Field, but little hitherto examin'd, by reaſon of the great Difficulty in doing it.

Having given a Deſcription of the ſeveral Sorts of Microſcopes in uſe amongſt us at preſent, and ſhewn what particular Advantages may be expected from each, I ſhall proceed to inſtruct the Ignorant in theſe Things, with all the Clearneſs I can, to find out the magnifying Powers of the Glaſſes they make uſe of, and calculate how many times they enlarge the Diameter, the Superficies, and the * Cube or ſolid Square of any Object under Examination. And this, I perſuade myſelf, will be highly ſatisfactory,

* Some, perhaps, may diſlike my ſuppoſing the Cube of an Object to be magnified, ſince in reality the Superficies only can be ſeen: but the Neceſſity of ſuch a Suppoſition will appear plainly in the Progreſs of this Work, when we come to conſider the true Size of Microſcopical Objects, by comparing them with larger Bodies.

and induce many People to be fond of this most delightful and instructive Study, when the Difficulties they imagined in it are removed, and they perceive it to be as easy as it is pleasant; when they find themselves able to judge of what they see, not by meer random Guess, but by certain and plain Principles.

CHAP. VIII.

To find the Magnifying Power of Glasses employed in Single Microscopes.

THE Appearance of any Object, as to Magnitude, is according to the Angle it is seen under; or, in other Words, according to the Nearness it can be brought to the Eye: for the less the Distance it can be view'd at is, the more it will appear enlarged.

The naked Eye is unable to distinguish any Object brought exceedingly near it: but looking through a convex Lens, however near the Focus of that Lens be, there an Object may be distinctly seen: and the smaller the Lens is, the nearer will be its Focus, and in the same Proportion the greater must be its magnifying Power.

From

From theſe Principles, it is eaſy to find the Reaſon, why the firſt or greateſt Magnifiers are ſo extremely minute; and alſo to calculate the magnifying Power of any convex Lens employed ſingly in a Microſcope. For ſuch as the Proportion of the natural Sight to the Focus of the Lens is, ſuch will be its Power of magnifying. If the Focus of a convex Lens (for Example) be at one Inch, and the natural Sight at eight Inches, which is the common Standard, an Object may be ſeen through that Lens at one Inch diſtant from the Eye; and will appear, in its Diameter, eight times larger than to the naked Eye. But as the Object is magnified every way equally, in Length, as well as Breadth, we muſt ſquare this Diameter to know really how much it appears enlarged; and we ſhall then find, that its Superficies is indeed magnified ſixty-four times.

Again: Suppoſe a convex Lens whoſe Focus is at one Tenth of an Inch diſtant from its Center: In eight Inches there are eighty ſuch Tenths of an Inch; and therefore an Object may be ſeen through this Lens, eighty times nearer than it can diſtinctly by the naked Eye. It will conſequently appear eighty times longer, and eighty times broader than it does to common Sight; and as eighty multiplied by eighty makes ſix thouſand and four hundred, ſo many times it really appears magnified.

To go one ſtep farther: If a convex Glaſs be ſo ſmall, that its Focus is no more than one twentieth of an Inch diſtant; we ſhall find, that eight Inches, the common Diſtance of Sight, contains an hundred and ſixty of theſe twentieth Parts; and, in conſequence, the Length and Breadth of an Object, when ſeen through ſuch Lens, will each be magnified an hundred and ſixty times; which, multiplied by an hundred and ſixty, to give the Square, will amount to twenty-five thouſand ſix hundred: and ſo many times, it is plain, the Superficies of the Object muſt appear larger than it does to the naked Eye at the Diſtance of eight Inches.

Therefore, in a ſingle Microſcope, to learn the magnifying Power of any Glaſs, no more is neceſſary than to bring it to its true Focus; the exact Place whereof will be known, by an Object's appearing perfectly diſtinct and ſharp when placed there. Then, with a Pair of ſmall Compaſſes, meaſure, as nearly as you can, the Diſtance from the Center of the Glaſs to the Object you was viewing, and afterwards applying the Compaſſes to any Ruler with a Diagonal Scale of the Parts of an Inch marked on it, you will eaſily find how many Parts of an Inch the ſaid Diſtance is: When that is known, compute how many times thoſe Parts of an Inch are contained in eight Inches, the common Standard of Sight, and

that will give you the Number of times the Diameter is magnified: ſquaring the Diameter will give you the Superficies; and if it be an Object whoſe Depth or whole Contents you would learn, multiplying the Superficies by the Diameter will ſhew the Cube or Bulk.

The Superficies of one Side only of an Object can be ſeen at one View; and to compute how much that is magnified is moſt commonly ſufficient. But ſometimes it is ſatisfactory to know how many minute Objects are contained in a larger: as, ſuppoſe, for Inſtance, I deſire to know, how many Animalcules would make up the Bigneſs of a Grain of Sand: To anſwer this, the Cube as well as the Superficies of the Animalcules muſt be taken into the Account; as will be ſhewn in the next Chapter.

As this Treatiſe is chiefly intended for thoſe who underſtand but little of ſuch Matters, it may neither be needleſs, nor unacceptable, to give a Table of the magnifying Powers of the convex Glaſſes commonly uſed in ſingle Microſcopes, according to their different Focus: whereby, upon meaſuring what the beſt Diſtance from the Glaſs to view the Object is, its Power of magnifying the Diameter, the Superficies, and the Cube of an Object will be found in one Line.

See the TABLE *.

As this Table is given in round Numbers, it is ſo clear and eaſy, that I believe whoever can but divide and multiply a few Figures will readily underſtand it.

I have taken no Notice of any Magnifier whoſe Focus is at a greater Diſtance than the half of an Inch; becauſe Glaſſes that magnify leſs than that, may very eaſily be calculated by the Rules above laid down: Nor, when I come to the greateſt Magnifiers, have I mentioned any of a ſhorter Focus than the one hundreth part of an Inch; ſince it is ſo difficult to grind a Lens to a Smallneſs beyond, or even ſo minute as this, that perhaps few of my Readers may ever meet with ſuch an one. And though Globules of Glaſs may be melted ſo extremely little, as to have their Focus at not half this Diſtance, and conſequently their magnifying Powers prodigiouſly greater; the uſe of them is ſo troubleſome, and attended with ſuch want of Light, ſuch Undiſtinctneſs and Uncertainty, that indeed they are of very little Service.

The magnifying Powers of the Glaſſes employed in WILSON's *Pocket Microſcope*, and alſo of thoſe belonging to the opake Microſcope, are to be calculated in the foregoing Manner. And as People will, no doubt,

be

* A TABLE
employed in S
Calculat

Shewing how many
when viewed

The Focus of a Glaſs at	

‡ The greateſt
Focus, as nearly a
magnifies the *Dia*
Single Microſcope
an Inch; whereb

See the TABLE *.

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The magnifying Powers of the Glaſſes employed in WILSON's *Pocket Microſcope*, and alſo of thoſe belonging to the opake Microſcope, are to be calculated in the foregoing Manner. And as People will, no doubt,

be

To be placed after Page 36.

* A TABLE of the MAGNIFYING POWERS of CONVEX GLASSES employed in SINGLE MICROSCOPES, according to the Distance of their *Focus*: Calculated by the *Scale of an Inch* divided into an Hundred Parts:

Shewing how many times the *Diameter*, the *Superficies*, and the *Cube* of an Object is *magnified*, when viewed through such *Glasses*, to an Eye whose natural Sight is at *Eight Inches*, or Eight Hundred of the Hundredth Parts of an Inch.

The Focus of a Glass at	Hundred Parts of an Inch:	*Magnifies the* Diameter,	*Magnifies the* Superficies,	*Magnifies the* Cube *of an Object*,	
$\frac{1}{2}$, or 50		16	256	4,096	
$\frac{4}{10}$, or 40		20	400	8,000	
$\frac{3}{10}$, or 30		26	676	17,576	
$\frac{1}{3}$, or 20		40	1,600	64,000	
15		53	2,809	148,877	
14		57	3,249	185,193	
13		61	3,721	226,981	
12		66	4,356	287,496	
11		72	5,184	373,248	
$\frac{1}{10}$, or 10		80	6,400	512,000	*Times.*
9		88	7,744	681,472	
8		100	10,000	1,000,000	
7		114	12,996	1,481,544	
6		133	17,689	2,352,637	
$\frac{1}{20}$, ‡ or 5		160	25,600	4,096,000	
4		200	40,000	8,000,000	
3		266	70,756	18,821,096	
$\frac{1}{50}$, or 2		400	160,000	64,000,000	
1		800	640,000	512,000,000	

‡ The greatest Magnifier in Mr. LEEUWENHOEK's Cabinet of Microscopes, presented to the *Royal Society*, has its *Focus*, as nearly as can well be measured, at one *Twentieth* of an Inch Distance from its Center, and consequently magnifies the *Diameter* of an Object 160 times, and the *Superficies* 25,600. But the greatest Magnifier in Mr. WILSON's Single Microscopes, as they are now made, has usually its *Focus* at no farther Distance than about the *Fiftieth* Part of an Inch; whereby it has a Power of enlarging the *Diameter* of an Object 400, and its *Superficies* 160,000 times.

To be placed after Page 36.

A TABLE of the MAGNIFYING POWERS

employed in Sinor's Microscopes, according to th

Calculated by the Scale of an Inch divided into

shewing how many times the Diameter, the Superficies, and th

when viewed through such Glasses, to an Eye which nat

or Eight Hundred of the Hundredth Par

		Hundred Parts of an Inch:	Magnifier the Diameter,	Magnifier the Superficies,
	$\frac{1}{2}$ or 50		100	2500
	$\frac{1}{4}$ or 40		200	4000
	$\frac{1}{5}$ or 30		250	6250
	$\frac{1}{10}$ or 20		400	16000
	1		523	27800
	14		571	32149
	13		615	37725
	12		666	43356
	11		727	52918
The Focus of a Glass at	$\frac{1}{16}$ or 10		800	64000
	9		888	78744
	8		1000	100000
	7		1142	130496
	6		1333	177689
	$\frac{1}{20}$ or 5		1600	256000
	4		2000	400000
	3		2666	711111
	$\frac{1}{40}$ or 2		4000	1600000
	1		8000	6400000

be pleaſed to know certainly what the Powers of their Glaſſes are, and conſequently what may be expected from them, it would be much better if the *Microſcope-Makers* would grind their Glaſſes according to ſome ſettled Standard, and not work by gueſs, as they uſually do at preſent, whereby no two Sets of Magnifiers can be ſuppoſed exactly alike. Such a Standard, which would afford a very uſeful Set of Glaſſes, magnifying one more than another in due Degrees, is, I think, as follows.

The FOCAL DISTANCES *of* Six Magnifiers *for Mr.* WILSON'S *Pocket Microſcope.*

Glaſs.	Diſt. of the Focus at --	100 Parts of an Inch.	Magnifies the Diam. Times.	Magnifies the Superficies, Times.
1.	$\frac{1}{50}$, or 2		— 400	--160,000
2.	$\frac{1}{20}$, or 5		— 160	— 25,600
3.	8		— 100	— 10,000
4.	16		— 50	— 2,500
5.	$\frac{5}{100}$, or 30		—26	— 676
6.	$\frac{1}{2}$, or 50		—16	— 256

The FOCAL DISTANCES *of* Four Magnifiers *for the Microſcope for* Opake Objects.

Glaſs		100 Pts. of an Inch.	Magnifies the Diam.		Magnifies the Superficies,	
1.	Diſt. of the Focus at---	8	100	Times.	10,000	Times.
2.		$\frac{3}{10}$, or 30	26		676	
3.		$\frac{6}{10}$, or 60	13		169	
4.		1 Inch,	8		64	

The magnifying Power of the Solar Microſcope muſt be calculated in ſomewhat a different Manner. For here, the Difference between the Focus of the Magnifier, and the Diſtance of the Skreen, or Sheet whereon the Image of an Object is caſt, is the Proportion of its being magnified. Suppoſe, for Inſtance, the Lens made uſe of has its Focus at half an Inch, and the Skreen be placed at the Diſtance of five Feet: The Object will then appear enlarged in the Proportion of five Feet to half an Inch: And as in five Feet there are one hundred and twenty half Inches, the Diameter will be magnified one hundred and twenty times, which multiplied by one hundred and twenty, ſhews the Superficies to be magnified fourteen thouſand and four hundred times: and by putting

ting the Skreen at farther Diſtances, you may magnify your Object to almoſt what Size you pleaſe. But I would adviſe all who uſe this Sort of Microſcope, to regard Diſtinctneſs more than Bigneſs, and place the Skreen juſt at that Diſtance where the Object is ſeen moſt ſharp and clear.

CHAP. IX.

Of the magnifying Power of Glaſſes in the double Microſcope.

I Should now ſhew the Method of computing the magnifying Power of our double Microſcope, as I have done of the ſingle ones: but a Calculation of the Powers of three combined Glaſſes, would appear ſo intricate and unintelligible to People unacquainted with Optics, (for whoſe Service chiefly I intend this Treatiſe) that I believe they will readily excuſe my perplexing them with it: and as for the learned in that Science, they probably will be better pleaſed to calculate for themſelves.

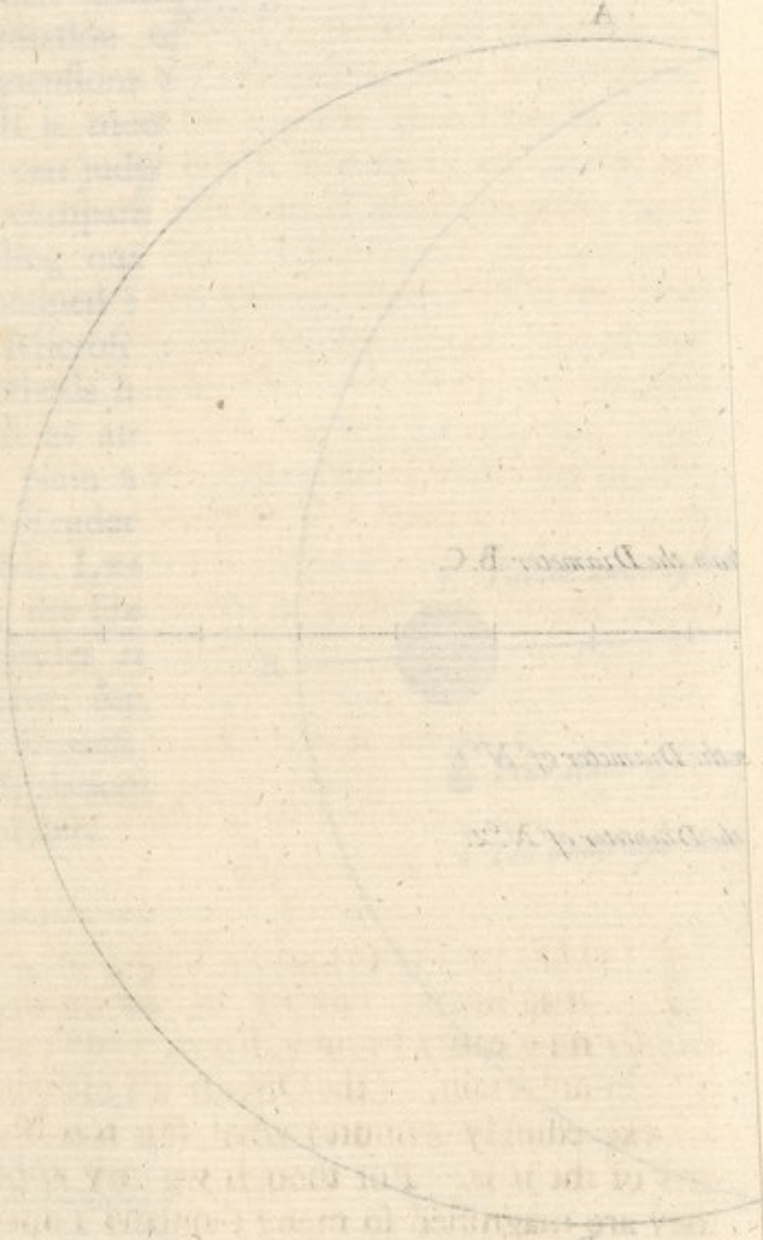
The double reflecting Microſcope, deſcribed p. 16. is the only Inſtrument at preſent made amongſt us for this Purpoſe, wherein ſuch a Combination of Glaſſes is employed. Here, indeed, the magnifying Power of the Object-

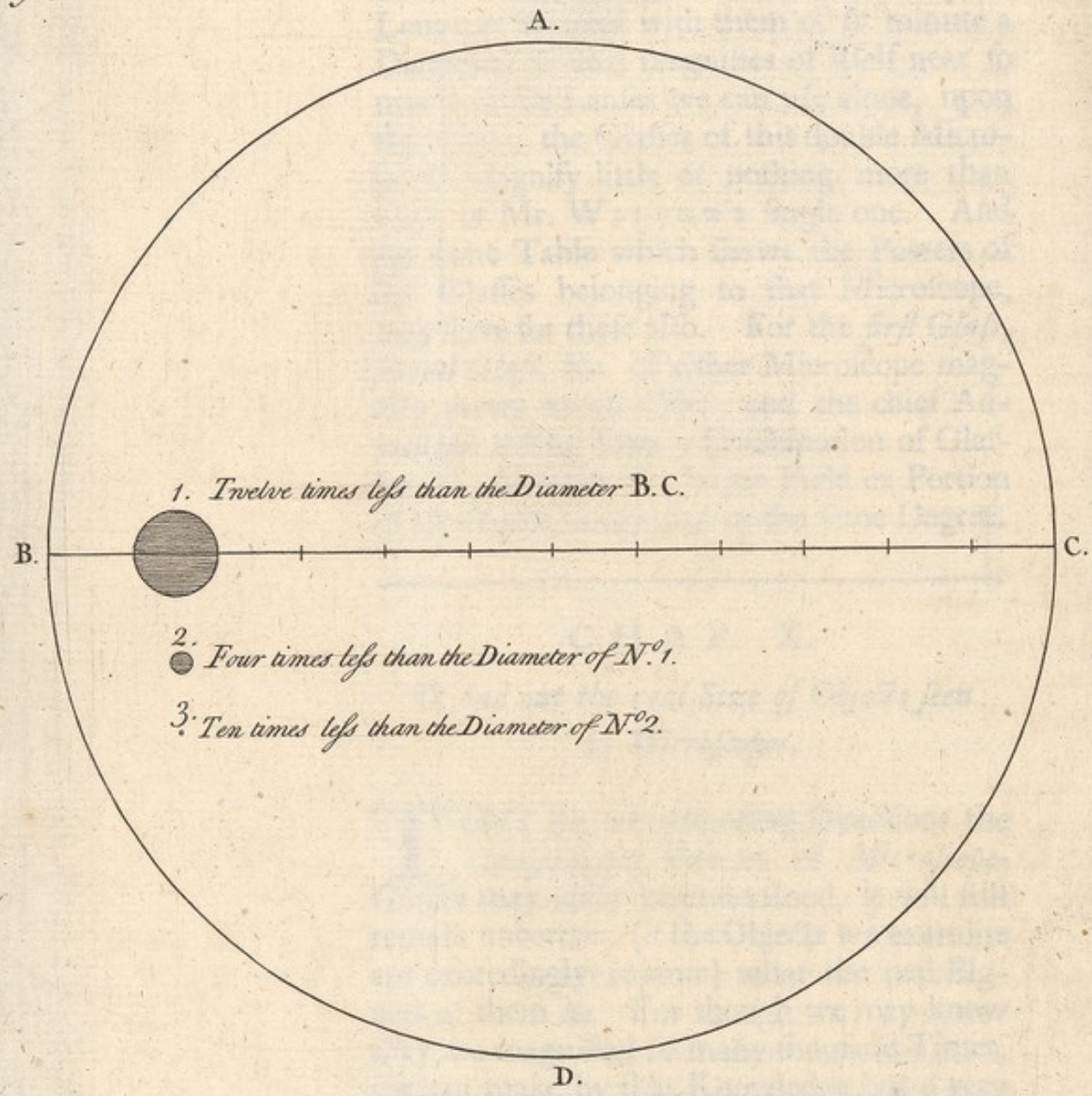
Object-Lens is greatly increaſed by the Addition of two Eye-glaſſes; but as no Object-Lens can be uſed with them of ſo minute a Diameter, or that magnifies of itſelf near ſo much as the Lenſes we can uſe alone, upon the whole, the Glaſſes of this double Microſcope magnify little or nothing more than thoſe of Mr. WILSON's ſingle one. And the ſame Table which ſhews the Powers of the Glaſſes belonging to that Microſcope, may ſerve for theſe alſo. For the *firſt Glaſs*, *ſecond Glaſs*, &c. of either Microſcope magnify pretty much alike; and the chief Advantage ariſing from a Combination of Glaſſes, is, the ſight of a larger Field or Portion of an Object, magnified in the ſame Degree.

CHAP. X.

To find out the real Size of Objects ſeen by Microſcopes.

THO' by the preceding Directions the magnifying Powers of *Microſcope-Glaſſes* may eaſily be underſtood, it will ſtill remain uncertain, (if the Objects we examine are exceedingly minute) what the real Bigneſs of them is. For though we may know they are magnified ſo many thouſand Times, we can make by that Knowledge but a very imperfect Computation of their natural and true


A
B


A.
1. Twelve times less than the Diameter B.C.
B.
C.
2. Four times less than the Diameter of N.° 1.
3. Ten times less than the Diameter of N.° 2.
D.

true Size; nor can we, indeed, come to any certain Concluſion as to that, but by the Mediation of ſome larger Object, whoſe Dimenſions we really know. For as Bulk itſelf is meerly comparative, the only Way we can judge of the Bigneſs of any thing, is, by comparing it with ſomething elſe; and finding out how many times the leſſer is contained in the larger Body. To do this in Microſcopical Objects, ſeveral ingenious Methods having been contrived; of which, ſuch as are come to my Knowledge, and are plain and practicable, I ſhall lay before the Reader.

Mr. LEEUWENHOEK's Way of computing the Size of Salts in Fluids, of the Animalcules *in Semine maſculino*, in *Pepper-Water*, &c. was by comparing them with the Bigneſs of a ‡ Grain of Sand; and his Calculations were made in the following Manner.

---

‡ *N. B.* It is proper to inform the Reader, that whereever, in this Treatiſe, Microſcopical Objects are compared with a Grain of Sand, which commonly was the Meaſure Mr. LEEUWENHOEK made uſe of, we muſt underſtand it to mean a Grain of coarſe *Sea-Sand* (uſually called *Scouring-Sand)* which is equal in Bigneſs to ſeveral Grains of our common Inland *Houſe-Sand*, or *Writing-Sand:* But to make our Calculations ſtill more certain, we muſt ſuppoſe them of ſuch a Size, that an Hundred of them, placed in a Row, ſhall extend an Inch in Length.

He

He view'd through his Microſcope a ſingle † Grain of Sand, which we'll ſuppoſe to be magnified as the round Figure ABCD. Then obſerving an Animalcule ſwimming, or running acroſs it, or coming near it, (which we'll imagine to be of the Size 1.) conſidering and meaſuring this by his Eye, he concludes, that the Diameter of this Animalcule is leſs, by a twelfth Part, than the Diameter of the Grain of Sand: conſequently, according to the common Rules, the Superficies of the Grain of Sand is one hundred forty four times, and the whole Contents thereof one thouſand ſeven hundred and twenty eight times larger than this Animalcule.

Suppoſe, again, that he ſees among theſe another and ſmaller Species of Animalcules; one of which [2.] he likewiſe meaſures with his Eye, by the help of a good Microſcope; and computes its Diameter to be five times, but, to be within compaſs, he reckons it only four times leſs than the former Animalcule 1. According then to the foregoing Rules, the Diameter of this will be ſixteen, and the whole Bulk ſixty-four times leſs than the Animalcule 1.

If farther, upon a nicer View, he diſcovers a third ſort of Animalcule [3.] ſo ex-

† Vide LEEUWEN. Experim. & Contempl. Tom. IV. pag. 23.

ceedingly

ceedingly minute, that, examining it in the former Manner, he concludes that the Diameter thereof is ten times ſmaller than the ſecond ſort: it will then follow, that a thouſand of theſe are but equal in Bigneſs to one of that ſecond ſort.

The firſt ſort multiplied by the ſecond, and the ſecond by the third, will plainly demonſtrate how many of this third and minuteſt ſort are requiſite to make up the Bulk of a ſingle Grain of Sand: the Proceſs of which is as follows.

Firſt ſort, 1. whoſe Diameter is leſs than that of a Grain of Sand,

12 times
12

144

Of the firſt ſort, 1,728 in a Grain of Sand.

Second ſort, 2. whoſe Diameter is leſs than that of the firſt ſort,

4 times
4

16
4

64 in one of the firſt ſort.

Third

Third ſort, 3. whoſe Diameter is leſs than than that of the ſecond ſort,

10 times
10

100
10

1000 in one of the 2d ſort.

1728 of the firſt ſort in a Gr. of Sand.
64 of the 2d ſort in one of the firſt.

6912
10368

110,592 of the 2d ſort in a Gr. of Sand.
1000 of the 3d ſort in 1 of the 2d.

110,592,000 of the 3d ſort in a Gr. of Sand.

After this manner, the comparative Size of all ſorts of Objects may very eaſily be computed, only ſubſtituting (for ſuch as are leſs minute) a ſmall Seed, or ſome other Body whoſe Size we are well acquainted with, in the room of a Grain of Sand. And, particularly, by the Solar Microſcope, our Calculations may be made with great Certainty; ſince the Image of the Object

enquired after, and of the Grain of Sand, the ſmall Seed, or whatever elſe is thought proper to compare with it, may be really meaſured by a Ruler, or a Pair of Compaſſes, and the Difference of their Diameters moſt exactly found.

The Method Mr. HOOKE made uſe of, to know how much an Object appears magnified, I ſhall give in his own Words.------ "Having (ſays he) rectified the Microſcope, "to ſee the deſired Object through it very "diſtinctly; at the ſame time that I look "upon the Object through the Glaſs with "one Eye, I look upon other Objects at "the ſame Diſtance with my other bare "Eye: by which means I am able, by the "Help of a Ruler divided into Inches and "ſmall Parts, and laid on the Pedeſtal of "the Microſcope, to caſt as it were the "magnified Appearance of the Object upon "the Ruler, and thereby exactly to mea-"ſure the Diameter it appears of through "the Glaſs; which being compared with "the Diameter it appears of to the naked "Eye, will eaſily afford the Quantity of its "being magnified."---This, for Multitudes of Objects, is a ready and good Way; and I can declare from my own Experience, that a little Practice will render it exceeding eaſy and pleaſant.

Another very curious Way for this Purpoſe, is deſcribed by the ingenious Dr. JURIN, in

in the 45th Page of his *Physico-mathematical Dissertations*; the Manner whereof is thus: Wind a Piece of the finest Silver Wire you can get a great many times about a Pin, or some other such slender Body, so closely as to leave no Interval between the Wire-Threads; to be certain of which they must be carefully examined with a Glass. Then, with the Points of a small Pair of Compasses, measure exactly what Length of the Pin the Wire covers: and applying the Compasses with that Measure to a diagonal Scale of Inches, you'll find how much it is: after which, by counting the Number of Wire-Rounds contain'd in that Length, you'll easily discover the real Thickness of the single Wire. This being known, cut it into very small Pieces, and when you examine an Object, if it be opake, strew some of these Wires upon it; if transparent, under it; and with your Eye compare the Parts of the Object with the Thickness of such Bits of Wire as lye fairest to your View.

By this Method Dr. JURIN observed, that four Globules of human Blood would generally cover the Breadth of a Wire, which he had found to be $\frac{1}{485}$th Part of an Inch; and consequently that the Diameter of a single Globule was $\frac{1}{1940}$th Part of an Inch. Which was also confirmed by Mr. LEEUWENHOEK's Observations upon human Blood, made with a Piece of the same Wire, sent

to

to him by Dr. JURIN. *Vide Philoſoph. Tranſ.* Numb. 377.

Mr. MARTIN, in his Optics, gives another Way, ſufficiently eaſy and ready on all Occaſions. On a circular Piece of Glaſs, let a Number of parallel Lines be drawn carefully with the fine Point of a Diamond, at the Diſtance of one fortieth Part of an Inch from each other. If this be placed in the Focus of the Eye-glaſs of a Microſcope, the Image of the Object will be ſeen upon theſe Lines, and the Parts thereof may be compared with the Intervals, whereby its true Magnitude, or Dimenſions, may be very nearly known: for the Intervals of theſe Lines, though ſcarce diſcernable to the naked Eye, appear very large through the Microſcope. A Contrivance of this Kind may alſo be invented for ſuch Microſcopes, as a Glaſs cannot be apply'd to in the above manner, by placing it under or behind the Object, which will anſwer the ſame Purpoſe.

Hereby it will be eaſy to find what Proportion an Object, or any Part thereof, bears to an Interval between two Lines, and then determine it in Parts of an Inch: for if the Width of an Object appears juſt one Interval, we ſhall know it to be juſt one fortieth Part of an Inch; if half an Interval, the eightieth; if a Quarter of an Interval, the one hundred and ſixtieth; if one fifth, only the two hundredth Part of an Inch.

Dr. SMITH has an Invention akin to this, for taking exact Draughts of Objects, viewed in double Microscopes; for he advises, to get a Lattice made with small Silver Wires, or small Squares drawn upon a plain Glass by the Strokes of a Diamond, and to put it into the Place of the Image form'd by the Object-Glass. Then, by transferring the Parts of the Object seen in the Squares of the Glass or Lattice upon similar corresponding Squares drawn on Paper, the Picture thereof may be exactly taken.

There are some other sorts of Micrometers, or Inventions for measuring the small Objects seen in Microscopes; but as they are more complex and difficult, I shall not swell this Volume with them.

CHAP. XI.

Of the Area *or* Portion *of an* Object *seen.*

THE visible Area, Field of View, or Portion of any Object seen through a Microscope, is in Proportion to the Diameter and Area of the Lens made use of, and its Power of magnifying, and may be thereby determined: since, if the Lens is extreamly small, it magnifies a great deal, and, consequently, a very minute Portion only of an Object

Object can be distinguished through it. For which Reason the greatest Magnifiers never should be employed but for the most minute Objects.-----This Consideration will direct how to suit the Magnifiers to the Size of the Objects to be examined, which is of the utmost Consequence in Microscopical Observations; and may serve to rectify the Mistake of Abundance of People unexperienced in Glasses, who, upon seeing a Mite or a Louse greatly magnified, are apt to cry out, with much Surprize, O that we had a Cricket, a Frog, or some other Creature; how finely that would appear! Whereas, in truth, such large Objects would intirely cover the Lens, and could not be seen at all.

Microscopes very happily assist us when Objects are so small as to evade our Sight; but it would be trifling and unnecessary to employ them on such large Things as we can see without their Help.

I shall not trouble the Unskilful with perplexing Calculations about the Area or Field of Objects seen by each Magnifier, but give this short Rule in general, that it differs not greatly from the Size of the Lens made use of, and that the Whole of any Object, much beyond that Size, cannot conveniently be viewed through it.

There is some Difference, as to the visible Area of an Object, between single and double Microscopes; for the double shew a larger

Portion of it than the ſingle, tho' magnified as much.

Having ſhewn the Structure and Powers of Microſcopes, I proceed now to deſcribe the Manner of chuſing, preparing, and applying Objects to them.

CHAP. XII.

Of Objects *in general.*

PRoper Objects to be examined by Microſcopes, are, (as Mr. HOOKE very judiciouſly diſtinguiſhes) "*exceeding ſmall Bodies*, "*exceeding ſmall Pores*, or *exceeding ſmall* "*Motions.*"

Exceeding ſmall Bodies, muſt either be the Parts of larger Bodies: or Things, the Whole whereof is exceedingly minute; ſuch as ſmall Seeds, Inſects, Sands, Salts, *&c.*

Exceeding ſmall Pores, are the Interſtices between the ſolid Parts of Bodies, as in Stones, Minerals, Shells, *&c.* or the Mouths of minute Veſſels, ſuch as the Air-Veſſels in Vegetables, the Pores in the Skin, Bones, *&c.* of Animals.

Exceeding ſmall Motions, are the Movements of the ſeveral Parts or Members of minute Animals, or the Motion of the Fluids

contained either in animal or vegetable Bodies.

Under one or other of these three Heads almost every thing around us affords Matter of Examination, and may conduce both to our Amusement and Instruction; as I hope more particularly to shew.

Many, even of those who have purchas'd Microscopes, are so little acquainted with their general and extensive Usefulness, and so much at a Loss for Objects to examine by them; that after diverting themselves and their Friends, some few times, with what they find in the Sliders bought with them, or two or three more common Things, the Microscopes are laid aside as of little farther Value: and, a Supposition that this must be the Case, prevents many others from buying them; whereas, among all the Inventions that ever appeared in the World, none can perhaps be found so constantly capable of entertaining, improving, and satisfying the Mind of Man.---To evince this, and excite those whose Time and Circumstances permit, to this delightful Study, is the Intention of my Writing; and, as Curiosity, the universal Passion of Mankind, may this Way continually be gratified, I hope I shall not write in vain. And if I can hereby induce any to pass those leisure Hours agreeably and usefully, in contemplating the Wonders of the Creation,

which otherwiſe would be ſpent in tireſome Idleneſs, or, perhaps, ſome faſhionable and expenſive Vice, I ſhall think theſe Sheets very happily beſtowed.

CHAP. XIII.

Of examining Objects.

AN Examination of Objects, in order to diſcover Truth, requires a great deal of Attention, Care, and Patience, together with ſome conſiderable Skill and Dexterity (to be acquired by Practice chiefly) in the preparing, managing, and applying them to the Microſcope. What little Knowledge in theſe Matters I may have gained, either from the Accounts of others, or my own Experience, after being converſant many Years therein, I ſhall readily communicate: in hopes my Pains may clear the Way to Diſcoveries that will prove of Conſequence to the World, and render this Study both deſirable and eaſy.

When any Object comes to be examined, the Size, the Contexture, and Nature of it ſhould be duly conſidered; in order to apply it to ſuch Glaſſes and in ſuch a Manner as may ſhew it beſt. The firſt Step towards this, conſtantly ſhould be, to view it through a Mag-

a Magnifier that can take in the Whole at once: for by obſerving how the Parts lie as to one another, we ſhall find it much eaſier to examine and judge of them ſeparately, if there be occaſion.---After having made ourſelves acquainted with the Form of the Whole, we may divide it as we pleaſe, and the ſmaller the Parts into which it is divided, the greater muſt be the Magnifiers wherewith to view them.

The Tranſparency or Opakeneſs of an Object muſt alſo be well regarded, and the Glaſſes made uſe of, muſt be accordingly ſuited thereto; for a tranſparent Object will bear a much greater Magnifier than one that is opake; ſince the Nearneſs a Glaſs that magnifies much muſt be placed at, unavoidably darkens an opake Object, and prevents its being ſeen, unleſs by the Microſcope on purpoſe for ſuch Subjects, deſcribed pag. 27. Moſt Objects, however, become tranſparent by being divided into extreamly thin or minute Parts. Contrivance therefore is neceſſary, to reduce them into ſuch Thinneſs or Smallneſs, as may render them moſt fit for Examination.

The Nature of the Object, whether it be alive or dead, a Solid or a Fluid, an Animal, a Vegetable, or a mineral Subſtance, muſt likewiſe be conſidered, and all the Circumſtances of it attended to, that we may apply it in the moſt convenient Manner. If

it be a living Animal, care muſt be taken to ſqueeze, hurt, or diſcompoſe it as little as poſſible, that its right Form, Poſture and Temper may be diſcovered. If a Fluid, and too thick, it muſt be thinned with Water: if too thin, we ſhould let ſome of its watery Parts evaporate. Some Subſtances are fitteſt for Obſervation when dry, others again when moiſtened; ſome when freſh, and ſome after being kept a while.

Light is the next Thing to be taken care of, for on this the Truth of all our Examination depends; and a very little Experience will ſhew, how different Objects appear in one Poſition and Kind of it, to what they do in another. So that we ſhould turn them every Way, and view them in every Degree of Light, from Brightneſs even to Obſcurity; and in all Poſitions to each Degree; till we are certain of their true Form, and that we are not deceived. For, as Mr. Hooke ſays, in many Objects it is very difficult to diſtinguiſh between a Prominency and a Depreſſion; between a Shadow and a black Stain; and in Colour, between a Reflection and a Whiteneſs. The Eye of a Fly, for Example, in one kind of Light, appears like a Lattice drilled through with Abundance of Holes: in the Sun-ſhine, like a Surface covered with golden Nails: in one Poſition, like a Surface covered with Pyramids, in another

another with Cones, and in other Positions of quite other Shapes.

The Degree of Light must be duly suited to the Object; which, if dark, will be seen best in a full and strong Light; but if very transparent, the Light should be proportionably weak: for which Reason there's a Contrivance, both in the single and double Microscope, to cut off abundance of its Rays, when such transparent Objects are examined by the greatest Magnifiers.

The Light of a Candle, for many Objects, and especially such as are exceedingly minute and transparent, is preferable to Day-light; and for others Day-light is best: I mean the Light of a bright Cloud. As for Sun-shine, it is reflected from Objects with so much Glare, and exhibits such gaudy Colours, that nothing can be determined by it with Certainty: and therefore it's to be accounted the worst Light that can be had.

This Opinion of Sun-shine must not, however, be extended to the Solar Microscope, which cannot be used to Advantage without its brightest Light; for, in that Way, we see not the Object itself whereon the Sun-shine is cast, but only the Image or Shadow of it exhibited upon a Skreen; and, therefore, no Confusion can arise by the glaring Reflection of the Sun's Rays from the Object to the Eye, which is the Case in other Microscopes. But then, in that Solar Way,

Way, we must rest contented with viewing the true Form and Shape of an Object, without expecting to find its natural Colour, since no Shadow can possibly wear the Colours of the Body it represents.

CHAP. XIV.

Of preparing and applying Objects.

MOST Objects require some Management, in order to bring them properly before the Glasses.----If they are flat and transparent, and such as will not be injured by Pressure, the best Method is to inclose them in Sliders, between two *Muscovy* Talcs or Isinglass. This Way the Feathers of Butterflies, the Scales of Fishes, the Farinæ of Flowers, *&c.* the several Parts, and even whole Bodies of minute Insects, and a thousand other Things, may very conveniently be preserved. Every curious Observer will therefore have them always ready to receive any accidental Object, and secure it for future Examination: and a Dozen or two of these Sliders, judiciously furnished, are a fine natural History, where we may read delightful Lessons of the high Perfection of God's Works, and his Wisdom in their Contrivance.

In making a Collection of Objects, the Sliders should not be filled promiscuously, but

but Care taken to ſort the Objects according to their Size and Tranſparency: in ſuch manner, that none be put together in the ſame Slider, but what may properly be examined by the ſame Magnifier: and then the Slider ſhould be marked with the Number of the Magnifier its Objects are fitteſt for: that is, the moſt tranſparent, or minuteſt Objects of all, which require the firſt Magnifier to view them by, ſhould be placed in a Slider, or Sliders marked with Number I. Thoſe of the next Degree in Sliders marked with Number II. and ſo of the reſt. This Method will ſave abundance of Time and Trouble in ſhifting the Magnifiers, which, without ſuch Sortment, muſt perhaps be done two or three Times in overlooking a ſingle Slider*. The Numbers marked upon the Sliders will likewiſe prevent our being at any Loſs what Glaſs to apply to each.

Small living Objects, ſuch as Lice, Fleas, Gnats, ſmall Bugs, minute Spiders, Mites, *&c.* may be placed between theſe Talcs, without killing or hurting them, if care be taken not to preſs down the Braſs Rings that keep in the Talcs: and will remain a-

* In placing your Objects in Sliders, a convex Glaſs of about an Inch Focus, to hold in the Hand, and thereby adjuſt them properly between the Talcs, before you faſten them down with the Braſs Rings, will be found very convenient.

live even Weeks in this Manner. But if they are larger than to be treated thus, either put them in a Slider with concave Glaſſes, intended for that Uſe, and deſcribed pag. 10. or in the Cell pag. 19. or elſe examine them ſtuck on the Pin, or held between the Plyers; either of which Ways they may be viewed at pleaſure.

If Fluids come under Examination, to diſcover the Animalcules that may be in them, take up a ſmall Drop with your Pen or Hair-pencil, and place it on a ſingle Iſinglaſs, (which you ſhould have in a Slider ready) or elſe in one of the little concave Glaſſes, and ſo apply it. But it caſe, upon viewing it, you find, as often happens, the Animalcules ſwarming together, and ſo exceedingly numerous, that running continually over one another, their Kinds and real Form cannot be known; ſome Part of the Drop muſt be taken off the Glaſs, and then a little fair Water put to the reſt, will make them ſeparate, and ſhew them diſtinct and well. And this Mixture of Water is particularly requiſite in viewing the *Semen Maſculinum* of all Creatures: for the Animalcules therein contained are ſo unconceiveably minute, and yet crowded together in ſuch infinite Numbers, that unleſs it be diluted a great deal, they cannot be ſufficiently ſeparated to diſtinguiſh their true Shape.

But,

But, if we view a Fluid, to find what Salts it may have in it, a Method quite contrary to the foregoing muſt be employed: for, then, the Fluid muſt be ſuffered to evaporate, that the Salts being left behind upon the Glaſs, may more eaſily be examined.

Another, and indeed the moſt curious Way of examining Fluids, is, by applying them to the Microſcope, in exceedingly ſmall capillary Tubes made of the thinneſt Glaſs poſſible. This was Mr. LEEUWENHOEK's Method for diſcovering the Shapes of Salts floating in Vinegar, Wine, and ſeveral other Liquors; and ſuch Tubes ſhould be always ready to uſe as occaſion requires.

For the Circulation of the Blood, Frogs, Newts, or Fiſhes, are commonly made uſe of; and there are Glaſs Tubes in the ſingle Microſcope, and a Fiſh-pan as well as Tubes in the double one, on purpoſe to confine theſe Creatures, and bring the proper Parts of them to view: which, in Newts and Fiſhes, are the Tails, and in Frogs the fine filmy Membrane between the Toes of the hinder Legs. Though, if we can contrive to faſten down the Creature, and bring our Object to the Magnifier, the Circulation cannot poſſibly be ſeen ſo plainly any where, as in the Meſentery, or thin tranſparent Membrane that joins the Guts together; and this Part, by pulling out the Gut a little, may eaſily be adjuſted to the Magnifier.

To diſſect minute Inſects, as Fleas, Lice, Gnats, Mites, *&c.* and view their internal Structure, requires a great deal of Patience and Dexterity: yet even this may be done, in a very ſatisfactory Manner, by means of a fine Lancet and Needle, if they are placed in a Drop of Water: for their Parts will then be ſeparated with Eaſe, and lie fair before the Microſcope, ſo that the Stomach and other Bowels may plainly be diſtinguiſhed and examined.

We ſhould always have ready for this Purpoſe little Slips of Glaſs about the Bigneſs neſs of a Slider, to place Objects on, occaſionally; ſome of which Slips ſhould be made of green, blew, and other different coloured Glaſs; many Objects being much more diſtinguiſhable when placed on one Colour than on another. We ſhould likewiſe be provided with Glaſs-Tubes of all Sizes, from the fineſt Capillaries that can be blown, to a Bore of half an Inch Diameter.

I believe there is no better Way of preſerving tranſparent Objects in general, than by placing them between clear Iſinglaſs in Sliders: But opake Bodies, ſuch as Seeds, Sands, Woods, *&c.* require different Management; and a Collection of them ſhould be prepared in the following Manner.

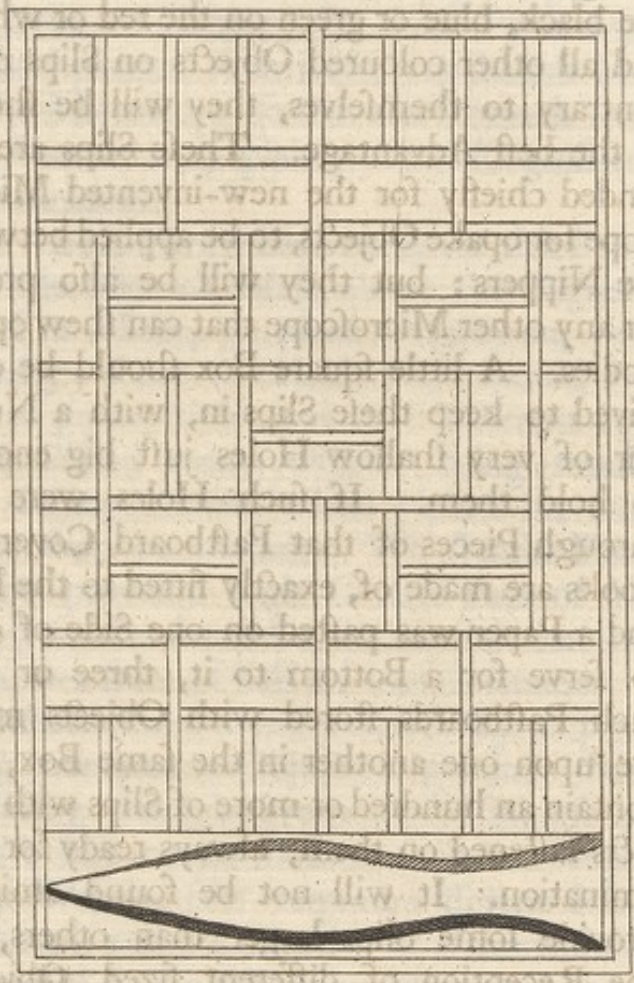
Cut Cards into ſmall Slips, about half an Inch in Length, and the Tenth of an Inch broad: wet them half their Length with a ſtrong

To dissect minute Insects, as Fleas, Lice, Gnats, Mites, &c. and view their internal Structure, requires a great deal of Patience and Dexterity: yet even this may be done, in a very satisfactory Manner, by means of a fine Lancet and Needle, if they are placed in a Drop of Water: for their Parts will then be separated with Ease, and lie fair before the Microscope, so that the Stomach and other Bowels may plainly be distinguished and examined.

We should always have ready for this Purpose little Slips of Glass about the Bignels of a Slider, to place Objects on, occasionally; some of which Slips should be made of green, blew, and other different coloured Glass; many Objects being much more distinguishable when placed on one Colour than on another. We should likewise be provided with Glass-Tubes of all Sizes, from the finest Capillaries that can be blown, to a Bore of half an Inch Diameter.

I believe there is no better Way of preserving transparent Objects in general, than by placing them between clear Pieces of Glass in Sliders: But opake Bodies; such as Seeds, Sands, Woods, &c. require different Management; and a Collection of them should be prepared in the following Manner.

Cut Cards into small Slips, about half an Inch in Length, and the Tenth of an Inch broad: wet them half their Length with a strong



ſtrong but very tranſparent Gum-water, and with that ſtick on your Object. As the Spots of Cards are red and black, by making your Slips of ſuch Spots you will obtain a Contraſt to Objects of almoſt any Colour: and by fixing black Things on the white, white on the black, blue or green on the red or white, and all other coloured Objects on Slips moſt contrary to themſelves, they will be ſhewn to the beſt Advantage. Theſe Slips are intended chiefly for the new-invented Microſcope for opake Objects, to be applied between the Nippers: but they will be alſo proper for any other Microſcope that can ſhew opake Bodies. A little ſquare Box ſhould be contrived to keep theſe Slips in, with a Number of very ſhallow Holes juſt big enough to hold them. If ſuch Holes were cut through Pieces of that Paſtboard Covers of Books are made of, exactly fitted to the Box, and a Paper was paſted on one Side of each to ſerve for a Bottom to it, three or four ſuch Paſtboards ſtored with Objects might lye upon one another in the ſame Box, and contain an hundred or more of Slips with Objects faſtened on them, always ready for Examination. It will not be found amiſs to provide ſome Slips larger than others, for the Reception of different ſized Objects: But the Pattern hereto annexed (*Plate* VI.) will

will better explain my Meaning *. The Box ſhould likewiſe be furniſhed with a Pair of Plyers, to take up and adjuſt the Slips.

CHAP. XV.

Cautions in viewing Objects.

BEware of determining and declaring your Opinion ſuddenly on any Object; for Imagination often gets the Start of Judgment, and makes People believe they ſee Things, which better Obſervations will convince them could not poſſibly be ſeen: therefore aſſert nothing till after repeated Experiments and Examinations in all Lights and in all Poſitions.

When you employ the Microſcope, ſhake off all Prejudice, nor harbour any favourite Opinions; for, if you do, 'tis not unlikely Fancy will betray you into Error, and make you think you ſee what you would wiſh to ſee.

Remember that Truth alone is the Matter you are in ſearch after; and if you have been miſtaken, let not Vanity ſeduce you to perſiſt in your Miſtake.

* Mr. CUFF, in *Fleet-ſtreet*, has already made ſome Boxes after this Pattern, which prove very convenient: He likewiſe makes and ſells all the *Microſcopes* with their *Apparatus* mentioned in this Treatiſe.

Paſs no Judgment upon Things over-extended by Force, or contracted by Dryneſs, or in any Manner out of their natural State, without making ſuitable Allowances.

There is no Advantage in examining any Object with a greater Magnifier than what ſhews the ſame diſtinctly; and therefore, if you can ſee it well with the third or fourth Glaſs, never uſe the firſt or ſecond; for the leſs a Glaſs magnifies, the better Light you'll have, the eaſier you can manage the Object, and the clearer it will appear.

It is much to be doubted, whether the true Colours of Objects are to be judged of, when ſeen through the greateſt Magnifiers: for as the Pores or Interſtices of an Object muſt be enlarged according to the magnifying Power of the Glaſs made uſe of, and the component Particles of Matter muſt by the ſame means appear ſeparated many Thouſands of times farther aſunder than they do to the naked Eye, their Reflections of the Rays of Light will probably be different, and exhibit different Colours. And, indeed, the Variety of Colouring ſome Objects appear dreſt in, may ſerve as a Proof of this.

The Motions of living Creatures themſelves, or of the Fluids contained within them, as ſeen through the Microſcope, are likewiſe not to be determined without due Conſideration: for as the moving Body and the Space wherein it moves are magnified, the

Motion must probably be so too. And therefore, that Rapidity, wherewith the Blood seems to pass along through the Vessels of small Animals, must be judged of accordingly. Suppose, for Instance, a Horse and a Mouse move their Limbs exactly at the same Moment of Time: if the Horse runs a Mile while the Mouse runs fifty Yards (tho' the Number of Steps are in both the same) we shall readily, I believe, allow the Horse's Motion to be swiftest. The Motion of a Mite viewed through a Microscope, or seen by the naked Eye, is, perhaps, not much less different.

Some People have made false Pretences and ridiculous Boasts, of seeing, by their Glasses, the Atoms of EPICURUS, the subtile Matter of DES CARTES, the * Effluvia of Bodies, the Emanations from the Stars, and other such like Impossibilities: But let no ingenious and honest Observer give Credit to these romantic Stories, or mispend his Time, and bewilder his Brains, in following such idle Imaginations, when there lies before him an Infinity of real Objects, that may be examin'd with Ease, Profit, and Delight.

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* Dr. HIGHMORE pretends, that the Effluvia of the Loadstone have been seen by Glasses, issuing from it in the Form of a Mist: And all the rest of the above Extravagances have been boasted of by others. *Vid.* LEEUWEN. *Arc. Nat.* Tom. ii. Part ii. pag. 348.

The

The MICROSCOPE *made Easy:*

OR, AN

ACCOUNT

Of what surprizing

DISCOVERIES

Have been already Made by the

MICROSCOPE;

WITH

Useful REFLECTIONS on them.

TOGETHER WITH

A great Variety of new EXPERIMENTS and OBSERVATIONS, pointing out many *uncommon Subjects* to the Enquiry of the CURIOUS.

PART II.

THE MICROSCOPE Made Easy, &c.

PART II.

HAVING described the most useful Kinds of MICROSCOPES made amongst us; shewn how to calculate the *magnifying Powers* of GLASSES, and the real *Size* of OBJECTS; taught the Ways of *preparing*, *examining*, and *preserving* OBJECTS; and given *proper Cautions* in our judging of what we view; I come now to the SECOND PART of my Design, which is, to shew what *surprizing Discoveries* have been already made by the MICROSCOPE, with useful *Reflections* on them: and also to set forth a great *Variety* of new *Experiments* and *Observations*, pointing out many *uncommon Subjects* for the Examination of the CURIOUS.

CHAP. I.

Of the ANIMALCULES *in Fluids.*

THE ſmalleſt living Creatures yet known are the *Animalcules* in Fluids: whereof many Kinds have been diſcovered by the Microſcope, of ſuch an exceeding Minuteneſs, that a Million of them would not equal the Bigneſs of a large Grain of Sand; and, it is probable, there may be numberleſs Species of a Size much leſs than theſe. It is alſo likely, that there are as many, or even more Kinds of theſe *Inviſibles* (if I may uſe the Term) than of thoſe whoſe Size is diſcernable by the naked Eye. Here, therefore, is abundance of Scope for Enquiry and Admiration, ſince every Drop of Water, or other Liquor, (excepting Oils and Spirits) either does already, or, upon ſtanding expoſed a few Days, will be full of *living Creatures*, of various Sizes and Forms. Some kinds of theſe *Animalcules* ſeem to be really Fiſh, and are natural Inhabitants of the Water all their Lives: others live there but occaſionally, in the manner of Gnats, which, from Eggs dropped by their Parents in the Water, become ſwimming Animals; but, after a while, ſhed their Skins, appear in a Form that bears no Reſemblance to what they wore before,

before, take Wing, and turn Creatures of the Air.

We may thus account how Water wherein *Pepper*, *Hay*, *Oats*, *Wheat*, or other *vegetable Subſtances* are infuſed, will ſoon become full of Life: for theſe *minute* and *inviſible little Flies*, which are every where hovering in the Air, and ſeeking Places to depoſit their Eggs, when a Fluid offers well ſtored with proper Nouriſhment for their future Offspring, may be ſuppoſed to reſort to it in Swarms, and lay their Eggs there. Theſe Eggs being ſoon hatched, the Infant Brood ſwim about and live happily in the Fluid; till grown to their ſtated Size, they, in due Time, change their Forms, employ their Wings, and fly away.

The Truth of this I have often experienced: for after obſerving ſome kinds of *Animalcules* in ſeveral Fluids to be grown to a certain Bigneſs, on a ſudden I have found them all gone away, and only a much ſmaller, and conſequently a younger Race of the ſame Kinds remaining; which alſo, when grown to a like Size, have ſoon after in the ſame Manner been gone too. Beſides, if the Infuſion be covered, tho' with a Muſlin or fine Lawn, I have conſtantly found that few *Animalcules* will be produced therein; but upon taking off the Cover, in a few Days it will be full of Life; which ſeems to prove, that the Eggs whence theſe *Animal-*

cules come, muſt either be depoſited by their own Parents, as I above ſuppoſe, or be brought along with the Air. And, indeed, both theſe Ways may poſſibly be: for as the Eggs of ſuch minute Creatures are lighter than Air, Millions of them may continually float therein, and, being wafted every where indifferently, may periſh in places unſuitable to their Nature, but hatch and thrive when they happen to be lodged in a proper *Nidus* for them. Some People imagine, that the Eggs of theſe little Creatures are lodged in the *Pepper*, *Hay*, or whatever elſe is put into the Water: but, were it ſo, I cannot think a thin Covering of Lawn, which does not exclude the finer Part of the Air, would prevent their being hatch'd; and therefore muſt conclude it a Miſtake.

Tho' Water that ſtands at reſt, and expoſed in the open Air, will, after a few Days, have ſome *Animalcules* in it, they will be found in no degree ſo numerous as when *vegetable Bodies* have been ſteeped therein: for no Creatures ſeem able to ſubſiſt on meer Water only, and what little Particles beſides may accidentally happen in it can maintain no great Number: But, when, by Infuſion of the abovementioned Subſtances, Water is ſtored with their proper Food, the Microſcope can ſhew Myriads of *living Creatures* in every little Drop.

As every curious Perſon will be deſirous to view theſe Wonders with his own Eyes, and communicate them to his Friends, the following Directions for making *Pepper-Water*, &c. to be kept always ready for Obſervation, may not perhaps be unacceptable.

CHAP. II.

To make PEPPER-WATER, *and of the* Animalcules *found therein.*

PUT common black Pepper, groſsly bruiſed, into an open Veſſel, to cover the Bottom of it about half an Inch in Thickneſs, and pour thereon Rain or River-water, till it riſes above the Pepper an Inch or thereabouts. Shake or ſtir the Water and Pepper very well together when firſt you mix them, but afterwards not at all. Expoſe your Veſſel to the Air uncovered, and in a few Days you'll perceive a little Pellicle or Skin upon the Surface of the Water, reflecting Priſm Colours. This Skin, examined by the Microſcope, will be found to contain Millions of *Animalcules*, ſcarce diſcernable at firſt, even by the greateſt Magnifier, but continually growing bigger till they come to their full Size. Their Numbers too will every Day increaſe exceedingly,

till at length almoſt the whole Fluid ſeems alive: tho' in reality, they lie chiefly on the Surface of the Water, and go not deep therein, unleſs frighted or diſturbed; but when that happens, they'll ſometimes dart down all at once, and not appear again for ſome time. In warm Weather this Skin riſes on the Surface ſooner, and you'll perceive them grow faſter than in cold: tho', even in the midſt of Winter, if the Water be not frozen, the Experiment will ſucceed.

About the Quantity of a Pin's Head of this Scum, taken up with the Nib of a new Pen, or a ſmall Hair Pencil, and applied on a ſingle Iſinglaſs, firſt to the third Magnifier, then to the ſecond, and then to the firſt, will ſhew ſeveral Sorts of *Animalcules* leſſer each than other, and differing a great deal in Shape as well as Size.

The Sorts that have been obſerved in *Pepper-Water*, are,

Firſt, The largeſt Sort of all, (repreſented Plate VII. Fig. I.) * The Length of theſe is about the Diameter of a Hair, and three or four times more than their Breadth. Their Bodies are very thin and tranſparent, but that Side which ſeems the Back is darker than the other. They turn themſelves in

* *Philoſoph. Tranſ.* Numb. 284.

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Pag. 7

Fig.
p. 72

Fig. I
p. 73

Fig. II
p. 74

Fig.
p. 77

Fig. VI.
p. 78.

Fig. X.
p. 79.

Fig. X.
p. 88.

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* *Philoſoph. Tranſ.* Numb. 284.

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Pag. 72.

Fig. I.
p. 72.

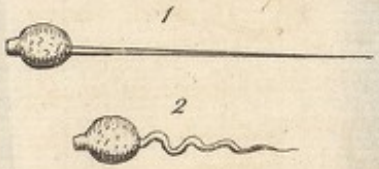


Fig. II.
p. 73.

Fig. III.
p. 73.

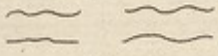


Fig. IV.
p. 74.

Fig. V.
p. 76.

Fig. VI.
p. 77.

Fig. VII.
p. 77.

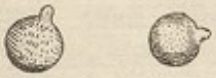


Fig. VIII.
p. 78.

Fig. IX.
p. 78.

Fig. X.
p. 79.

Fig. XI.
p. 85.

Fig. XIII. a. Fig. XIII. b.
p. 208.

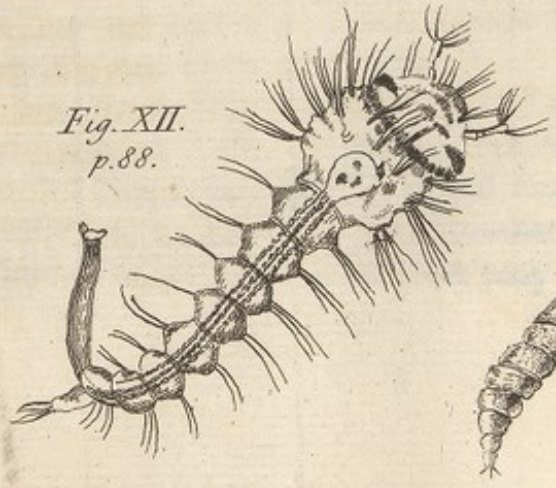
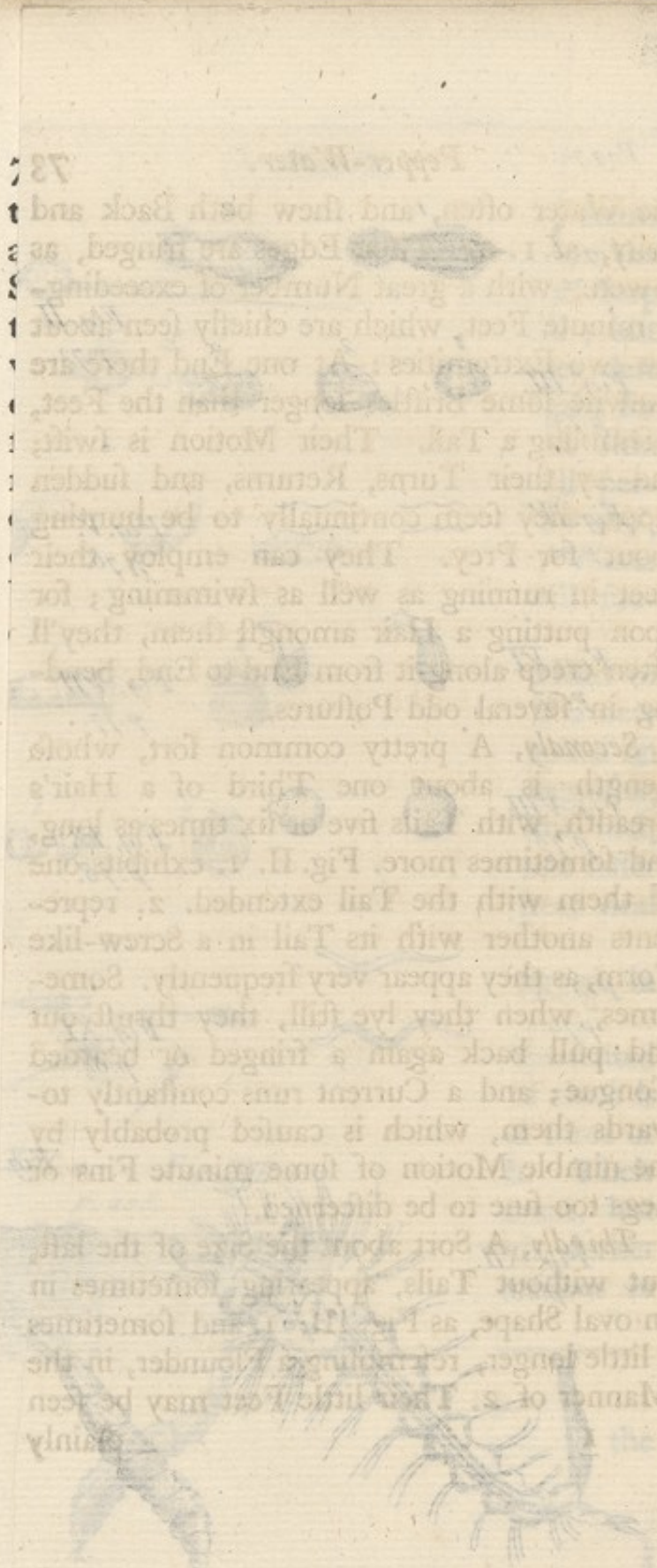


Fig. XII.
p. 88.



the Water often, and ſhew both Back and Belly, as 1. 2. Their Edges are fringed, as it were, with a great Number of exceedingly minute Feet, which are chiefly ſeen about the two Extremities: At one End there are likewiſe ſome Briſtles longer than the Feet, reſembling a Tail. Their Motion is ſwift; and by their Turns, Returns, and ſudden Stops, they ſeem continually to be hunting about for Prey. They can employ their Feet in running as well as ſwimming; for upon putting a Hair amongſt them, they'll often creep along it from End to End, bending in ſeveral odd Poſtures.

Secondly, A pretty common ſort, whoſe Length is about one Third of a Hair's Breadth, with Tails five or ſix times as long, and ſometimes more. Fig. II. 1. exhibits one of them with the Tail extended. 2. repreſents another with its Tail in a Screw-like Form, as they appear very frequently. Sometimes, when they lye ſtill, they thruſt out and pull back again a fringed or bearded Tongue; and a Current runs conſtantly towards them, which is cauſed probably by the nimble Motion of ſome minute Fins or Legs too fine to be diſcerned.

Thirdly, A Sort about the Size of the laſt, but without Tails, appearing ſometimes in an oval Shape, as Fig. III. 1. and ſometimes a little longer, reſembling a Flounder, in the Manner of 2. Their little Feet may be ſeen

plainly when the Water is juſt evaporating, for then they move them nimbly. Now and then two of them are ſeen conjoyned, as 3.

Fourthly, Another ſort appear like ſlender Worms, about fifty times as long as broad, and whoſe Thickneſs is about the one hundredth Part of a Hair. Their Motion is equable and ſlow, waving their Bodies generally but little in their Progreſſion. They ſwim with the ſame Facility backwards or forwards, and being every where of the ſame Thickneſs, it is difficult to diſtinguiſh which End the Head is placed at. See Fig. IV.

A *fifth Sort*, is ſo amazingly ſmall, that an Hundred of them in a Row would not equal the Diameter of a Grain of Sand, and, conſequently, a Million of them are but equal to a Grain of Sand in Bigneſs: their Shape is almoſt round.

A *ſixth Sort*, are about the Thickneſs of the foregoing, but almoſt twice as long: and, beſides theſe, there are doubtleſs other Sorts which have not duely been attended to.

It is agreeable enough, while theſe little Creatures are before the Microſcope, to obſerve the different Effects ſeveral kinds of Mixtures produce among them. For Example, putting to them the ſmalleſt Drop imaginable of Spirit of Vitriol upon the Point of a Pin,

Pin, they immediately ſpread themſelves, and appear to tumble down dead. Diſſolved Salt kills them, but with this Difference, that inſtead of becoming flat as in the former Caſe, they ſhrink into oval Forms. Tincture of Salt of Tartar throws them into convulſive Motions, after which they ſoon grow faint and languid, and then dye without any Change of Shape. Ink kills them as ſoon as Spirit of Vitriol, but ſeems to contract them ſeveral Ways. Freſh Blood, Urine, and Spittle kill them in a little while. Sugar diſſolved does the ſame; but thereby ſome dye flat and others round *.

If the Water be permitted to dry away without any Mixture, ſome Sorts of the Animalcules will burſt, but others not: and if a freſh Drop of Water be put to them, in a little while many of them will revive and ſwim about again.

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* *Philoſoph. Tranſ.* Numb. 203.

CHAP.

CHAP. III.

Of HAY-WATER, &c.

HAY, Straw, Graſs, Oats, Wheat, Barley, or any other vegetable Production, being infuſed in Water, in the Manner adviſed before, after ſome Days a ſort of whitiſh Scum or Motherineſs will appear upon the Surface, which, examined by a Microſcope, will be found to contain inexpreſſible Numbers of minute *living Creatures* of various Sizes, Forms, and Kinds.

And of theſe ſome are the ſame exactly as were juſt now deſcribed in *Pepper-Water:* for it is to be obſerved, that certain Kinds of theſe *Animalcules* are met with, univerſally, in all Waters that have ſtood any conſiderable Time expoſed to the open Air. The moſt general among them is an oval ſort of *Animalcule*, ſomewhat in the Shape of an Emmet's Egg (See Fig. V. Plate VII.) They are extreamly nimble, and in a continual ſwift Motion backwards and forwards: but ſometimes they ſtop on a ſudden, and turn round on their own Axis numberleſs times with ſurprizing Velocity, firſt one way, and afterwards the contrary *. This Gyra-

* The Solar Microſcope has diſcovered, that this ſtrange Motion is produced by the Action of a great Number of Legs or Fins, placed in a circular Order.

tion,

tion, or twirling round as it were on a Point, I have taken notice of in other Kinds alſo of the Animalcules found in Fluids.

Another pretty common Sort, and in Shape ſomewhat reſembling the foregoing, is ſhewn (Fig. VI.) Their Motion is very ſwift, and always with the ſharp End foremoſt, whence one may reaſonably ſuppoſe it to be the Head. Some of them are clear from End to End, but curiouſly ribbed in the Manner of a Melon: Others are tranſparent at their ſmall Extremity only, but have their Bottle-End opake. No Legs or Fins can be diſcerned in either.

We find another ſort, as long almoſt as the largeſt in *Pepper-Water*, which are very briſk and active, and have a Power of contracting or extending themſelves as they ſwim along. At the End that ſeems to be the Fore-part, ſeveral Feet are viſible; but eſpecially when the Water is almoſt evaporated: for then they ſhrink into a Globular Form, and their Feet ſtanding out may be perceived to move very nimbly. Fig. VII. 1. repreſents one of theſe Animalcules at its full Length: 2. ſhews another of them when contracted.

There's likewiſe a Species of *Animalcules* whoſe Bodies are Spherical, but pointed ſomewhat like a Pear, and reſembling Bladders fill'd with Water, wherein a vaſt Number of dark Particles ſeem in a continual Agita-

Agitation. Their Motion is chiefly a revolving one, turning round perhaps above an hundred times in a Minute, firſt one way, and then the contrary: and all this without moving a Hair's Breadth out of their Place. But ſometimes they move forward very briſkly, turn, return, and fetch a large Compaſs with ſeveral Deviations: keeping however, throughout their whole Progreſſion, their pointed End always foremoſt. See Fig. VIII.

I once diſcovered in the Scum on the Surface of *Hay-Water* a kind of *minute Serpents*; for ſo I call them from their Motion, which was like that of a Serpent, and from their coiling up themſelves in the manner Serpents do. I kept this Water ſome Weeks, and ſhewed them to ſeveral of my Friends, but ſince that time have never met with them in any Infuſion of the ſame ſort, or in any other Fluid. Their manner of moving forward, and alſo of coiling themſelves up, is ſhewn Fig. IX. 1, 2. They were larger than any of the *Eel-kinds* of *Animalcules*, their Motion very different, and not near ſo quick. The End that ſeemed to be the Head was thicker and ſomewhat more opake than the other.

Animalcules in the Shape of *Eels* are frequently met with in many of the Infuſions I am now mentioning, and likewiſe in ſeveral other Liquors. The Bigneſs of them

is

is very different, ſome being an hundred times larger than others, and probably they may differ alſo very much in Kind. They have in general a nimble wriggling Motion, but ſome Sorts of them are more active and vigorous than others.

Vinegar after ſtanding a few Days uncover'd, and eſpecially in the Summer Seaſon, will frequently abound with a kind of theſe *Eels*, large enough to be diſcerned by the naked Eye: which has encouraged ſome People erroneouſly to aſſert, that the Sharpneſs of Vinegar is owing to nothing elſe but the ſtriking of theſe Creatures upon the Tongue and Palate with their acute Tails: Whereas it is very certain, that many times none of them can be diſcovered even in the ſoureſt Vinegar; and beſides, Mr. LEEUWENHOEK has demonſtrated, that its Sharpneſs proceeds only from the pointed and penetrating Figure of the Salts floating in it, as I ſhall find occaſion to obſerve more fully by and by.

The Shape of theſe *Eel-like Animalcules* is delineated *Fig.* X.

Dr. POWER tells us,* That if Vinegar wherein *Eels* abound, be but moderately heated at the Fire, they will all be killed, and ſink down to the Bottom; but that Cold does them no Injury. For after ſuch Vine-

* POWER's *Microſcop. Obſerv.* pag. 35.

gar had been expoſed a whole Night to the ſevereſt Froſt, and was frozen, and thawed, and frozen again, and ſo ſeveral times over, they were as briſk as ever. He likewiſe informs us, that, in cold Weather, he put ſome Vinegar full of theſe *Eels* into a Glaſs, and poured thereon about the ſame Quantity of Oyl, which floating on the Vinegar, all the *Eels* would conſtantly creep up into the Oyl when the Vinegar began to freeze; but, upon thawing the Vinegar, they as conſtantly return'd to it again. Theſe are pretty and curious Experiments.

A Drop of Oyl of Vitriol mixed with the Vinegar kills them in the ſame manner as Fire does.

If ſome Grains of Sand be put among the *Eels* before the Microſcope, it will be highly entertaining to ſee them ſtruggling and embarraſſed, as it were, amongſt large Stones.

CHAP. IV.

Of EELS *in* PASTE.

WHOEVER is desirous to be furnish'd with *minute Eels* always ready for the Microscope, needs only boil together a little Flour and Water, and make such Paste thereof as Bookbinders commonly use; or it may be bought of them. It should neither be very stiff, nor very watery, but of a moderate Consistence. Expose it to the Air in an open Vessel, and prevent its hardening or becoming mouldy on the Surface, by beating it well together when you find any Tendency that way; for if it grows hard or mouldy, your Expectation will be disappointed. After some Days it will turn sour, and then if examined attentively, you'll discern Multitudes of exceedingly small, long, slender, wriggling *Animalcules*, which grow larger daily, till you'll be able to see them with the naked Eye.

To promote their coming forward, pour every now and then a Drop of Vinegar on your Paste: and after they are once produced you may keep them all the Year, by putting to them sometimes a little Vinegar, or Water, if the Paste becomes too dry, and sometimes a little Supply of other sour Paste; taking care continually to preserve

the Surface in a right Condition, which will eaſily be done when it is well ſtock'd with theſe *Animalcules:* the continual Motion of them preventing any Mouldineſs thereon.

A Water-Glaſs, or ſome other Glaſs Veſſel, is the moſt convenient to keep your Paſte in; for by holding it up againſt the Light, you'll oftentimes perceive the *Eels* wriggling themſelves above the Surface of the Paſte upon the Sides of the Glaſs, and may be able to take ſeveral of them with a Pen or Hair Pencil, much more diſengaged from the Paſte, and conſequently fitter for View, than if you are obliged to examine the Paſte itſelf in order to find them in it.

Apply them to your Microſcope upon a ſingle Talc or Iſinglaſs, after having firſt put on it a very ſmall Spot of Water for them to ſwim about in. The thicker your Paſte is, and the more they are invelop'd in it, the greater Proportion of Water will be requiſite to dilute it, that they may diſentangle themſelves, and be render'd diſtinctly viſible.

They are very entertaining Objects, examin'd by any kind of Microſcope, but particularly the Solar one, by which I have magnified them ſometimes to an Inch and half, or two Inches in Diameter, with a Length proportionable, and have found 'em anſwer exactly the Appearance of ſuch fiz'd Eels. The internal Motion of their Bowels may very plainly be diſtinguiſh'd, and when the

the Water is dry'd almoſt away, and they are near expiring, their Mouths may be ſeen opening to a conſiderable Width.

CHAP. V.

Of RAIN-WATER *and other Waters.*

MR. LEEUWENHOEK ſays, that at firſt he could diſcern no *living Creatures* in Rain-Water; but after ſtanding ſome Days, he diſcovered innumerable *Animalcules* many thouſands of times leſs than a Grain of Sand, and in Proportion to a Mite as a Bee is to a Horſe.

In other Rain-Water, which had likewiſe ſtood ſome time, he found the ſmalleſt ſort he had ever ſeen; and in a few Days more, met with others eight times as big as theſe, and almoſt round.

In another Quantity of Rain-Water, that had been expoſed like the former, he diſcovered a kind of *Animalcules* with two little Horns, in continual Motion. The Space between the Horns was flat, tho' the Body was roundiſh, but tapering a little towards the End, where a Tail appeared, four times as long as the Body, and the Thickneſs of a Spider's Web. He obſerved ſeveral Hundreds of theſe within the Space a Grain of Sand would occupy. If they happened on

the leaſt Filament or String, they were entangled in it, and then would extend their Bodies into an oblong Round, and ſtruggle hard to diſengage their Tails. He obſerved a ſecond ſort of an Oval Figure, and imagined the Head to ſtand at the ſharpeſt End. The Body was flat, with ſeveral ſmall Feet moving exceeding quick, but not diſcernable without a great deal of Attention. Sometimes they changed their Shape into a perfect Round, eſpecially when the Water began to dry away. He met alſo with a third ſort, twice as long as broad, and eight times ſmaller than the firſt: yet in theſe he diſcerned little Feet, whereby they moved very nimbly. He perceived likewiſe a fourth ſort, a thouſand times ſmaller than a Louſe's Eye, and which exceeded all the reſt in Briſkneſs: he found theſe turning themſelves round, as it were upon a Point, with the Celerity of a Top. And he ſays, there were ſeveral other Sorts.

It is common, in Summer-time, for the Water that ſtands in Ditches to appear ſometimes of a * greeniſh and ſometimes of a reddiſh Colour, which, upon Examination with

* The Inſects that moſt commonly diſcolour the Waters are of the *Shrimp-Kind*, called by SWAMMERDAM *Pulex aquaticus arboreſcens*, from the branching out of their little Horns: they are often ſo numerous in ſtagnating Waters, in *May* or *June*, at which time they copulate, as to make them

with the Microſcope, is found intirely owing to infinite Millions of *Animalcules* crowded together on the Surface of it, and giving it ſuch Appearance. Their Bodies are oval, and tranſparent at both Ends, but the Middle either green or red, according to the Colour of the Water they are ſwimming in. This middle Part, viewed with the firſt or ſecond Magnifier, ſeems compoſed of Globules, and bears ſo near a Reſemblance to the Rows or Spawn of Fiſhes, that 'tis reaſonable to believe it really may be the ſame: and the more ſo ſtill, as they are found after ſome time perfectly clear and colourleſs, and therefore may be preſumed to have ſhed their Spawn.

The Water that drains from Dunghills, and looks of a deep brown Colour, is ſo thronged with *Animalcules*, that it ſeems to be all alive; and muſt be diluted with Water, before they can be ſufficiently ſeparated to diſtinguiſh their various Kinds. Amongſt theſe one Sort is found, which I don't remember to have ſeen elſewhere, and therefore give a Draught of (Plate VII. Fig. XI.) Their middle Part appears dark, and beſet with Hairs, but both Ends of them tranſ-

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them appear of a pale or deep Red, and ſometimes of a Yellow Colour, according to the Colour of themſelves. The green Scum ſo commonly ſeen on the top of ſtanding Waters in Summer-time, is nothing but innumerable green Animalcules. Vid. DERHAM's *Phyſic. Theol.* pag. 178.

parent: their Tails are tapering with a long Sprig at the Extremity, and their Motion is ſlow and waddling. This Dunghill-Water abounds alſo with a ſort of *capillary Eels*, that are extreamly active.

An Infuſion of any *Herb*, *Grain*, *Fruit*, or *Flower*, made in common Water, will be found after a few Days to contain ſome Kinds of *Animalcules* peculiar to itſelf; and this, tho' aſtoniſhing, may be accounted for in a very reaſonable manner; for a little Obſervation will ſhew, that every *Herb*, *Grain*, *Fruit*, or *Flower*, is allotted by Providence to be the Food of ſome particular ſort of Bird, Beaſt, or Inſect, of the viſible and larger Kinds; and we may ſuppoſe it, in like manner, when infuſed in Water, to afford alſo a proper Nouriſhment for ſome or other of thoſe numberleſs Species of *minute Creatures*, which are *inviſible* to the naked Eye, and not to be diſcovered without a good Microſcope. And as to this Particularity of *Animalcules*, I refer the Curious (who have not yet been convinced by Trials of their own) to the Obſervations of Monſieur JOBLOT, *(Profeſſor Royal of the Mathematicks, and of the Royal Academy of Painting and Sculpture at Paris)* on the various Kinds diſcovered by him in the ſeveral Infuſions following: the Pictures of which *Animalcules* he has given, as well as a Deſcription of them. He examined the Infuſions of *Pepper*, black, white

white, and long: of *Senna*, of *Pinks*, of *Cyanus* or *Blewbottle*, of *Roſes*, *Jeſſamin*, *Raſberry-Stalks*, *Tea*, *Barberries*, *Fennel* and *Sage*, *Marigold-Flowers*, *ſour Grapes*, and *Melon Rind*, and found different *Animalcules* in them all. *Hay*, new and old, abounded with many Kinds; *Rhubarb*, *Muſhrooms*, *ſweet Baſil*, *Citron-Flowers*, had their particular *Animalcules*. The *Anemony* afforded ſome very wonderful ‡; *Celery* produced many Kinds: *Wheat-Ears* and *Straw*, many Kinds: *Straw* of *Barley*, *Rye*, *Oats*, and *Turkiſh Corn*, many Kinds: *Oak-Bark*, new and old, afforded great Variety. Some of theſe Infuſions he kept a whole Year round, and obſerved, not only that each Infuſion had *Animalcules* of Shapes quite different from thoſe in others; but, likewiſe, that in the ſame Infuſion different Kinds of *Animalcules* appeared at different times.

N. B. It is highly probable, that the Place where Infuſions are made, in a City, or in the Country, expoſed to the open Air, or ſhut up within a Houſe, as alſo the Seaſon of the Year, and its Temper as to Heat or Cold, may occaſion great Differences in the

‡ Mr. Joblot's Draught of the Animalcules in this Infuſion repreſents an exact Satyr's Face upon their Backs: I recommend the Tryal to the Curious.

Kinds of *Animalcules* to be found in the ſame Infuſions.

We ſometimes find in our Infuſions of *vegetable Productions*, and in other Waters that have ſtood a while uncovered, an Animal much larger than any before deſcribed, of a very ſingular and ſurprizing Form, as pictured Plate VII. Fig. XII. This little Creature is in its middle State; it lately was a Worm, and will ſoon become a Gnat. For ‡ Gnats depoſit their Eggs in a kind of ſlimy Matter on the Surface of the Water, and faſten them to ſomething that may prevent their being waſhed away or ſeparated too ſoon. From theſe Eggs proceed a number of minute Worms, which ſinking to the Bottom of the Water, make for themſelves Caſes or Coverings of fine Sand or Earth cemented together with a ſort of Glew, but open at both Ends, for them to come out of or retire into, as they find occaſion. After a time, quitting theſe Habitations, and the Figure of Worms, they re-aſcend to the top of the Water in the Shape now before us, ſhelled all over, with a large Head and Mouth, a Couple of black Eyes, two Horns, ſeveral Tufts of Hairs or Briſtles on different Parts of the Body, and a Tail with a Bruſh of Hair at the End of it, which being

‡ *Spectacle de la Nature, Engliſh* Edit. 12mo, pag. 123. Hooke's *Microg.* p. 186.

ſmeared

ſmeared over with an oily Fluid, ſerves like a Cork to keep them above Water; their Heads being ſometimes lifted into the Air, and ſometimes plunged into the Water, while the Tail ſlides along the Surface. And if the Oil on the Tail begins to dry, they ſhed from their Mouth a new Supply upon it, which reſtores its Ability of ſteering where they pleaſe, without being wetted or prejudiced by the Water. After living in this Manner the Time appointed by Providence, a ſtranger Change ſucceeds: for reſigning their Eyes, Horns, and Tail, and caſting off their whole Skin, there iſſues forth a Race of Inſects of a quite different Element: the moſt beautiful and delicate Plumage adorns their Heads; their Limbs are conſtituted with the fineſt Texture: they have Wings curiouſly fringed and ornamented; their whole Bodies are inveſted with Scales and Hair, and they are actuated by a ſurprizing Agility: in ſhort, they become *Gnats*, and ſpring into the Air. And, what is moſt amazing, a Creature that but a Minute ſince was an Inhabitant of the Water, would now be drowned if it were plunged therein.

I have been the more particular in my Account of this *Metamorphoſis*, as I apprehend many ſorts of the *Animalcules* in Fluids undergo Changes in ſomewhat a like manner. I ſhall only add here, that the little Creature, whoſe Picture I have given,

is a delightful Object for the *Microscope*, its white Heart beating distinctly, and the Motion of all its Intestines being perfectly visible and extraordinary.----Of the *Gnat* I shall speak farther in its proper Place.

The Waters every where abound with Life, and are an endless Subject of Employment for the *Microscope:* Seas, Rivers, Ponds, Ditches, and almost every Puddle can by its Assistance present us with living Wonders never before discovered: for such Examinations have as yet been but little attended to, even by People that have got these Instruments, and also a Genius to use them. But I am in hopes this Treatise may excite them to be more industrious, and not suffer a little Difficulty, or a few Disappointments, to discourage them from a Study that can so amply reward their Pains.

In several of * Mr. LEEUWENHOEK's Letters to the *Royal Society*, we meet with an Account of some surprizing *Animalcules* found adhering to the Roots of the *Lens Palustris*, or *Duck-Weed*, (which in Summer-time floats plentifully on the Surface of Ponds and Ditches) as examined by him in a Glass Tube filled with Water. One Sort

* Vid. *Phil. Trans.* Numb. 283, 295, 337.

of

Pag. 90

Fig

b

b

b

Fig. I

Fig. II p

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* Vid. *Phil. Transf.* Numb. 283, 295, 337.

of

Fig. I. p. 91

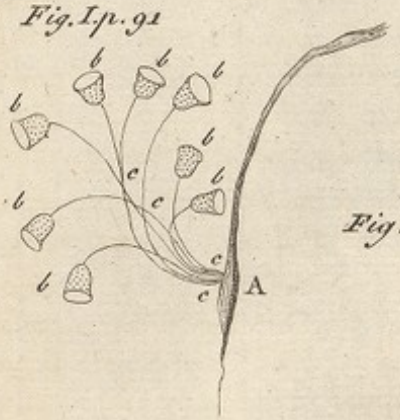

Fig. II. p. 91

Fig. III. p 91

Fig. IV. p 91

Fig. V. p 91

Fig. VI p. 93

Fig. VII. p. 93

Fig. VIII. p. 93

of these was shaped like Bells, with long Tails, whereby they fastened themselves to the Roots of these Weeds; and sometimes twenty of these were seen together, gently extending their long Tails and Bodies, and then, in an Instant, contracting them again. See the Draught, Plate VIII. Fig. I.

A. represents a Root of *Duck-Weed* with the Tails of many *Animalcules* adhering to it.

b b b b, *&c.* shew their Bell-like Bodies.

c c c c, their long Tails.

Another extraordinary Kind of *Animalcule* (which see Fig. II.) appears in a Sheath or Case, *a*, *b*, *c*, the End whereof it fastens to the *Duck-Weed* Roots. This little Creature has two seeming Wheels with a great many Teeth or Notches, coming from its Head, and turning round as it were upon an Axis, *d*, *e*. At the least Touch it draws the Wheel-work into its Body, and its Body into the Sheath, after which it appears as Fig. III. But when all is quiet, it thrusts itself out again, and the Rotation of the Wheel-work is renewed. Mr. LEEUWENHOEK took notice of one of these, whose Case seem'd composed of minute Globules (Fig. IV. *a b.*) and in this he discover'd the Wheel-work to consist of four roundish Parts with little Divisions between each, tho' only three of those roundish Parts could be seen, the fourth lying behind, as represented Fig. V. This convinced him how much he had been mistaken, in believ-

ing

ing them, from their common Appearance, to be two Wheels, whereas the real Form of this Wheel-work is as at Fig. V.

To find these *Animalcules*, choose *Duck-Weed* that has long Roots; for young Plants with short Roots seldom afford any. Be careful too that they are not cover'd with a rough Matter, or tending to Decay, as they will often be. Let the Roots sink gently down in a Glass Tube filled with Water, and so apply them to the *Microscope*. Two or three *Animalcules* will be found sometimes adhering to one Root; and at other times you may examine several, and not be able to meet with any.

In the Water or slimy Matter found in Leaden Pipes or Gutters, Mr. LEEUWENHOEK met with various Kinds of *Animalcules*, and, among the rest, with Multitudes that appear'd to have a sort of Wheel-work, turning round somewhat in the former manner †. These Creatures, when the Water dries away, contract their Bodies into a globular or oval Figure and reddish Colour, and become fixt in the dry Dirt, which grows as hard as Clay: but whenever a piece of such Dirt is put in Water, in about half an Hour's Time they open, and by

† *Phil. Transf.* Numb. 289. LEEUWEN. *Arc. Nat.* Tom. II. Epist. 149.

degrees

Fig. II. p. 93.

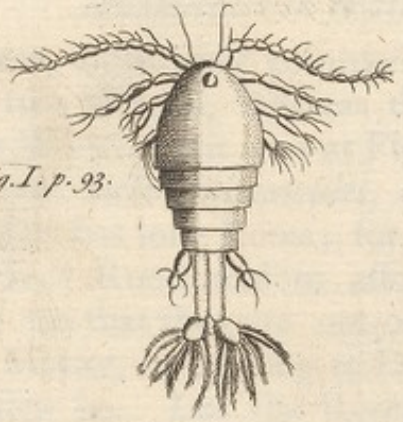

Fig. I. p. 93.

Fig. VII. p. 96.

Fig. VI. p. 96.

Fig. III. p. 94.

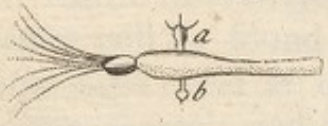

Fig. V. p. 96.

Fig. IV. p. 95.

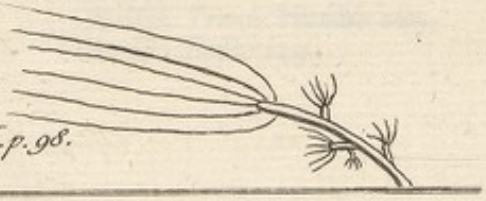

Fig. VIII. p. 98.

degrees extend their Bodies, and ſwim about: and this they did after ſome of this Gutter-Dirt had been kept dry for twenty one Months together. Whence he concludes, that the Pores of their Skin are cloſed ſo perfectly, as to prevent all Perſpiration, by which means they are preſerved till Rain falls, when they open their Bodies, ſwim about, and take in Nouriſhment.

Fig. VI. VII. ſhew two of theſe *Animalcules* in different Poſitions.

Fig. VIII. is the Form they appear in when dry and contracted.

We may find in the Waters of our Ditches ſeveral Species both of Teſtaceous and Cruſtaceous *Animalcules:* two of the latter ſort, which are moſt remarkable, are ſhewn (Plate IX. Fig.I and II.) in a ſwimming Poſture, with their Backs towards the Eye. Their Legs are ſomewhat like Shrimps or Lobſters, but of a much more curious Structure. They are leſs than a very ſmall Flea, but are all Breeders, and carry their Spawn either under their Tail, or in two ſeeming ‡ Bags hanging from their Sides, as in Fig. II. Theſe Bags may ſometimes be obſerved broken, and the Spawn (conſiſting of Globules very large in Proportion to the Crea-

‡ *Arcan. Nat.* Tom. II. Epiſt. 121. *Philoſoph. Tranſact.* Numb. 288.

ture)

ture) ſcatter'd about the Water. There is alſo a third Sort, as beautiful as the foregoing, but not near ſo large; its Shape more reſembles a Shrimp, and it carries its Spawn as the Shrimp does. Theſe three Species of *Animalcules* appear to have only one Eye, and that placed in the middle of the Forehead, without ſo much as the leaſt Trace of even a dividing Line. They are often to be found ſo tranſparent, that the Motion of their Bowels is ſeen diſtinctly by the *Microſcope*, together with a regular Pulſation in a little Part, which therefore we may ſuppoſe to be the Heart.

I ſhall finiſh this Head, with deſcribing a very wonderful Kind of *minute Animal*, the extraordinary Form whereof (about thrice the Bigneſs it appeared to the naked Eye) whilſt in the Water and faſtened to the Root of a Weed, is given Fig. III. This was a large one of the Sort, and had eight Horns; whereas the ſmaller ones have ſeldom more than ſix. It is likewiſe ſhewn here as extended to its full Length, but when contracted is not a fourth Part ſo long. It fixes by the Tail to the Roots or Stalks of Water-Plants. On the upper Side a very ſmall *Animalcule (a)* is repreſented coming out of the other's Body. This was ſuppoſed at firſt to have faſtened itſelf there by ſome Accident; but by obſerving it narrowly,

rowly, it was discover'd to be a young one in the Birth: for though it had but four very small Horns when first seen, after sixteen Hours its Horns and Body were grown much larger; and in four Hours more it was quite excluded its Mother's Body. Against this, on the upper side, appeared a little round Knob which gradually increased in Bigness, and in a few Hours became pointed as at *(b)*. Thirteen or fourteen Hours after, it was grown much larger, and also had two Horns. In twenty-four Hours four Horns were seen upon it, one whereof was small, the second larger, and the other two very large, extending and contracting more vigorously than their Fellows. Three Hours afterwards this *Animalcule* likewise fell off from its Mother, and shifted for itself.

The above Account is the Substance of Mr. LEEUWENHOEK's Letter to the *Royal Society*, *Phil. Transf.* Numb. 283.---And in Numb. 288. we meet with a farther Description of the same *Animalcule* by an *English* Gentleman, whom Mr. LEEUWENHOEK's Relation had put upon hunting after it. He says, he discovered one of them in some clear Water taken out of a Ditch, but with the utmost Attention could find no more therein. It appeared the first Day as in Fig. IV. but he tells us, it varied every

Moment, and the Knob *(a)* which looked like the Gut *Cæcum*, was sometimes a little longer. Two or three Days after he perceived some white Fibres at the Extremity of the Knob, and on the fourth Day it lay extended at full Length, and appeared as in Fig. V. and he was then convinced, that what he imagin'd an Excrescence, was in Reality a young *Animalcule* of the same Species, issuing from the old one, and having six Horns. Next Day he found it in the Water entirely separated, and about a third of its Parent's Length. The Horns come out like Radii, not from the Extremity, but quite round a small Knob, which probably is the Head: They have a vermicular Motion, and can extend or contract themselves either singly or altogether. The other End is flat, and by that it often fastened to the Bottom or Side of the Glass wherein he kept it. It also contracts and dilates its Body, and can bring both Body and Horns into a small Compass, as in Fig. VI. and Fig. VII. The Horns are perfectly white, the Body yellowish, and not easily discernable by the naked Eye; being, when extended, no thicker than a large Horse-Hair.

Mons. BUFFON in a Letter to MARTIN FOLKES, Esq; now PRESIDENT of the *Royal Society*, dated at the Garden of *Versailles*, 18 *July* 1741. sends an Account (as

(as a new Discovery in natural History) of a Creature called * *Polype*, found adhering to the *Lens Palustris*, which, being cut through the Middle, from the upper Half a Tail proceeds, and from the lower Half a Head: so that one Animal becomes two. If it be divided into three, the middle Part shoots forth a Head and Tail, the upper Part a Tail, and the lower Part a Head; and all three become as perfect Animals as the first. Whence he concludes, that in the boundless Variety of the Works of Providence, every Thing that can be, is.

Another Letter to the same Gentleman, dated at the *Hague*, *Sept.* 15. 1741, from the Honourable WILLIAM BENTINCK, Esq; says, That a young Man of *Geneva*, looking for small Insects in Water, saw some little Things which he took for Plants, but examining them carefully, he perceived some Motions in them, and found them contract when touch'd. It was a long while, however, before he could determine whether they were Plants or Animals: for he saw several young Shoots coming out upon them, and that as far as four Generations, hanging to one another. But he has since found them to eat

* The Name *Polypus*, or *Many Feet*, is given to several Fishes of the *Star-Fish* and *Cuttle-Fish* Kind, some whereof, besides several Claws, have two long Trunks, which they can extend to a great Distance to seize their Prey: and this *Animalcule*, I suppose, is called *Polype* from somewhat of a like Form.

Insects, and even raw Meat. They fasten themselves by one Extremity to some Plant, or the Side of a Glass, and have at the other End six or eight Horns, wherewith they hold their Prey.

Fig. VIII, is taken from a Drawing sent with this Account.

He cut one of these Creatures to see what would become of it, and some Days after found new Arms growing out where others had been cut away. Since that, he has divided them the long way, the broad way, oblique, and every way possible, all with the same Success. He has also gone on subdividing them, and has not found them propagate any other Way than by Shoots, and without Copulation.

Both these Letters seem to mean the same *Animalcule* Mr. LEEUWENHOEK describes: though with farther extraordinary Particulars, which I believe the Curious will judge it worth their while carefully to examine into*.

Upon

* Since the Publication of the above Accounts, such farther Particulars concerning this *Animalcule* have been received both from *Holland* and *France*, in answer to the ingenious Enquiries of MARTIN FOLKES, Esq; President of the ROYAL SOCIETY, and by him communicated to the said Society, that it would appear an unpardonable Neglect should I take no Notice of them.

The Honourable WILLIAM BENTINCK, Esq; F. R. S. in a Letter from the *Hague*, dated 15th *January* N. S. 1743. incloses some Observations and Experiments drawn up by

Mr.

Upon the Whole, this *Animalcule* appears to be ſomewhat of the *Star-Fiſh* Kind, or between

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Mr. TREMBLEY, (the young Gentleman mentioned page 97. as the firſt Diſcoverer of the Singularity of this Inſect, who now reſides in *Holland*) and Mr. BENTINCK ſays, that he can anſwer for the Truth of the Facts therein contained, as there is not one of them but what he has ſeen repeated above twenty times.

Mr. TREMBLEY gives a Drawing of the *Polype*, with eleven Horns or Arms, and adhering by the Tail to a little Twig, but in all other Reſpects exactly conformable to Fig. IV. and V. Plate IX. The Horns, he ſays, ſerve for Legs and Arms, and at the End whence they come out, is a Mouth or Paſſage into the Stomach, which extending the whole Length, forms a Body like a Pipe or Gut open at both Ends. He knows two Species, and has ſeen ſome ſtretch their Bodies to an Inch and half in Length, but that is rare; few, even of the larger Kind, being above nine or ten Lines long: and ſuch can contract themſelves to not above a ſingle Line, ſtopping, if they pleaſe, at any Degree, between the utmoſt Contraction and the utmoſt Extenſion. Their Horns differ in Length according to the Species: one Sort can extend them ſeven Inches: their Number of Horns is alſo different, but a full grown *Polype* has ſeldom leſs than ſix.

They don't ſwim, but crawl; either upon the Ground, on aquatic Plants, Pieces of Wood, Leaves, *&c.* all which are to be taken from the Bottom, Surface, Edges, or Middle of Ditches (when we hunt after theſe Animals) and put into a Glaſs of clear Water; where, after a little Reſt, if there be any *Polypes*, they will be ſeen to extend their Arms, which they contracted upon being diſturbed.

Their common Poſture is, to faſten their Tails to ſomething, and then extend the Body and Arms into the Water: and they make uſe of their progreſſive Motion to place themſelves conveniently for this Purpoſe. Their Arms are ſo many Snares, ſtretched out to catch ſmall Creatures in the Water: and when any Inſect happens to touch an Arm, it is caught, and conveyed to the Mouth by the contracting of that Arm, or if the Creature ſtruggles the other Arms aſſiſt.

between that and the *Sea-Muſhroom*, or *Anemone*: which is a little *Animal* found frequently

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They are voracious Animals: A *Polype* can ſwallow a Worm whole, twice or thrice its own Length. If the Worm comes Endways it is ſwallowed in that manner, otherwiſe it goes down double, and makes ſeveral Foldings in the Stomach, which diſtends wonderfully for its Reception. The Worm ſoon dies there, and after it has been ſqueezed or ſucked, is voided by the Mouth. They eat more or leſs, ſeldomer or oftener, as the Weather is hotter or colder, and grow in proportion to what they eat: they can live whole Months without Food, but waſte proportionably to their Faſting.

He ſays, the Account (in the *Philoſophical Tranſactions* before quoted p. 95.) of the Manner how theſe Inſects multiply, is true and exact, and the more one ſearches into it, the more evidently it will appear to be done by a true Vegetation. The *Polype* brings forth its Young from the exterior Parts of the Body, and that not always a ſingle young one at once: it is common to ſee 5 or 6, nay ſometimes 9 or 10 at the ſame time, and when one drops off, another comes in its Place.

For two Years, thouſands of them have been under his Eye, but he could never obſerve any thing like Copulation amongſt them. And leſt it ſhould happen in ſome ſecret Manner between the Old and Young, he has ſeveral times cut off a young One from its Parent, and kept it in a Glaſs alone; notwithſtanding which it bred very plentifully. And that no Copulation might poſſibly be performed between the young ones themſelves, he has cut them off, one by one, as they ſprouted out, and has kept each of them alone, and that for ſeven ſucceſſive Generations; but without finding any Difference as to their Increaſe. He has likewiſe ſeen a *Polype* bring forth young ones, and thoſe again producing others, before the firſt has been ſeparated from its Parent. They multiply more or leſs in proportion to their Feeding, and the Warmneſs of the Weather.

But the moſt amazing Part of Mr. TREMBLEY's Account, is, what he tells us, concerning his Operations on theſe Creatures. If one of them be cut in two, tranſverſly, the Fore-Part, which contains the Head, Mouth and Arms, lengthens itſelf, creeps, and eats, on the very ſame Day. The Tail-

Part forms a Head and Mouth at the wounded End, and ſhoots forth Arms, more or leſs ſpeedily as the Heat is favourable. In Summer they will be ſhot out in 24 Hours, and the new Head perfected in a few Days.

Cut a *Polype* where or into what Parts you pleaſe, tranſverſly, each Part becomes a compleat *Polype*. But being too ſmall an Animal to admit of being divided into many Parts at once, he firſt cut one into four Quarters, and let them grow; then divided each Quarter, and proceeded, ſubdividing, till he obtained fifty out of one: and has ſtill by him ſeveral Pieces of the ſame *Polype* thus cut above a Year ago, which have produced Numbers of young ones.

If a *Polype* be cut the long Way, through the Head, Stomach and Body, each Part is half a Pipe, with half a Head, half a Mouth, and ſome of the Arms at one of its Ends. The Edges of theſe half Pipes gradually round themſelves, and unite, beginning at the Tail End; and the half Mouth and half Stomach of each becomes compleat. All this he has ſeen done in leſs than an Hour, and the two *Polypes* thus formed differed nothing from whole ones, but in having fewer Arms; which Defect a few Days ſupplied. A *Polype* has been cut, lengthways, between 7 and 8 in the Morning, and between 2 and 3 in the Afternoon, each Part has devoured a Worm as long as itſelf.

Cutting a *Polype*, lengthways, through the Head and Body, but not quite through the Tail, in a ſhort time there will be two perfect Heads and Bodies with but one Tail: which Heads and Bodies, may, ſoon after, be again divided in like manner: and thus, Mr. TREMBLEY ſays, he has produced a *Polype* with ſeven Heads and Bodies conjoined by one Tail. Theſe ſeven Heads being cut off at once, ſeven others grew in their ſtead; and each of the ſeven Heads ſo cut off, putting forth a new Body, became a compleat *Polype*.

He cut a *Polype*, tranſverſly, aſunder, and putting the two Parts cloſe together, they united where they had been cut. The Creature eat the next Day, is grown ſince, and has multiplied. The Fore-Part of one *Polype* united in the ſame manner to the Hind Part of another. This compound Animal eat likewiſe the next Day, and has ſince produced young ones from each of the Parts that formed it. But theſe two Experiments don't always ſucceed.

'Twas ſaid before, that the Body of a *Polype* is a ſort of hollow Gut or Tube: this he has found means to turn inſide out, as one may turn a Stocking; and has ſeveral, at preſent, by him, whoſe Inſides remain to be their Outſides; notwithſtand-

ing which, they eat, grow, and multiply, as if nothing had been done to 'em. He has repeated all these Experiments several times, with the utmost Precaution, Assiduity and Attention; and might appeal, he says, to the Quality and Number of the Persons who have seen them made by him, as well as of those who have made the same themselves. He adds, that in the History of the *Polype*, which he has in Hand, all the Methods and Contrivances used by him in his Observations will be described, but even before its Publication he is ready and willing to communicate any Information that may enable others to perform the like.

Mr. REAUMUR, Fellow of the Royal Academy of Sciences in *France*, declares (in the Preface to the sixth Volume of his *History of Insects* just published at *Paris*) that he has repeated all Mr. TREMBLEY's Experiments, not only by himself, but with Mr. JUSSIEU and several others of the said Academy, and found them succeed as they had done in *Holland*, of which he gives a general and succinct Account. When first he saw two compleat Animals forming themselves from the Parts of one *Polype* cut asunder, he knew not, he says, how to believe his Eyes; and he can't yet behold it, without new Amazement, tho' he has seen it an hundred and an hundred times. He adds, that the Curious in *France* soon began to try if other Creatures might not be found with the same extraordinary Faculty. That Mr. BONNET soon discovered a slender Water-Worm about one Inch and half long that had the same Property; and Mr. LYONETT found another above three Inches long and the Thickness of the treble String of a Violin, which being cut into thirty or forty Parts afforded the same Phænomena.

Mr. REAUMUR imagining that some Sea Productions, whose Shape somewhat resembles this *fresh Water Polype*, such as the *Urticæ marinæ* and *Star-Fish*, might have the like Faculties, engaged Mr. GUETTARD and Mr. JUSSIEU to make Variety of Experiments on the Coasts of *Poictou* and *Normandy*. They broke and cut *Star-Fish* into several Parts, and had the Pleasure to see the several Parts continue alive, and their Wounds cicatrize and heal: and tho' they could not stay long enough in the Country to see new Parts shoot forth instead of those cut away; Mr. GERRARD DE VILLARS has seen the *Urticæ* on the Coasts near *Rochelle* reproduce all the Parts cut off, and the *Star-Fish* putting forth new *Radii* in the Room of those they had been deprived of. When the Fishermen saw Mr. JUSSIEU tearing and cutting one of those Animals in Pieces, they told him, 'twas Labour in vain, he could not kill

it;

frequently on the Coasts of *Normandy* *. They are seen sticking on the Declivity of Rocks; some red, some green, and some of other Colours: where they look like Mushrooms while shut and folded up, but like Anemonies when they open and display themselves. There is no opening them by Force without destroying them; but on Pressure they sometimes eject several young ones of different Sizes: which seems to prove them both Male and Female, and also to be viviparous. If you loosen their Hold, carry them away, and keep them in Water, they will fix themselves to the first convenient Place they find. When the *Sea-Mushroom* is about to open, it raises itself, and thrusts out two little white and striped Bodies like Bladders, round which appears a great Variety of Points or Trunks of different Sizes and Colours; whence some Naturalists have called it the *Sea-Anemone*. This Opening, not unlike the blowing of a Flower, has inclined others to look upon it as a sort of Plant, or else as partaking both of the Ani-

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it: Experience having taught them what Men of Learning had never so much as heard of. Mr. Reaumur and Mr. Bonnet found also some sorts of Earth-Worms, which being cut in two, each half had all its Deficiencies reproduced after some Months. Many indeed died, but as some succeeded, the Miscarriages must be imputed to want of Care, and not to the want of such an Ability in these Animals.

* Vid. *Spectacle de la Nat.* Part II. Dial. 22.

mal

mal and Vegetable Nature. But as all these little Points or Studs are not Leaves, but a sort of Snouts or Trunks, through which this Creature sucks in its Nourishment, as the *Sea-Urchin* and *Star-Fish* do through their fine Reeds or Prickles, we can't deny it a Place in the Rank of Animals; and especially after so remarkable a Circumstance (confirmed by ocular Testimony) as that of three or four young ones issuing from the Parent upon squeezing it.

There is a sort of *Star-Fish*, called by RONDELETIUS pag. 121. *Stella Arborescens*, which from a Body somewhat like the *Sea-Urchin*, sends out five Branches in Form of a Star: these five divide into ten, those ten again into twenty; the twenty into forty, the forty into eighty, the eighty into one hundred and sixty: the one hundred and sixty into three hundred twenty; the three hundred twenty into six hundred forty; the six hundred forty into one thousand two hundred eighty; the one thousand two hundred eighty into two thousand five hundred sixty; the two thousand five hundred sixty into five thousand one hundred twenty; the five thousand one hundred twenty into ten thousand two hundred forty; the ten thousand two hundred forty into twenty thousand four hundred eighty; the twenty thousand four hundred eighty into forty thousand nine hundred sixty; and those

again

again into eighty one thouſand nine hundred twenty.----The farther Diviſions could not certainly be traced; tho' probably, when the Fiſh was alive, they might have been diſtinguiſh'd much beyond this Number †. All theſe ſlender Threads, thro' their whole Length, have minute Claſpers iſſuing from them, and appear very amazing when examin'd by the *Microſcope*.

To conclude this Chapter.——If the ſmalleſt living Creatures that have been yet diſcovered are produced in the Waters, in them we find alſo the largeſt and moſt monſtrous. No Bird or Beaſt comes near the Size of many Kinds of Fiſhes, nor can the Elephant itſelf be brought in Compariſon with the Whale.

JOANNES FABER LYNCEUS aſſures us, that in the Year 1624, he ſaw himſelf a Whale, that was caſt upon the Shore near *Santa Severa*, about thirty Miles from *Rome*, ninety one Palms in Length, and fifty in Thickneſs: its Mouth was ſixteen Palms long and ten high, and being opened and kept gaping, a Man on Horſeback might therein find Room enough. Its Tongue was twenty Palms, that is, about fifteen Foot in Length. He adds, that four Years before, another Whale was caſt near the Iſland of *Corſica*, not far from the Coaſt of *Italy*, which, be-

† Vid. *Philoſoph. Tranſact.* Numb. 57.

ing a Female, was found big with a Cub thirty Foot long, and fifteen hundred Pounds in Weight. He ſays, the *Carnea Pinguedo* [Lard or Fat] only of the Parent Whale, weighed one hundred and thirty five thouſand Pounds.

Let us now reflect how amazing the Diſparity between ſuch a Fiſh as this, and a minute Animalcule leſs than the thouſandth Part of a Grain of Sand in Bigneſs! How innumerable muſt the Kinds of Creatures be, that form the Progreſſions from one Size to the other! And how equally wonderful does the Hand of Providence appear, whether it actuates an enormous Mountain of Matter, or enlivens an Atom!

CHAP. VI.

An Examination of the BLOOD *in Animals.*

WE cannot employ the *Microſcope* to any more uſeful Purpoſe, than to view the natural Courſe of the *Blood* within its Veſſels, or examine the Contexture of it when extracted from them: For the Preſervation or Reſtoration of the Health of Man may be greatly advantaged by ſuch Enquiries.

By ſeeing it within the Veſſels, we may judge of the Situation, Dimenſions, Arrangement, and Ramifications of the *Arteries* and *Veins* through which it paſſes, together with the general State of the Fluid, the Degree of

its Impulſe, Progreſſion, or Motion, and the Tendency or Direction of its Current paſſing through them.

When taken from the Veſſels, we can examine it more minutely, and obſerve all the little Alterations that may happen in the Mixture, Size, Form, and Quality of the Particles compoſing its more ſolid or more fluid Parts.

I ſhall now ſhew how the *Microſcope* may be employed in both theſe Ways; but think proper to premiſe a ſhort Account of the *Blood* itſelf, ſince our Knowledge of that will the better enable us to make a right Judgment when we come to ſee it circulate.

CHAP. VII.

Some Account of the BLOOD, *as examined by the* MICROSCOPE.

HUman *Blood*, and the *Blood* of *Land-Animals*, is found by the Microſcope to conſiſt of *round red Globules floating in a tranſparent Water or Serum*. Each red Globule is made up of ſix ſmaller and more tranſparent ones: and Mr. LEEUWENHOEK has diſcovered, that each of theſe again is compoſed of ſix Globules ſtill more minute and colourleſs: ſo that every common red Globule is compounded of at leaſt thirty-ſix

ſmaller

ſmaller ones; and perhaps the Diviſion may ſtill go on much farther *.

The ſpecific Gravity of theſe Globules is ſomewhat more than of the Serum wherein they float, as is ſhewn by their ſubſiding in Blood extracted from the Veins and at reſt: They have alſo a conſiderable Attraction to each other, and when brought in Contact, cohere ſo ſtrongly (unleſs ſoon ſeparated again by Motion) as to form a Subſtance reſembling ſoft Fleſh.

'Tis not difficult to imagine, how ſix ſoft and flexible Globules, eaſily compreſſible into any Shape, may compoſe one larger Globule: but to make it the better underſtood, I ſhall borrow two Draughts from Mr. LEEUWENHOEK.

Fig. I. Plate X. ſhews one ſuch large Globule, wherein five of the ſmaller ſort that compoſe it appear in Contact, the ſixth lying behind.

Fig. II. ſhews, how by their mutual Attraction to, or Preſſure againſt each other, they readily unite to form a perfectly round Body.

It is alſo eaſy to conceive, that theſe ſix Globules, and even the more minute ones ſtill whereof they are compounded, may occaſionally be ſeparated, in order to paſs thro' ſuch extreamly minute Veſſels as without Separation they cannot poſſibly enter;

* *Vid.* LEEUWEN. *Arc. Nat.* Tom. IV. pag. 12.

and

ſmaller ones; and perhaps the Diviſion may ſtill go on much farther *.

The ſpecific Gravity of theſe Globules is ſomewhat more than of the Serum wherein they float, as is ſhewn by their ſubſiding in Blood extracted from the Veins and at reſt: They have alſo a conſiderable Attraction to each other, and when brought in Contact, cohere ſo ſtrongly (unleſs ſoon ſeparated again by Motion) as to form a Subſtance reſembling ſoft Fleſh.

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* *Vid.* LEEUWEN. *Arc. Nat.* Tom. IV. pag. 12.

and

Fig. I. p. 104

Fig. II. p. 104

Plate X.

Fig. III. p. 119

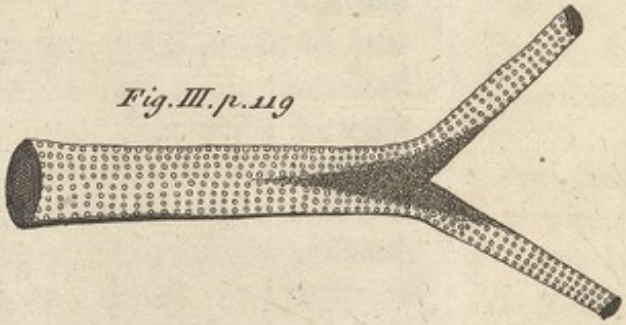

Fig. IIII. p. 120

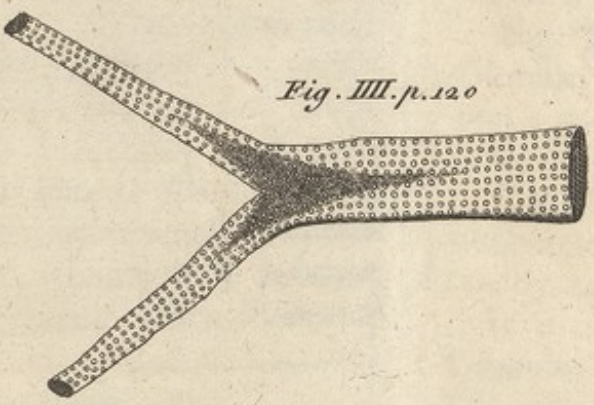

Fig. V. p. 131

and may re-unite when they meet again in Veſſels where they have more Room. And we are very certain, that ſometimes they cohere in greater Numbers, and form larger Maſſes than are conſiſtent with a free and healthy Circulation.

Mr. LEEUWENHOEK and Dr. JURIN after the moſt accurate Admeaſurement, by the Way deſcribed pag. 46th, agreed, that the Diameter of a common red Globule of human Blood is equal to the * one thouſand nine hundred and fortieth Part of the Length of an Inch. Mr. LEEUWENHOEK before this had computed that † twenty-five thouſand of them were but equal to a Grain of Sand.

Suppoſing, then, the Blood, in People of ſound Health, to conſiſt of Globules of ſuch Size and Compoſition as before mentioned, ſoft, flexile, and eaſily ſeparable; it muſt neceſſarily happen, that a conſiderable Alteration in any of theſe Particulars will occaſion a morbid State.---Should the Globules, for Inſtance, be divided too minutely, and not readily again cohere; ſhould they become rigid and unflexible, either when ſeparated

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* Vide *Philoſoph. Tranſact.* Numb. 106.

† If the Diameter of one thouſand nine hundred and forty Blood-Globules be equal to the Length of one Inch; and if, as *Geometricians* demonſtrate, Spheres be to each other as the Cubes of their Diameters, it muſt neceſſarily follow, that a Sphere whoſe Axis is one Inch in Length, muſt be equal to ſeven thouſand three hundred and one millions, three hundred and eighty four thouſand ſuch Globules.

or

or united; or should they coagulate and become inseparable, bad Consequences must ensue.

The great BOERHAAVE says, that Health consists in an equal Motion of the Fluids, and an equal Resistance of the Solids. Now the Fluids move equally when their Force is no greater in one Part than another; and the Resistance of the Solids is equal, when they compress the Fluids every where so equally that no Sense of Pain arises.

But when the Globules of the Blood cohere in Masses too large, and will not easily be so separated as to pass freely thro' the minutest Vessels, the Force of the Fluid must there be greater, and consequently unequal; the Resistance of the Solids must also be thereby increased, and rendered likewise unequal: whence some Distemper must arise. If, on the other hand, the Globules are broken, or separated into smaller Masses than the natural Standard Size, they will take up more Room than they did before; and, being crowded too abundantly into the capillary Vessels, will occasion Distension, Uneasiness, and perhaps a partial Stagnation there: whilst, in the larger Vessels, the Current rolls along with too great Rapidity, the Force of the Fluids, and the Resistance of the Vessels are both rendered unequal, and the Ballance between the Solids and Fluids is entirely overturned. None of the Secretions in this State can duely be performed,

and

and unleſs ſome means be found to reſtore the Equilibrium, the Event muſt ſoon be fatal.

I believe it will be allowed, that where One Perſon dies from a Diſorder in the containing Veſſels, Twenty miſcarry by ſome unnatural Alteration in the Fluids that paſs through them: and therefore if we can find what their natural State is, the Means whereby it may be preſerved in ſuch State, by what Accidents it may be prejudiced, and how it may be reſtored, our Pains will be well employed.

In order to obtain this uſeful Knowledge, it will be neceſſary to examine the human Blood and other Juices, frequently, with the *Microſcope*, in every Condition, and under every Diſtemper, as well as in a State of Health: by which we ſhall have ocular Demonſtration of its different Appearances in each State, and of the Changes it undergoes; and by Experiments of various Mixtures with it, may poſſibly diſcover by what means it can be altered from one Condition to another; as from a thin and broken to a more firm and conſiſtent State, and ſo on the contrary.

Would our learned Phyſicians, who are beſt able to judge of ſuch Matters, be induced to take this Method into their Practice, it is reaſonable to believe, that in a few

Years the Cauſes of Diſeaſes would be better known, and the Art of Healing brought to a much greater Certainty than it is at preſent. An Obſervation of Mr. LEEUWENHOEK is very well worth regarding: he took notice, that when he was greatly diſordered, the Globules of his Blood appeared hard and rigid, but grew ſofter and more pliable as his Health returned: whence he infers, that in an healthy Body it is requiſite they ſhould be ſoft and flexible, that they may be capable of paſſing through the capillary Veins and Arteries, by eaſily changing their round Figures into Ovals, and alſo of re-aſſuming their former Roundneſs when they come into Veſſels where they find larger Room.

Changes are produced in Fluids ſurprizingly and ſuddenly, as a very few chymical Experiments will demonſtrate: the *Bite* of *Venomous Creatures*, and *Inoculating* for the *Small Pox*, ſhew likewiſe, how minute a Proportion of poiſonous Matter will contaminate the whole Maſs of human Blood; which can no otherwiſe be effected but by altering the Solidity, Figure, Size, or Motion of its component Parts or Globules. And it is probable, that in many Caſes, it may be changed from a morbid to a healthy State, by ways not leſs eaſy, could we be ſo happy as to find them out; for we cannot reaſonably

ably ſuppoſe, that the beneficent Author of Nature has given more certain and ready Means of doing Miſchief than of doing Good.

Many Diſtempers might perhaps be cured by an immediate Admiſſion of ſome Medicine into the Veins, which elude the Power of all that can be taken by the Mouth. For the Stomach, by its Heat, its Action, and a Mixture of its Juices, works ſuch an Alteration in things, before they can be admitted into the Blood, that they are unable to produce the ſame Effects as if they were received into it ſimply and unchanged.

Some Trials that have been made already, may ſerve in a great meaſure towards confirming the above Suppoſition. Dr. FABRICIUS injected with a Syphon into the Median Vein of a Soldier's Right Arm, in the Hoſpital at *Dantzick* *, about two Drams of a certain Purgative Medicine, which in about four Hours began to operate, and gave the Patient five Stools. His Caſe was Venereal, and in ſo terrible a Manner, that there were Nodes on the Bones of his Arm. But by this ſingle Injection, and without any other Medicine, the Protuberances gradually diſappeared, and the Diſeaſe was quite cured. He likewiſe injected into the Vein

* *Philoſoph. Tranſact.* Numb. 30.

of a married Woman, thirty-five Years old, and troubled from her Birth with Epileptic Fits, a ſmall Quantity of a purging Rozin diſſolved in an Anti-Epileptic Spirit: this occaſioned a few gentle Stools; after which the Fits were leſs violent every time than other, and in a ſhort time returned no more at all.

Dr. SMITH †, of the ſame City, injected Alteratives into the Veins of three Patients; one was lame with the Gout, another exceedingly Apoplectic, the third afflicted with that ſtrange Diſtemper, called the *Plica Polonica*; and they were all cured by the ſaid Injections.

S. FRACASSATI injected *Aqua Fortis* into the jugular and crural Veins of a Dog, which died immediately. The Blood was found fixed in the ſmaller Veſſels, and the larger Veſſels burſt. Whereupon he remarks, that as an Apoplexy is cauſed by a Coagulation of the Blood, it may probably be cured by ſome *Diſſolvent* injected.----Another Dog, in whoſe Veins *Oil of Vitriol* was injected, complained a great while, foamed like Epileptics, breathed ſhort, and died. His Blood was fixed and grumous, reſembling Soot.— *Oil of Tartar* was injected into a third Dog, who after much bemoaning, appeared ſwell'd, and died.

† *Philoſoph. Tranſact.* Numb. 39.

His

His Blood was not in the leaſt curdled, but thinner and more florid than common. —— This proves too great a Separation as well as a Coagulation mortal.

Mr. BOYLE found, that by putting a little *Aqua Fortis*, *Oil of Vitriol*, or *Spirit of Salt* into warm Blood, it did not only loſe its pure Colour and become dirty, but in a Moment was coagulated; whereas urinous Spirits abounding in volatile Salts, ſuch as *Spirit of Sal Armoniac*, mingled with it, did not curdle it, or debaſe its Colour, but made it redder, kept it fluid, and preſerved it a long while from Putrefaction.

As the *Microſcope* has informed us of the *Structure of the Blood*, which without its Help could never have been diſcovered, and as its continual Aſſiſtance is needful to examine and diſtinguiſh minutely any Changes that may be wrought therein, either for the better or the worſe, by Accident or by Medicine; I hope this Diſcourſe will not be judg'd too long, or foreign to my Subject, ſince Hints of this Kind may prove highly beneficial to Mankind, if they ſhould be ſo fortunate to fall into the Hands of thoſe who are inclinable to purſue and improve upon them.

I come now to deſcribe the Manner of bringing the *Blood* to a ſtrict Examination before

the *Microſcope*, and ſhall offer ſuch Ways as I have myſelf experienced, not doubting but the Ingenious will contrive others, as they may find Occaſion.

CHAP. VIII.

Of viewing the BLOOD *with the* MICROSCOPE.

TAKE (with the Tip of a Feather, or a ſoft Hair Pencil) a ſmall Drop of *warm Blood* immediately from the Vein: ſpread it, as thin as poſſible, on the cleareſt ſingle Iſinglaſs placed on a Slider on purpoſe, and apply it to the firſt or ſecond Magnifier: the Globules will then be ſeen diſtinctly, and a little Practice will enable to form a Judgment of any Alteration that may happen in the *Size*, *Figure*, *Colour*, or *Appearance* of them. We may alſo examine the Blood extreamly well, by taking up a little of it in a very ſmall capillary Tube of the thinneſt Glaſs, and then placing the Tube before the Magnifier.

If a Drop of the ſame Blood be diluted with warm Water, and applied in either of the above Ways, ſome of the larger Globules will appear more aſunder, and a great many of them will be ſeen divided into the ſmaller ones which compoſe them.

If ſome of the ſame Blood be mixed with a little warm Milk, ſeveral red unbroken Globules will be ſeen diſtinctly; but thoſe that are again ſeparated into their ſmaller ones will be confounded with the Milk itſelf, of which the greateſt Part is nothing elſe but Heaps of ſuch like-ſized minute Globules.

If we deſire to try by Experiment what Alteration any Liquor, either poiſonous or medicinal, can produce on the Contexture of the Blood, the Liquor ſhould be blended with it at the very Inſtant of its iſſuing from the Vein: for if the Blood be in the leaſt coagulated before ſuch Mixture, no certain Concluſions can be formed. Putting the Veſſel into which we receive it into a Baſon of Water a little hotter than the Blood, will preſerve it longer fluid, and make our Experiment by any Mixture with it ſucceed the better.----I would alſo adviſe, to get your Inſtrument in perfect Readineſs, by adjuſting the Magnifier before the Vein is opened; and likewiſe to make your Obſervations in a warm Place, leſt the Blood become congealed before you can finiſh your Enquiry.

In all Enquiries of Conſequence, it is beſt to draw the Blood from a large Vein: becauſe what we can gain (by the Prick of a Pin or Needle) from the Finger or any ſuch Part, iſſues from ſome extreamly minute capillary Veſſels only, and perhaps is not ſo

good a Sample of the Contexture of the whole Maſs.——— Some Trials on both may however not be amiſs, to diſcover what Difference there is between them.

By mingling with the Blood the leaſt imaginable Quantity of the *poiſonous Juice* which iſſues from the Teeth of a *Viper* when enraged, or from any other *Animal*, *Vegetable*, or *Mineral*, we ſhall diſcover its immediate Effect upon the Globules; and by conſidering, that the Alteration we obſerve is wrought in it, tho' at reſt, we ſhall be able to judge and calculate what Conſequences muſt enſue from ſuch a Mixture with the Blood, as it circulates through the Veins of a living Creature.

Mr. WILLIAM COWPER examining a Solution of *Opium* with the *Microſcope*, found its diſſolved Particles in the Shape of fringed Globules: whence he concludes, that ſuch Particles circulating in the Maſs of Blood, may be ſo entangled in its Serum, or thicken it in ſuch a Manner, as to retard its Velocity when over-violent, and render its Motion calm and equal; whereby all painful Senſations will be taken off. And from the ſame Principles it is eaſy to account for all its other Effects, and how too great a Number of ſuch fringed Globules muſt cauſe a total Stagnation of the Blood, and conſequently kill. Vid. *Philoſ. Tranſ.* Numb. 222.

Spirits,

Spirits, Oils, dissolved Salts, Tinctures, Essences, and all other chymical Preparations furnish us with numberless Subjects of Experiment; and are certainly capable of producing the most sudden and amazing Effects, either good or bad, if injected into the Blood-Vessels of living Animals: the Causes of which Effects may in a great Degree be discovered and accounted for, by microscopical Observations on Mixtures of them with the Blood when extracted from the Veins.

A little Blood being mixed with about four Times its Quantity of * *Sal Volatile Oleosum,* and viewed through a *Microscope,* there appeared an immediate Separation of the Globules. In about the eighth Part of a Minute some of them were much diminished, and in a Quarter of a Minute many of them were much dissolved and entirely disappeared. Sometimes twenty Globules were seen near together, which soon lessened to eighteen, then to sixteen, and became fewer and fewer till only two or three were left. Whence it is probable, that *Sal Volatile Oleosum* taken with the Food, and so carried into the Lacteals and Blood-Vessels, may retain its Power of preventing such Coagulations as would otherwise happen.

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* *Arc. Nat.* Tom. IV. page 36.

The *Urine*, *Saliva*, *Semen*, *Sweat*, *Fæces Alvi*, and all other *Animal Juices*, are likewiſe Objects for the Microſcope; to be examined either alone, or mixed with the aforeſaid Liquors: whence much uſeful Knowledge may be acquired.

As to Colour in the Blood, a Blackneſs ariſes in it from a Deficiency of Serum, as Paleneſs does from too great an Abundance of it: for it will be always found, that when Globules cohere together in too great Numbers they give a black Appearance. When this therefore is the Caſe, means of diluting ſhould be found out, and made uſe of; ſince it is abſolutely requiſite to Health, that the Globules of the Blood ſhould float in a due Quantity of Serum, and be thereby circulated freely through the minuteſt Veſſels, a contrary State to which has proved the Death of thouſands.——Mr. LEEUWENHOEK tell us, that whenever he found his Blood too deep coloured, his Way was to drink four Diſhes of *Coffee* in a Morning, in the Room of his uſual two; and ſix Diſhes of *Tea* in the Afternoon, inſtead of three. He drank it as hot as poſſible, and went on in this Manner, till he perceived his Blood grow paler, and conſequently its Globules farther ſeparated.

CHAP.

CHAP. IX.

The CIRCULATION *of the* BLOOD.

IN order to view *the Blood circulating through its Veſſels*, we muſt make uſe of ſuch *ſmall Creatures* as by their Tranſparency permit us to look within them, and ſee what paſſes there: for, in a Man, or any of the large Animals, the Skin is ſo opake, that we cannot diſcern even the fine Blood-Veſſels themſelves, and much leſs the Current that runs along them. Our Information, however, will not be greatly different; for the whole Animal Creation is eſtabliſhed on one and the ſame Plan, and the Circulations in the meaneſt living Creature are carried on through Veſſels of a like Structure (in the general) and are accelerated, or retarded, by the ſame Cauſes as in the nobleſt.

And, in Truth, as to the Circulations of the Fluids, and the Motions of the Bowels, the Brain, or any of the internal Parts, more Knowledge may be gained by inſpecting *Inſects* and *ſmall Animals* with the *Microſcope*, than by the moſt ſkilful and curious Diſſections, or anatomical Experiments on larger Subjects. For the Skins of ſome of theſe little Creatures are ſo tranſparent, that we may ſee plainly through them the Order and Diſpoſition of the Veſſels underneath;

and the Coats of these Vessels are, again, of such an amazing Thinness and Delicacy of Contexture, that they are little or no Impediment to our View of the secret, tho' regular, Operations of Nature, and the Laws she acts by, when undisturbed and quiet: whereas our Dissections of larger Animals, while alive, may shew her at work, indeed, but in such Confusion, by our breaking in upon her violently, that all her Motions, then, must be in great Disorder, and consequently uncapable of affording any satisfactory Information as to the Circulations.

In this Sort of Creatures too, after viewing, as long as we think fit, the natural and regular Current of the Blood, as it is carried on in a State of Health; we may by Pressure, and several other Ways, impede, disturb, and divert its Course; and may find Means, by various Mixtures with it, of inducing a morbid State; and at last, by letting the Creature dye before our Glass, we may perceive all the Changes it undergoes, and what occasions the intermitting, vibrating, trembling Pulse of expiring People.

In several of these little Creatures we can not only see the general Course of the Blood, but are able perfectly to distinguish the Figure and Circumstances of the Globules whereof it is compounded, and the Alterations they suffer, when they pass out of the larger into the more minute Vessels. For

many

many of the Veſſels are ſo ſmall, that even ſingle Globules cannot poſſibly find a Paſſage thro' them without being compreſſed into oval Shapes: and yet theſe Veſſels are large in compariſon of the fineſt Veſſels of all, to paſs through which, the Globules muſt be divided and ſubdivided into their ſmalleſt and moſt minute component Globules.

'Tis amazing to obſerve, how careful Providence has been to prevent the Blood from coagulating, or cohering in Maſſes dangerous to Life, by the very Diſpoſition of the Veſſels it runs through: which, whether ſeparating or uniting, are ſo contrived, as to cauſe the Globules to come frequently together with a briſk Colliſion, or ſtriking againſt each other. The *Arteries*, for Example, which convey the Blood from the Heart to the Extremities of the Animal, and in their Progreſs continually leſſen their Diameters, and divide into ſmaller Branches almoſt *ad infinitum:* in theſe *Arteries*, I ſay, at every ſuch Diviſion, many of the Globules of the Blood muſt ruſh, with a conſiderable Force, againſt an Angle directly in their Way; whence recoiling back on thoſe immediately behind, they muſt ſtrike upon one another, and cauſe a kind of Commotion, e'er the Current can divide readily into the two ſmaller Branches. See Fig. III. Plate X. ——In the *Veins*, which, on

on the contrary, return back the Blood from the Extremities to the Heart, whoſe Diameters enlarge as the Tide rolls along, and whoſe ſmall Branches are continually uniting and making larger Veſſels, till at laſt all their Streams fall into one; here, at every Conjunction of two Branches, their Currents ruſh againſt each other with Violence: by which Concuſſion unnatural Coheſions are broken, or prevented; and of this the *Microſcope* can afford us ocular Demonſtration. Vide Fig. IV.

CHAP. X.

Of viewing the CURRENT *and the* CIRCULATION *of the* BLOOD.

BY the *Current of the Blood*, I mean, its *ſtreaming* or *paſſing on* either *from* or *towards* the *Heart*, through any *Veſſel*, whether it be *a Vein* or *Artery*.

By the *Circulation* I would be underſtood to intend, the *Courſe* or *Current* of it, *from* the *Heart* along the *Arteries* to the *Extremities* of the *Body*: together with its *Return* by the *Veins* from the *Extremities* back again *towards* the *Heart*.

Both theſe the *Microſcope* can bring to View; but the latter is ſomewhat more difficult

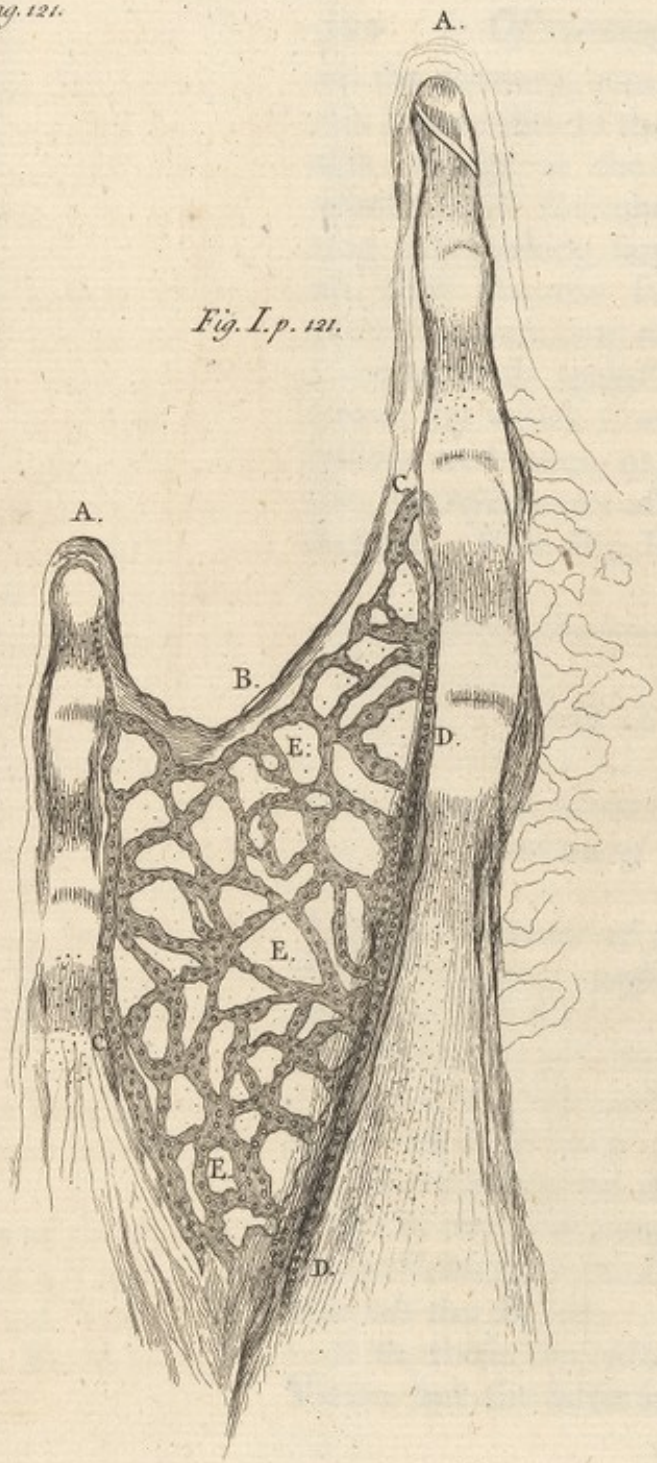


Fig. I. p. 121.

Fig. II. p. 124.

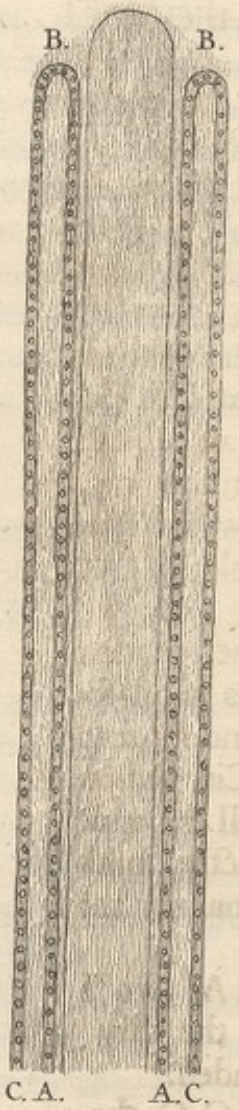


Fig. III. p. 143.

ficult to be assured of than the former; for when the Vessels before us are extreamly small, it is not always easy to distinguish which of them are Veins and which are Arteries.

The larger Arteries are indeed distinguishable by a Protrusion of the Blood at each Contraction of the Heart, then a Stop, and then a new Protrusion, which may plainly be seen continually succeeding one another: whereas the Current passes through the Veins with an equal and unintermitting Stream. But in the more fine and extream Branches of the Arteries this Difference is not perceivable.

The transparent Membrane between a Frog's hind-foot Toes is the Object most commonly employed for viewing the Current and Circulation of the Blood; and, in this, if well expanded, it may be seen fairly and distinctly, both in the Veins and Arteries, in the manner represented Plate XI. Fig. I.

A. A. two Toes of a Frog's hinder Foot.

B. the thin Membrane between the Toes, extended.

C. C. C. the Trunks of the Arteries.

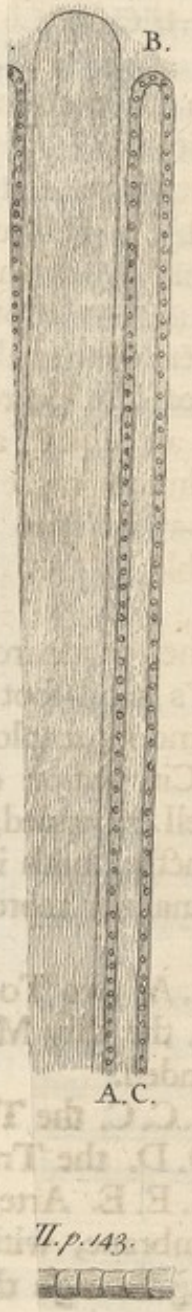
D. D. the Trunk of a Vein.

E. E. E. Arteries and Veins in the fine Membrane, with the Blood-Globules circulating through them.

The

Plate XI.

Fig. II. p. 124.



II. p. 143.

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E. E. E. Arteries and Veins in the fine Membrane, with the Blood-Globules circulating through them.

The

The Way of applying it to the Microſcope was deſcribed Page 13; and therefore needs not be repeated here.

The Tails or Fins of ſmall Fiſhes may likewiſe be uſed very commodiouſly to this Purpoſe, and preſent to View great Numbers of Veins and Arteries with the Blood paſſing different Ways through them.

It is difficult here in *London* to meet with any Fiſhes alive and proper for this Inſpection, except *Eels* and *Flounders:* either of theſe will ſerve however exceeding well; but the ſmaller they are the better.----Put your *Eel* into a Glaſs Tube fill'd with Water, after wiping off its Slime, which would obſcure your Glaſs. Then having ſtopped both Ends, to prevent the Water's running out, apply the Tail or Fin to your Microſcope, and you'll ſee the Circulation in a very agreeable Manner. If you put not Water in your Tube, the Slimineſs of the Eel will immediately foul the Glaſs and prevent your Pleaſure.

The flat Figure of the *Flounder* will not permit us to put it in a Tube as we do the *Eel*, or view it by every Kind of Microſcope: but if a plain Piece of thin Glaſs be placed over the Hole, where Objects are applied to the Double Reflecting Microſcope, its Tail may be ſpread advantagiouſly upon the ſaid Glaſs: and by ſetting a Book, or

ſome-

ſomething elſe of a proper Height to ſupport the Body of the Fiſh, it will lye in a very good Poſition for View, and the Circulation may be ſeen diſtinctly.

Eels and *Flounders* live a long while out of Water, and are therefore moſt uſeful for this Service here at *London*; but in the Country many Sorts of other ſmall Fiſhes may be found much more tranſparent.

Mr. LEEUWENHOEK informs us *, that he ſaw, with great Admiration, in the utmoſt Extremities of a very minute Fiſh's Tail, how the larger Arteries were there divided into the moſt fine or evaneſcent ones; and that many of the ſmalleſt Veins, returning from the ſaid Extremities, met together at laſt in ſome larger Vein. There appeared alſo in ſome Veſſels, ſuch an Agitation of that Blood (which was protruded from the larger Arteries towards the evaneſcent Ones at the very Extremity of the Tail, and returned afterwards through many minute Veins into a large One) as hardly can be conceived. In the larger Arteries he could perceive a continual new Protruſion, or Acceleration of the Blood's Courſe, received from the Heart; but in the ſmaller Arteries the Motion ſeemed equable, without any

* *Arcan. Nat.* Tom. IV. Epiſt. 65.

ſuch repeated Propulſion: and though in the minuteſt Veſſels there appeared no Colour, yet in the larger Vein or Artery, though near the End of the Tail, the Blood was plainly red.

We cannot properly call any Veſſel an Artery farther than the Pulſation reaches; beyond that, and returning towards the Heart, it muſt be accounted a Vein: for Veins are only Arteries elongated; but as they frequently divide into Branches that evade Diſcovery, it is, perhaps, impoſſible to determine exactly, where the Arteries end and where the Veins begin.

They do not always, however, branch out ſo extreamly fine before their Inoſculation or Communication with the Veins; for the ſame curious Obſerver tells us, that on each Side the little Griſtles, which gave a Stiffneſs to the Tail of the Fiſh abovementioned, he could ſee a very open Communication of the Veins and Arteries: the Blood running towards the Extremities through Arteries, and returning back again thro' Veins that were evidently a Continuation of thoſe Arteries, and of the ſame Diameter with them: And this he ſaw in thirty-four different Places, in as many Arteries, and as many Veins. The Manner whereof, as by him delineated, is ſhewn, Tab. XI. Fig. II.

A. A.

A. A. Repreſent two Arteries, one of which runs on each Side a minute Griſtle.

B. B. Their open Communication with the two Veins C. C.

As this whole Fiſh was not half an Inch in Length, how ſmall muſt the Tail thereof be, in which, notwithſtanding, the Circulation of the Blood was viſible in thirty-four Places, and the Current of it in ſixty-eight Veſſels! and yet theſe Veſſels were very far from being the moſt minute of all. How inconceivable then muſt be the Number of its Circulations in an human Body! Nor need we wonder to behold it iſſuing forth at every Prick of a Pin or Needle. Upon conſidering this, Mr. LEEUWENHOEK adds, that he is fully perſuaded, a thouſand different Circulations of the Blood are continually carried round in every Part of a Man's Body that is not larger than the Breadth of his Fore-finger Nail *.

The Tail of a *Newt*, or *Water-Lizard*, applied in a Glaſs Tube, after the Manner directed for the Eel, affords an entertaining Proſpect of the Circulation through Numbers of ſmall Veſſels. But nothing can ſhew it finer, than an exceeding ſmall † *Newt* of

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* LEEUWEN. *Arcan. Nat.* Tom. IV. pag. 169.

† *Phil. Tranſ.* Numb. 288.

this Water-Kind, which ſometimes may be found leſs than an Inch long, and ſo tranſparent, that the Blood may be ſeen running in all Directions, not only through the Veſſels of the Tail, but throughout the whole Body: And it is particularly delightful, to behold, in the little Toes, the Stream thereof running to the Extremity in one Channel, and returning back again by another. Juſt below the Head are on either Side three Fins, or ſomewhat like Fins, which, in ſwimming, the Creature makes Uſe of to poiſe and guide its Body: each of theſe appears by the Microſcope divided, like *Polypody*, into many pointed Branches; in any one whereof, as in the Toes, the Blood is ſeen coming along an Artery to the Extremity, and then immediately returning towards the Heart again, through a Vein that lies parallel, and almoſt cloſe thereto, and with which its Communication is very apparent.---As thirty or forty of theſe Branchings preſent themſelves before the Eye, ſometimes at once, with the Blood diſtinctly circulating in all, they afford a charming Sight: and they may be viewed by the third or fourth Magnifier: for the Globules of the Blood in *Newts* are larger than in any other Creature I have examin'd, and are fewer in Proportion to the Serum or Water they float along in. To which I may alſo add, that the Figure of them, as they are carried

carried along the Veſſels, changes in a moſt ſurprizing Manner.

In Spring-time, if a little *Frog's Spawn* be kept ſome Days in a ſmall Quantity of the Ditch Water wherein you found it, you'll be furniſhed with a Number of exceedingly ſmall *Tadpoles*, which, when firſt they begin to ſwim, are almoſt wholly tranſparent: and if placed before the Microſcope, in a Tube proportionably ſmall, with ſome Water in it, you'll eaſily diſcern the Heart and its Pulſation, together with the Blood circulating in every Part of the Body; and, particularly, in the Tail, more than fifty Veſſels preſent themſelves at one View.

Theſe *Tadpoles* become leſs clear every Hour, and in a Day or two their Skin grows ſo opake, that the Circulation of the Blood can be ſeen no longer, unleſs it be in the Tail, or better ſtill in the Fins, at the joining on of the Head.

A ſmall *Muſcle* taken carefully from its Shell, and placed before the Microſcope on an Iſinglaſs, affords a View of many Arteries and Veins, through which the Circulation of the Blood may be very clearly ſeen: and one great Advantage in this Object is, that it lies always quiet; whereas moſt other Creatures are difficult to be kept ſtill long enough for Obſervation. The Motion of the

Blood continues in it ſix or ſeven Hours with little Alteration: and, by moiſtening it now and then with ſalt Water, may probably be continued much longer.

I can alſo aſſure you, from my own repeated Experiments, that if a large *Muſcle* be carefully opened, and a Piece of the thin tranſparent Membrane adhering to the Shell be ſnipped off with a Pair of ſharp Sciſſars, and applied to the Microſcope, the Blood will be ſeen paſſing through Numbers of Veins and Arteries; and if the Extremity of the Membrane be viewed, the true Circulation, or the Return of the Blood from the Arteries through the Veins, will be ſhewn in a delightful and ſatisfactory manner, and continue for a long Time. There are likewiſe other tranſparent Parts of the *Muſcle*, where the Paſſage of the Blood is very diſcernable: And, as *Muſcles* are to be got moſt times of the Year in *London*, the Knowledge hereof will, I hope, oblige the Curious.

We are told by Mr. LEEUWENHOEK, that in the fartheſt Joints of the hinder Legs of little* *Crabs*, he beheld the Blood circulate through the Arteries and Veins, with greater Rapidity than he had ever obſerved it in any other Creature; and, moreover, that the red Globules thereof were twenty-five

*LEEUW. *Arc. Nat.* Tom. IV. Ep. 84. Again Ep. 86.

times

times fewer in Proportion to its Serum than in any other Land or Water-Animal he had ever before examin'd.

At the proper Time of Year, exceeding ſmall *Crabs* may be found, in great Abundance, under Stones and Brick-bats on the Shores of the River *Thames*, when the Tide is out: and as many of them are not larger than a little *Spider*, it is highly probable ſuch may be tranſparent in many Places of the Limbs and Body; notwithſtanding Mr. LEEUWENHOEK found his, which were an Inch broad, opake every where but in the extreameſt Joints of the hinder Legs. Perhaps too, they may appear more tranſparent, if they are applied to the *Microſcope* in a little Tube filled with Water, than if they are viewed dry; for 'tis obſervable, that many Objects acquire a Tranſparency by being wetted, in the ſame manner as Paper becomes clear by being rubbed with Oil.

The Blood may be ſeen circulating in the Legs and Tails of *Shrimps*, eſpecially if viewed in Water; but then the Water muſt have a little Salt put thereto, or elſe they will ſoon expire. In *Shrimps* the Blood is not red; which has given Occaſion to call them as well as many other Inſects *exangues*, or *bloodleſs*: tho' in reality no living Creature is without Blood; for animal Life conſiſts in a Circulation of ſome Fluid through

Arteries and Veins, and that Fluid, whatever Colour it may be of, is properly to be accounted Blood. In *Graſshoppers* the Globules (which may be ſeen paſſing through the Veſſels in their Wings) are green, and yet I am apt to think, no body that views them will heſitate to call them, with the Serum wherein they ſwim, Blood.

In the tranſparent Legs and Feet of ſeveral ſmall *Spiders*, the Current of the Blood may plainly be diſtinguiſhed both in the Veins and Arteries: alſo in the Legs of very ſmall *Punices* or *Bugs* it is remarkably viſible, together with an extraordinary Vibration of the Veſſels, which I never have obſerved in any other Creature. In theſe too, if clear, as they may ſometimes be found, the wonderful Motions of all the internal Parts will afford an agreeable Entertainment to the Curious, and may be examin'd as long and as often as they pleaſe. For I have kept a *Bug* alive in a Slider between two Pieces of Iſinglaſs at leaſt ſix Weeks together, notwithſtanding it was confined ſo cloſe as to be uncapable of ſtirring: and altho' during that time it often ſeem'd dead and motionleſs, when I placed it before the Microſcope a little Warmth would ſet the Bowels at work again, and renew the Current of the Blood as briſkly as ever.

After

After many Obſervations made by Mr. LEEUWENHOEK on the Blood of *Cocks*, *Sparrows*, *Frogs*, *Trout*, *Perch*, *Cod*, *Salmon*, &c. he affirms, that the red Particles in the Blood of *Birds*, *Fiſhes*, and *Water-Animals*, are conſtantly * flat and of an oval Figure, that is, they are longer than their Breadth, and appear as in Plate X. Fig. V. The ſerous Part of the Blood in *Fiſhes* and *Aquatic Animals* is alſo greatly more, in Proportion to the red Particles, than it is in *Beaſts* or *Men*, and the Particles themſelves are larger: ſo that, by being bigger, and ſwimming farther aſunder, they may be ſeen much better.

Mr. LEEUWENHOEK obſerved the Blood circulating in the filmy Wings of a † *Bat*, and likewiſe in its Ears, and found the Globules thereof perfectly round: Wherefore, allowing his Aſſertion, that in Fiſhes and Birds they are always flat and oval, we need no longer heſitate how to claſs this odd Creature; but, notwithſtanding its flying, ſhall pronounce it to be a *Beaſt*.

He tells us, that *Bats* can ſee as well by Day as Night: but he ſuppoſes the Heat and Dryneſs of the Day-Air would ſhrivel up the thin Membranes of their Wings, and conſequently ſtop the Circulations there:

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* *Arc. Nat.* Tom. I. P. II. p. 51. Again, Tom. II. Epiſt. 128. Again, Tom. IV. Epiſt. 65.

† *Arc. Nat.* Tom. IV. Epiſt. 67.

whereas

whereas the cool Dews of the Evening render them moiſt and pliable; which makes them chuſe that time to come abroad.

In viewing ſeveral of the Objects here mentioned, one ſhall often obſerve the Blood paſſing through Veſſels ſo minute, that the Globules of it cannot glide along otherwiſe than ſingle, and ſqueezed into oblong Forms: yet an hundred of the red Globules of ſuch Blood, if placed cloſe to one another in a Row, would not equal the Length of the Diameter of a large Grain of Sand; and conſequently a Million of them exceeds not a Grain of Sand in Bigneſs *.

The Effects of Heat and Cold upon the Blood are well worth taking notice of: for as Heat relaxes the Veſſels, the Blood finds more Room to move in, its Globules float at greater Diſtances, and it circulates more freely: whereas Cold ſo contracts the Veſſels, that the Globules are compreſt together, and the Blood is impeded, and in ſome Degree coagulated in the minute Capillary Veins and Arteries of the extream Parts; as is evident from the Swelling and Blackneſs of the Hands and Feet when expoſed to ſevere Cold.

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* Leeuwen. *Arc. Nat.* Tom. I. Par. I. p. 35.

Before

Before I close this Chapter, I shall briefly communicate some Experiments, I had the Pleasure of making last Summer, with my most ingenious and valuable Friend Doctor ALEXANDER STUART, Physician to her late Majesty, in order to view the Circulation of the Blood by the *Solar* or *Camera Obscura Microscope*, which has the Advantage of magnifying Objects beyond any other sort of Microscope: but must refer the Curious to a more full Account thereof laid by this Gentleman before the *Royal Society*, and which will be published in the *Philosophical Transactions*.

I must first describe a particular Apparatus, invented by the *Doctor*, for examining the Circulation of the Blood in *Frogs*, *Mice*, *Bats*, or any Creatures of the like Size. In this Contrivance, the Looking-glass, Tube, and convex Lens are just the same, and placed in the Hole of a Window-Shutter in the same manner as described Pag. 22. But here, instead of using WILSON's little *Pocket Microscope*, he has got the Belly-Part of a large Reflecting one fixed horizontally on a Pedestal, at a Height exactly equal to the Tube. This stands on a little Shelf made to support it; and to the Snout thereof, which lies on a Level with the Tube, the Magnifiers are screwed. The Object being extended and fastened with Strings and Pins on a Frame convenient for the Purpose, is applied between the Tube and the Magni-

fier: whereby the Sun's Rays reflected from the Looking-glaſs, through the Tube, upon the Object, paſs on through the Magnifier, and exhibit upon the Screen an Image of the Object moſt prodigiouſly enlarged. This I hope may give ſome Idea of our Inſtrument: and now I come to the Application.

Our Object was a *Frog*, whoſe Limbs being extended and faſtened on the Frame, we opened the Skin of the Belly from near the Anus to the Throat; then giving it a little Snip ſideways both at the Top and Bottom, by ſticking a *Fiſh-Hook* in each Corner of the Skin, it was eaſily ſtretched out before the *Microſcope*, and preſented on the Screen a moſt beautiful Picture of the Veins and Arteries in the Skin, with the Blood circulating through them. In the Arteries we could plainly perceive the Blood ſtopping, and as it were receding a little, at each Dilatation of the Heart, and then immediately ruſhing forwards again at each Contraction; whilſt in the Veins it rolled on in a continual Current with inexpreſſible Rapidity *.

After conſidering this as long as we thought needful, we opened the *Abdomen*, and extending the Muſcles before the *Micro-*

* When the Arteries were magnified very much, by removing the Screen to a conſiderable Diſtance, the alternate Expanſion and Contraction of their Sides were very viſible and remarkable.

ſcope,

ſcope, by the ſame Means as we had done the Skin, we had the Pleaſure of viewing their Structure, which we found to conſiſt of Bundles of tranſparent Strings or Fibres, lying parallel to one another, and joined together by a common Membrane. Theſe Strings or Fibres appeared through their whole Length made up of minute roundiſh Veſicles, or, in other Words, ſeemed like Ruſhes divided the long Way. We could not be certain of any Circulation through the Muſcles, though ſometimes we imagin'd we ſaw a very ſlow Motion of ſome tranſparent Fluid: but the Object growing dry and rigid, obliged us to leave that Enquiry to a farther Examination.

We then proceeded to our laſt Experiment, which was to draw out gently a Part of the *Frog*'s Gut, in order to apply the *Meſentery* to the *Microſcope*: and herein we ſucceeded ſo happily, that I believe the Circulation of the Blood was never before ſeen in ſo diſtinct and fine a Manner. No Words can deſcribe the wonderful Scene that was preſented before our Eyes! We beheld the Blood paſſing through numberleſs Veſſels at one and the ſame Inſtant, in ſome one Way, in others the quite contrary. Several of the Veſſels were magnified to above an Inch in Diameter, and the Globules of the Blood rolling through them ſeem'd near as large as Pepper-Corns; whilſt in many of the minuteſt

nuteſt Veſſels only ſingle Globules were able to find a Paſſage, and that too not without changing their Figure into that of oblong Spheroids. We ſaw here likewiſe, much better than we had done before, the Pulſation and Acceleration of the Blood in the Arteries, in the Manner before deſcribed, and could clearly diſtinguiſh two or three Veſſels lying over one another, with Currents running different Ways. In ſhort, it appeared like a beauteous Landſcape. where Rivers, Streams, and Rills of running Water are every where diſperſed.

During this Examination, we took notice of a Veſſel extreamly minute, iſſuing from the Side of a larger, and turning backwards from it in a curve Line. We perceived, at unequal Intervals, ſometimes one, ſometimes two, and ſometimes three colourleſs Globules, dropt or ſqueez'd out of the larger Veſſels into this minute one, and gliding through it ſingly and very ſlowly; which made the *Doctor* imagine it might be a *ſecretory Duct*. We obſerved likewiſe, that as the Animal grew languid and near expiring, the Blood in the Arteries would ſtop on a ſudden, ſeem as it were coagulating, and then run backwards for ſome time; after which, it would again recover its natural Courſe with a great deal of Rapidity. ---A due Conſideration of theſe Appearances might poſſibly account for the Intermiſſions,

Starts,

Starts, and Irregularities in the Pulse of Persons near the Point of Death.

CHAP. XI.

The Pulsation of the HEART.

THIS wonderful Phænomenon may be seen distinctly in several small Insects, some whereof I shall here mention, with short Directions how to find it.

Divide a * *Bee*, particularly an *Humble-Bee*, near the Neck: and its *Heart*, which is a white pulsing Particle, may be seen beating briskly.

The Head of the ‡ *Horse-Fly* being cut off, just at the setting on of the Neck, a little Particle (which is the *Heart)* will appear with a Pulsation in it for half an Hour.

The † *Grasshopper* has a green Film or Plate over its Neck and Shoulders, which being raised with a Pin, its *Heart* may be seen beating, very orderly, for a long while together.

Cut off the Head of that little flying Beetle, known to every Child by the Name of § *Lady-Bird*, or *Cow-Lady*: erect it per-

* Dr. POWER's *Microscop. Observ.* p. 4. ‡ Ibid. 7.
† Ibid. p. 24. § Ibid. 30.

pendicu-

pendicularly, and you'll see two small black Eyes, each set between three white Plates like polish'd Ivory, on one side two small ones, and a large one on the other. Pull off both the crustaceous and filmy Wings, which cover a tender black Skin, and, removing that Skin, the Pulsation of the *Heart* may be seen beating vigorously for twelve or fourteen Hours.

The *Heart* of a * *Snail* is to be found exactly against the round Hole near its Neck, of a white Colour, † and may be seen beating a quarter of an Hour after Dissection.

It may also be seen in a *Louse*, as I shall shew when I come to describe that Creature; and I make no doubt the curious and diligent Enquirer will be able to discover it in Multitudes of other little Animals.

The *peristaltic Motion* of the Stomach and Bowels may be seen very distinctly in *Lice*, *Gnats*, *Flies*, &c. and a Multitude of other Insects.

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* Power's *Microscop. Observat.* p. 36.
† Swammerd. *Hist. Generale des Insectes*, p. 77.

CHAP.

CHAP. XII.

Of the muſcular *or* fleſhy Fibres *of* Animals.

THE *fleſhy Fibres* of the *Muſcles* (according to the Obſervations of *Monſieur* MUYS) are compoſed of other ſmaller Fibres or Fibrils, the Size of a ſlender Hair; five or ſix hundred of which Fibrils go to the making up of one *fleſhy Fibre*, whoſe Diameter is no more than the twenty-fourth part of an Inch. Each of theſe Fibrils is again compoſed of more than three hundred ſmall tranſparent *Tubuli*, ſo extreamly ſlender, that were one of thoſe Blood-Globules (which Mr. LEEUWENHOEK ſuppoſes but the Millionth Part of a Grain of Sand) divided into twenty-four Parts, even theſe minute Parts could hardly enter and paſs through ſuch exceedingly ſmall Tubes. And yet, that they do enter and paſs through them is evident by the Redneſs of the Fleſh of Animals. We muſt therefore infer, that the *Tubuli* forming a Fibril are really hollow: that the Extremities of the Arteries open into them, and empty there a Part of their Liquor, which is carried back again by the Veins to the Heart: and that the Globules of the Blood are, for this Purpoſe, divided into Parts inconceivably ſmall. *

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* Vid. *Phil. Tranſ.* Numb. 339.

Mr. LEEUWENHOEK ſays, each *Muſcular Fibre* is compoſed of many ſmaller Filaments or Fibrils; which, however minute, he could plainly diſtinguiſh to be vaſcular: for, if he cut acroſs their Length, the Light appeared through the Mouths of the Veſſels; but if he cut them ever ſo little obliquely no Light was to be ſeen †. He found alſo, that each Fibril is inveſted with a * minute Membrane, which is only a Congeries of Blood-Veſſels, conveying Juices and Nouriſhment thereto, tho' their Fineneſs renders them inviſible. It is not, however, to be imagined, that each Fibril has its peculiar Membrane: but that all the Membranes together are like a Net finely ſpread, with a Fibril iſſuing through each of its Meſhes.

This Structure of the Fibres he obſerved in the Fleſh of an Ox, and of a Whale; but more plainly in that of a Whale, the Beef-Fibres lying more compact and cloſe. He alſo found that the Fibres of a Mouſe were of the ſame Thickneſs as thoſe of an Ox, though thirty thouſand Mice are not equal to one Ox in Bigneſs: whence he concludes, that the different Size of Animals is entirely owing to the greater or leſs Number and Length of the Fibres ‡.

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† *Phil. Tranſ.* Numb. 367.

* GORTER. *Medic. Compend.* p. 58. 59. LEEUW. *Arc. Nat.* Tom. III. p. 58. ‡ *Ibid.* 61.

Theſe

Theſe *fleſhy Fibres* appear through their whole Length encompaſſed with circular Wrinkles. If a Thread were twiſted about a fine Needle in a Screw-like Form, with ſpiral Circumvolutions, ſo that each Thread be diſtant from another the Diameter of the Needle, it would naturally repreſent the Manner of theſe circular Twiſtings. And this Diſpoſition is wonderfully contrived for the ready *Diſtenſion* or *Contraction* of the Fibres: for as a Cord will be diſtended or contracted *quicker*, or *ſlower*, in proportion to its Length, the ſame muſt alſo be the Caſe in *Animal Fibres*; and, therefore, on theſe Principles we may calculate how much more nimbly the Leg of a Mouſe can move than the Leg of an Ox.

The Method of viewing the *Muſcular Fibres* is, to cut carefully, and with a very ſharp Razor or Pen-knife, a Slice of dryed Fleſh or Fiſh, as thin as poſſible. Lay it on a Piece of Glaſs, and moiſten it with warm Water; which, drying ſoon away, will leave the Veſſels open and diſtinguiſhable.-----It is obſervable that the Fibres of Fiſh are larger than thoſe of Fleſh.

That the *Muſcular Fibres* are vaſcular, or made up of little hollow Veſſels, is ſuppoſed by MALPIGHIUS, BORELLI, GORTER, our own Countryman Mr. HOOKE, who ſays,

they appeared to him like Strings of Pearls; and, very lately, by Dr. ALEX. STUART, in his learned and ingenious Treatiſe *de Motu Muſculorum*; where, from ſuch a Structure, and by the Influx of the nervous Fluid, he accounts, very reaſonably, for the elaſtic Force, the Contraction, the Diſtenſion, and all the Actions of the Muſcles *. But as theſe Gentlemen differ ſomewhat in the Figure of the little Veſicles, ſuppoſed to make up the muſcular Fibres, the Curious will do well to examine, with the *Microſcope*, into this Matter, as carefully as poſſible; and that, by contriving all the Ways they can think of to view the Fibres in living Animals. For, whatever Form the Veſſels may have when replete with a nervous or other Fluid, I am afraid, when the Fibres have been dried, or the Veſſels collapſe together by not being ſupplyed with ſuch Fluid, the true Form and Structure of them can never be fully known.

Our Obſervations, 'tis probable, may be made with moſt Succeſs on *Inſects*, their fleſhy Fibres, as Mr. LEEUWENHOEK tells us, being no leſs viſible than thoſe of larger Creatures: which he found, by cutting off and examining the fleſhy Parts of the Legs of † *Flies*, *Gnats*, *Ants*, &c. in all which he

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* *Vid.* GORTER *de Fabrica & Motu Muſculor.* STUART *de Motu Muſc.* p. 49. † *Arc. Nat.* Tom. III. p. 108.

could

could plainly distinguish the circular Wrinkles or Circumvolutions encompassing the Fibres, as they are pictur'd Plate XI. Fig. III.

CHAP. XIII.

Of BONES.

UPON examining of *Bones* with a *Microscope*, their superficial Part is found to consist of a great many small Vessels, and some few of a larger Size: which last, when they come to the Surface of the Bone, appear invested with either a Membrane or bony Substance perfectly transparent. The Inside of the Bone has a spongy or cellular Substance, consisting of long Particles closely united, which are composed of numberless small Vessels, some running length-ways, and others taking their Course towards the Sides of the bony Particles, which, notwithstanding their great Number of Apertures are extreamly hard, and lye some parallel, and others perpendicular to the Length of the Bone.

Mr. LEEUWENHOEK discovered, once, in a small Bit of a Shin-Bone, four or five Vessels, with Apertures large enough for a Silk to pass through; each whereof seem'd furnish'd with a Valve, disposed in such a Man-

ner as to let out what was contained in the Veſſel, but ſuffer nothing to return into it *.

" It may poſſibly be conceived by ſome, " ſays Dr. GREW, that the *Bones*, at leaſt " ſome of them, are hard at the firſt: as " Salts and other cryſtallizing Bodies are as " hard upon the very firſt Inſtant of their " Shooting, as they are when grown into " large Cryſtals. But it is ſo far evident " that all the *Bones* are ſoft at the firſt, that " I am of Opinion, they are originally a " Congeries of as true *Fibres* or *fibrous Veſ-* " *ſels* as any other in the Body; which by " Degrees harden into Bones, in like Man- " ner as the inmoſt Veſſels of a Plant do in " time harden into Wood. And as in a " Plant there are ſucceſſive Additions of " Rings or Tubes of Wood, made out of " Veſſels: ſo in an Animal, it ſeems plain, " that there are Additions ſucceſſively made " to the Bones out of the *fibrous Parts* of " the Muſcles: eſpecially thoſe whiteſt Fibres " which run tranſverſly, and make the Sta- " men or Warp of every Muſcle. So that, " as in the Bark of a Plant, part of the Veſ- " ſels are ſucceſſively derived outward to the " Rind, and part inward to the Sap, which " afterwards becomes hard Wood; ſo, in the " Fleſh of an Animal, Part of the white " tranſverſe Fibres are ſucceſſively derived

* *Philoſoph. Tranſ.* Numb. 366.

" to

" to the Skin (of which it chiefly consists)
" and Part of them inwardly, making still
" new *Periosteums* one after another, as the
" old Ones become so many Additions to
" the Bones." *

Whoever would examine the *Bones*, must shave off, with a sharp Pen-knife, very thin Pieces lengthways, crosways, and obliquely, and that from the Inside, Outside, and Middle of the Bone. Apply to the *Microscope* some of these Shavings dry, and others moistened with warm Water, and thus the Vessels will be seen in all Directions. But the best Way of shewing the bony Structure is, by putting the Bones in a very clear Fire till they are red hot; then taking them out carefully, you'll find the bony Cells, though tender, perfect and entire: And being now quite empty, they may be viewed with great Ease and Pleasure.

CHAP. XIV.

Of the NERVES.

MR. LEEUWENHOEK endeavoured to discover, by his *Microscope*, the *Structure* of the *Nerves*, in the Spinal Marrow

* GREW's Rarities of *Gresham* College, p. 6.

of an Ox; and ſaw, with great Delight, that minute hollow Veſſels, of an unconceivable Fineneſs, inveſted with their proper Membranes, and running out in Length parallel to one another, make up their Compoſition. And though ſome Hundreds of theſe Veſſels go to the Formation of the leaſt Nerve that can poſſibly be examined, he did not only diſcern the Cavities of them, which he computed to be three times leſs than their Diameters, but, in ſome, perceived the Orifices, as plainly, as the Holes in a pricked Paper are to be ſeen when looked at againſt the Sun. It requires however great Dexterity and Expedition to make this Examination with Succeſs; for after a thin Slice of the Spinal Marrow is placed before the *Microſcope*, in leſs than a Minute's Time it becomes dry, and the whole Appearance vaniſhes *.

The ſame ingenious Enquirer into Nature examined likewiſe the Brain of ſeveral Creatures, ſuch as an *Indian* Hen, a *Sheep*, an *Ox*, a *Sparrow*, &c. and could there diſtinguiſh Multitudes of Veſſels, ſo extreamly ſmall, that if a † Globule of the Blood (a Million whereof exceed not a Grain of Sand in Bigneſs) were divided into five hundred Parts, thoſe Parts would be too large

* *Arc. Nat.* Tom. III. p. 310, 355. 440.
† *Ibid.* Tom. I. Part I. p. 30.

to

to pass into such Vessels. He observed farther, ‡ that the Vessels in the Brain of a Sparrow are not smaller than in an Ox; and argues from thence, that there really is no other Difference between the Brain of a large Animal and that of a small one, but only a greater or smaller Number of Vessels; and that the Globules of the Fluid passing through them are in both of the same Size.

Though it does not directly relate to *Microscopes*, I hope I may be excused for taking Notice here, that in the Year 1711, Dr. ALEX. STUART * made a Discovery, that the Nerves are not elastic, contrary to the Opinion of all preceding *Authors*; and proved it by the following Experiment: "Laying "a Piece of Twine, about four Inches in "Length, parallel to the Nerve, Artery and "Vein of the Inside of the Thigh in an human Subject, and tying these together above "and below, as soon as they were cut out of "the Body, and laid on a Board; the Artery "and Vein were seen to contract equally, to "the Loss of a quarter Part of the Length "they had in the Body before Excision; but "the Nerve continued of the same Length "with the Twine, as in the Body."

‡ *Arc. Nat.* Tom. I. Par. I. p. 38.

* Vid. STUART's *Lectures on Muscular Motion in the Year* 1738. p. 3.

CHAP.

CHAP. XV.

Of the GENERATION *of* ANIMALS *and* VEGETABLES.

EQuivocal or *ſpontaneous Generation*, that is, a Production of Plants without Seeds, and of living Creatures without any other Parents but Accident and Putrefaction, however abſurd it may ſeem to us, was an Opinion that prevailed, almoſt univerſally, till *Microſcopes* overturn'd it; by demonſtrating that all Plants have their Seeds, and all Animals their Eggs: whence other Plants and other Animals, exactly of the ſame Species, are perpetually and unalterably produced.

Nothing ſeems now more contrary to Reaſon, than that *Chance* and *Naſtineſs* ſhould give a Being to Uniformity, Regularity, and Beauty: That two ſuch unlikely Principles ſhould produce, in different Places, Millions of Vegetables of the ſame Kinds, and alike, exactly, even in the moſt minute Particularities; or, what is yet more amazing, that dead *corrupting Matter* and blind *uncertain Chance* ſhould create living Animals, fabricate a Brain, conſtitute Nerves iſſuing from it, compoſe a Contraſt of Muſcles, furniſh out Eyes, Lungs, a Heart, a Stomach, Bowels, and all other Parts uſeful to ſuch Creatures: and that too not after an awkard, ſlovenly, variable, undeſigning and unfiniſh'd

unfiniſh'd manner; but with a Contrivance, Dexterity, Elegance, Perfection and Conſtancy beyond the utmoſt Power of Art to imitate. This, however, was the Opinion, not only of the Ignorant and Illiterate, but of the moſt learned grave Philoſophers of preceding Ages; and would, probably, ſtill have been taught and believed, had not *Microſcopes* diſcovered the manner how all theſe Things are generated, and reſtored to GOD the Glory of his own amazing Works ‡.

The Eye, aſſiſted by a good *Microſcope*, can diſtinguiſh plainly, in the *Semen maſculinum* of Animals, Myriads of *Animalcules* alive and vigorous; though ſo exceedingly minute, that, it is computed, three thouſand millions of them are not equal to a Grain of Sand, whoſe Diameter is but the one hundredth Part of an Inch †: And the ſame Inſtrument will inform us beyond all Doubt, that the *Farinæ* of Vegetables, are nothing elſe but a Congeries of minute *Granula*, whoſe Shapes are conſtant and uniform as the Plants they are taken from.

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‡ I would as ſoon ſay, that Rocks and Woods engender Stags and Elephants, as affirm, that a Piece of Cheeſe generates Mites. Stags are born and live in Woods, and Mites in Cheeſe; but they both owe their Being to that of other Animals. *Spect. de la Nat.* Eng. Edit. 12mo. Vol. II. p. 11,

† Vid. KEIL's *Anat.* 5th Edit. p. 116.

And

And as the Seeds of Plants are proved, by repeated Experiments, to be unprolific, if the *Farinæ* be not permitted to ſhed, it has been ſuppoſed, that all its *Granula* contain *ſeminal Plants* of their own Kind.

The Growth of Animals and Vegetables ſeems to be nothing elſe but a gradual Unfolding and Expanſion of their Veſſels, by a ſlow and progreſſive Inſinuation of Fluids adapted to their Diameters; until, being ſtretch'd to the utmoſt Bounds appointed them by Providence at their Formation, they attain their State of Perfection, or, in other Words, arrive at their full Growth.

'Tis thought probable, according to this Theory, that, in Animals (of the larger and more perfect Kinds at leaſt) the *Semen* of the Male being received into the *Matrix* of the Female, ſome of the *Animalcules* it contains in ſuch Abundance, find an Entrance into the *Ovaria*, and lodge themſelves in ſome of the *Ova* placed there by Providence as a proper *Nidus* for them.

An *Ovum* becoming thus inhabited by an *Animalcule*, gets looſen'd in due Time from its *Ovarium*, and paſſes into the *Matrix* through one of the *Fallopian* Tubes. The Veins and Arteries that faſtened it to the *Ovary*, and were broken when it dropp'd from thence, unite with the Veſſels it finds here, and compoſe the *Placenta*. The Coats of the *Ovum* being ſwell'd and dilated by the

the Juices of the *Matrix* form the other Integuments needful to the Preſervation of the little Animal, which receiving continually a kindly Nouriſhment from the ſame Juices, gradually ſtretches and enlarges its Dimenſions, becoming then quickly viſible with all the Parts peculiar to its Species, and is called a *Fœtus*.

In Plants, which are uncapable of removing from Place to Place as Animals can, it was requiſite a Repoſitory for their *Farinæ* ſhould be near at Hand, to prevent its being loſt: And accordingly we find, that every Flower producing a *Farina*, has likewiſe in itſelf a proper *Uterus* for the Reception of it: Where the *Ova* thereby impregnated, are expanded by the Juices of the Parent Plant to a certain Form and Bulk, and then becoming what we call ripe Seeds, they fall to the Earth, which is the natural Matrix for them.

According to the above Suppoſition, a ripe Seed falling to the Earth, is in the Condition of the Ovum of an Animal getting looſe from its Ovary, and falling into the Uterus: And, to go on with the Analogy, the Juices of the Earth ſwell and expand the Veſſels of the Seed, as the Juices of the Uterus do thoſe of the Ovum, till the ſeminal Leaves unfold, and perform the Office of a *Placenta* to the Infant included Plant, which mibibing ſuitable and ſufficient Moiſture, gradually

dually extends its Parts, fixes its own Root, shoots above the Ground, and may be said to be born.

As Discoveries made by the *Microscope*, of infinite Numbers of *Animalcules* in the *Semen Masculinum* of all living Creatures, and likewise of a Regularity and Constancy in the *Farina* of each Species of Vegetables, analogous to the said *Animalcules* in the Animal *Semen*, have been the principal Means of convincing us that all Things are produced by Parents of their own Kind, according to the eternal and unalterable Laws established at their first Creation; I hope this short Account of Generation, before my entering upon those Subjects, will not be judg'd improper.

CHAP. XVI.

Of the ANIMALCULES *in* SEMINE MASCULINO.

AT the Beginning of the Year 1678, Mr. NICHOLAS HARTSOEKER, of *Rotterdam*, declared in a Treatise of *Dioptrics*, by him then publish'd, that it was twenty Years since he first began to examine the *Semen Masculinum* of several living Creatures by the Help of *Microscopes:* that, as far

far as he knew, he was the first Person who had ever done so; that he had found in such *Semen* infinite Numbers of *Animalcules*, most exceedingly minute, almost in the Shape of Tadpoles or young Frogs; and that he had made this Discovery known to all the World in the 30th of the *Ephemerides Eruditorum*, printed at *Paris* in the same Year 1678.

Mr. LEEUWENHOEK, in the 113th of his Epistles, dated *January* 1678.) is very angry at this Claim; and asserts, that he himself first discovered the *Animalcules* in *Semine*, and sent an Account thereof to the *Royal Society* in *November* 1677, as he proves by the *Philosophical Transactions*, published in *December* 1677, and in *January* and *February* 1678: nay, he further affirms, that Letters had past between him and Mr. OLDENBURG on this Subject in 1674. This Dispute concerns us no farther than as it shews about what Time the Existence of these *Animalcules* was first discovered, which some of my curious Readers may perhaps be inquisitive to know.

The general Appearance or Figure of the *Animalcules* in the *Semen Masculinum* of different Kinds of living Creatures is very much the same: that is, the Bodies of them all seem of an oblong oval Form, with long tapering slender Tails issuing therefrom; and as by this Shape they somewhat resemble

ſemble *Tadpoles*, they have frequently been called by that Name; tho' the Tails of them, in proportion to their Bodies, are much longer than the Tails of *Tadpoles* are: and it is obſervable, that the *Animalcules* in the *Semen* of Fiſhes have Tails much longer and ſlenderer than the Tails of thoſe in other Animals, inſomuch that the Extremity of them is not to be diſcerned without the beſt Glaſſes and the utmoſt Attention: their Bodies are alſo much ſmaller.

The general Appearance of them as above deſcribed, is ſhewn Plate XII. Fig. I.

In the Spring Seaſon, at the Time that Frogs engender, upon opening the Teſticles of a Male, and applying ſome of the *ſeminal Matter* before the Microſcope, Multitudes of *Animalcules* appeared therein, about * one thouſandth Part of the Thickneſs of the Hair of a Man's Head, as nearly as could be computed: whence it follows, that a thouſand Millions of them would be but equal to a Globe whoſe Diameter is the Thickneſs of the Hair of a Man's Head. And there ſeemed to be ten thouſand of them at leaſt for each one of the Female *Ova*.

The Shape of them is given in the ſame Plate, Fig. II.

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* Leeuwen. *Arcan. Nat.* Tom. I. Par. I. p. 51.

Upon

Fig. I. p. 12

Fig

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The Shape of them is given in the ſame Plate, Fig. II.

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* Leeuwen. *Arcan. Nat.* Tom. I. Par. I. p. 51.

Upon

Fig. I. p. 154

Fig. II. p. 154

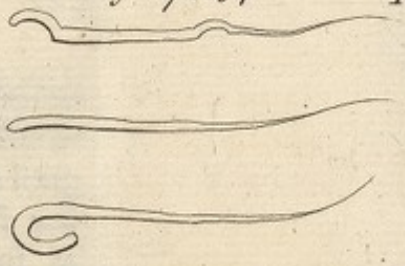
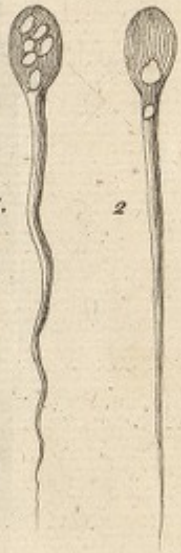


Plate XII.

Fig. III. p. 160

Fig. IV. p. 160

Fig. V. p. 161

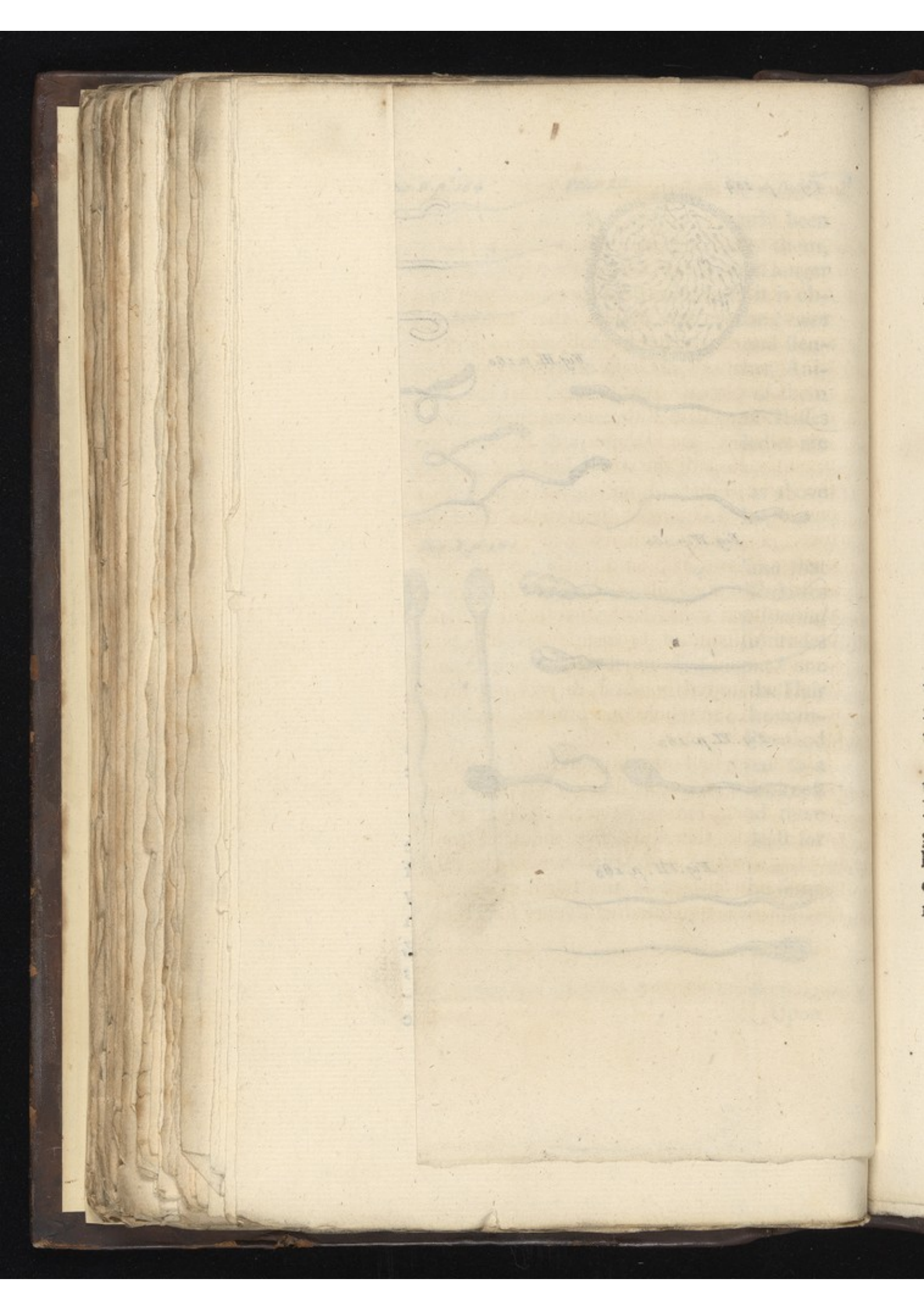


1.

2

Fig. VI. p. 162

Fig. VII. p. 163



Upon viewing the *Milt* or *Semen Maſculinum* of a living Cod-Fiſh with a *Microſcope*, ſuch Numbers of *Animalcules* with long Tails were found therein, that at leaſt ten thouſand of them were ſuppoſed to exiſt in the Quantity of a Grain of Sand. Whence Mr. LEEUWENHOEK argues, that the Milt of that ſingle Cod-Fiſh contained more living *Animalcules*, than there are People alive upon the Face of the whole Earth at one and the ſame Time: * for he computes, that one hundred Grains of Sand make the Diameter of an Inch; wherefore in a cubic Inch there will be a Million of ſuch Sands. And as he found the Milt of the Cod-Fiſh to be about fifteen cubic Inches, it muſt contain fifteen Millions of Quantities as big as a Grain of Sand. Now, if each of theſe Quantities contains ten thouſand *Animalcules*, there muſt be in the whole one hundred and fifty thouſand Millions.

Then, to find out, in a probable manner, the Number of People living upon the whole Earth at one Time; he reckons, that in a great Circle there are five thouſand four hundred *Dutch* ſquare Miles; whence he calculates the Surface of the Earth to contain nine Millions, two hundred ſeventy ſix Thou-

* *Arc. Nat.* Tom. I. Par. II. p. 9.

ſand, two hundred and eighteen ſuch ſquare Miles: and ſuppoſing one Third of the Whole, or three Millions, ninety two Thouſand and ſeventy two Miles to be dry Land; and of this, two Thirds, or two Millions, ſixty one Thouſand, three Hundred and eighty two Miles to be inhabited: and ſuppoſing farther, that *Holland* and *Weſt-Frieſland* are twenty-two Miles long and ſeven broad, which make one hundred and fifty four ſquare Miles; the habitable Part of the World is thirteen Thouſand three Hundred and Eighty-five times the Bigneſs of *Holland* and *Weſt-Frieſland*.

Now, if the People in theſe two Provinces be ſuppoſed a Million, and if all the other inhabited Parts of the World were as populous as theſe, (which is highly improbable) there would be thirteen thouſand three hundred and eighty-five Millions of People on the Face of the whole Earth: but the Milt of this Cod-Fiſh contained one hundred and fifty thouſand Millions of *Animalcules*, which is ten times more than the Number of all Mankind.

The Number of theſe *Animalcules* may be computed another Way: for the ingenious Author of *Spectacle de la Nature* ſays *, that

* Vid. *Spect. de la Nat.* Eng. 12mo Edit. Vol. I. p. 231.

three

three curious People counted, with all the Care they were able, as many of the *Eggs* or *Row* of a female Cod-Fiſh as weighed a Dram, and agreed pretty well in the Number, which they wrote down. They then weighed the whole Maſs, and ſetting down eight times the Sum of one Dram for every Ounce, which contains eight Drams: all the Sums together produced a Total of nine Millions three hundred and thirty four thouſand Eggs. *

Now ſuppoſing (as Mr. LEEUWENHOEK does of the *Semen Maſculinum* of Frogs) that there are ten thouſand *Animalcules* in the Milt for each One of the Female Ova in the Row, it will follow, that ſince the Female Row is found to have nine Millions three hundred thirty four thouſand Eggs, the whole Milt of the Male may be reckoned to contain ninety three thouſand four hundred and forty Millions of *Animalcules*: which, tho' greatly ſhort of the firſt Calculation, is almoſt ſeven times as many as the whole human Species.

To find the comparative Size of theſe Animalcules, Mr. LEEUWENHOEK placed a

* Four Millions and ninety ſix thouſand Eggs were computed in the Row of a *Crab*, each of which received its Nouriſhment by a Rope from the *Crab*'s Body. Vid. *Arc. Nat.* Tom. I. Par. II. p. 240.

* Hair of his Head near them, which Hair through his *Microſcope* appeared an Inch in Breadth; and he was ſatisfied that at leaſt ſixty ſuch *Animalcules* could eaſily lye within that Diameter; whence, their Bodies being ſpherical, it muſt follow, that two hundred and ſixteen thouſand of them are but equal to a Globe whoſe Diameter is no more than the Breadth of ſuch an Hair.

He obſerved, that when the Water wherewith he had diluted the *Semen* of a Cod-Fiſh was exhaled, the little Bodies of the *Animalcules* burſt in Pieces, which did not happen to thoſe in the *Semen* of a Ram: which he imputes to the greater Firmneſs and Conſiſtency of the latter, as the Fleſh of a Land-Animal is more compact than that of a Fiſh. He likewiſe takes Notice, that the Tails of thoſe in Fiſhes are ſo extreamly ſlender, that he could never be certain of his ſeeing the very Tips or Extremities of them.

In the Milt of a Jack, at leaſt † ten thouſand *Animalcules* were diſcernable, in a Quantity not bigger than a Grain of Sand, exactly, in Appearance, like thoſe of the Cod-Fiſh; and upon putting ‡ four times as much Water to it, they were perceived to become ſtronger and briſker, and to ſwim

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* *Phil. Tranſ.* Numb. 270. † *Arc. Nat.* Tom. I. Par. II. p. 2. ‡ *Phil. Tranſ.* Numb. 270.

as

as if in Purſuit of Prey, with greater Velocity; tho' being viewed in a Capillary Tube) their whole Courſe was no longer than the Diameter of a Hair.

If you would view the *Animalcules* in the Milt or ſoft Row of Fiſhes, ſqueeze out a little of it, and putting the Quantity of a Pin's Head upon a ſingle Iſinglaſs, dilute it with Rain or River Water, till the little Creatures have ſufficient Room to ſwim about freely, and ſhew themſelves to advantage; which they can by no means do unleſs it be made very thin. Or, after you have mixed ſome Water with it, apply it to the *Microſcope* in one of your ſmalleſt capillary Tubes; which Way Mr. LEEUWENHOEK informs us, he found the moſt uſeful for the Examination of the *Semen* of different Creatures. [N. B. * The *Eggs* in the Row, and *Animalcules* in the Milt of Fiſhes of one Year old, are as large as in thoſe of the ſame Species of twenty Years old.]

Upon opening the *Seminal Veſſels* of a Cock, ſqueezing out a ſmall Drop of the *Semen*, and viewing it with a *Microſcope*, Legions of *Animalcules* appeared therein, ſwimming in Crowds together, and croſſing one

* *Arc. Nat.* Tom. III. p. 188.

another with as much Briſkneſs and Vigour as if the Cock had been but newly dead, tho' it was killed the Day before: And by ſeveral Trials on the *Semen* of other Cocks it has been found, that the *Animalcules* therein will live many Hours in a capillary Glaſs Tube.—— To a ſlight Obſerver they ſeem in the Form of Eels; but if the greateſt Magnifiers be uſed with due Attention, they will be found ſhaped as Fig. III. Plate XII.---- Their Size is ſo extreamly minute, that a † Million of them are ſuppoſed not to exceed the Bigneſs of a Grain of Sand, and their Tails cannot be diſcerned without much Difficulty, being ten thouſand times more ſlender than the Hair of a Man's Hand.

A little of the *Seminal Matter* taken from the Teſticle of a Dog, abounded with *Animalcules*, ‡ a Million whereof would hardly equal a large Grain of Sand: and after ſome of this Matter had been kept ſeven Days in a Glaſs Tube, ſeveral of the *Animalcules* remained alive and vigorous. [Their Form is ſhewn Fig. IV.]——The *Teſticles* of a Hare, tho' four Days dead, were alſo exceedingly full of *Animalcules* like thoſe in Dogs, ſwimming in a clear Liquor, but without Motion.

† *Arc. Nat.* Tom. II. Par. II. p. 369.
‡ *Arc. Nat.* Tom. I. Par. II. p. 160.

Killing a Female Rabbet immediately after the Coitus, and opening the Uterus thereof, innumerable *Animalcules* were found in a ſmall Drop, taken from the Mouth of the *Fallopian Tube* where it opens into the Matrix: but none were diſcerned in the Uterus itſelf, or farther along the Tube. They had long Tails, and for the moſt Part * ſix tranſparent Globules appeared on the Body of each, as in Fig. V. 1: tho' ſome had only one Globule at the End of the Body, and another in the Tail, as Fig. V. 2.

Examining a Drop of *Semen* taken from the Teſticles of a Ram, it abounded with *Animalcules* in as great Numbers as the ſeminal Matter of other Creatures; but with this extraordinary † Singularity, that Multitudes of them ſwam the ſame Way together, and

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* *Arc. Nat.* Tom. I. Par. II. p. 160.

† Mr. LEEUWENHOEK open'd the Uterus of an Ewe, which about ſeventeen Days before had been coupled with a Ram, and in one of the Cornea obſerved a little *reddiſh fleſhy Subſtance* wherein no Shape could be diſtinguiſhed. He put this in a Glaſs Tube the Thickneſs of a Quill, fill'd with *Oyl of Turpentine*, and apply'd it to his *Microſcope*, but could make nothing of it in that Manner. Wherefore he took it from the Tube, and extending it very gently out of the round Figure in which it lay, he perceived extreamly plain the Formation of all the Vertebræ, with the Blood-Veſſels and Ramifications paſſing over them, and in two Places could ſee the Spinal Marrow. He could alſo diſtinguiſh not only the Head, but alſo the Mouth, Brain, and Eyes the Bigneſs of two Grains of Sand, and clear as Cryſtal: He ſaw likewiſe

and ſeemed to have the Inclination of Sheep, to follow their Leader and move in Flocks. Mr. LEEUWENHOEK ſays, he found ſo much Pleaſure in obſerving this, that he called in ſome Neighbours to ſhare it with him.

Their Form was that of Fig. VI.

A Buck being killed in Rutting-time, the ‡*Vaſa Deferentia* were found turgid with a milky Fluid, a Drop whereof, when applied to the *Microſcope*, appeared full of *Animalcules* moving very briſkly. The greateſt Difficulty was to lay them properly before the *Microſcope:* for when the Matter is too thick, nothing can be ſeen but a confuſed Motion, and when ſpread thin it dries away immediately; but by diluting it with warm Water, juſt enough to change its Colour, they were ſeen diſtinctly.

The human *Semen* has likewiſe been viewed by the *Microſcope*, and found no leſs

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the Ribs and Inteſtines: though the whole Creature was no larger than the eighth Part of a Pea.---After this he open'd the Uterus of another Ewe, but three Days from the Coitus; and ſearching the Liquor coming from it very diligently with a Magnifying Glaſs, obſerved a *little Particle* the Size of a Grain of Sand; which, examining with an excellent *Microſcope*, he with great Pleaſure found to be an exceedingly minute Lamb lying round in its Integuments, and could plainly diſcern its Mouth and Eyes. Vid. *Arc. Nat.* Tom. I. Par. II. pag. 165, & 173.

‡ Vid. *Phil. Tranſ.* Numb. 28[1].

plentifully

plentifully ſtocked with Life than that of other Animals: for more than ten thouſand living Creatures were ſeen, by Mr. LEEUWENHOEK, moving in no larger a Quantity of the fluid Part thereof than the Bigneſs of a Grain of Sand; and in the thicker Part they were ſo throng'd together, that they could not move for one another. Their Size was ſmaller than the red Globules of the Blood, and even leſs than the millionth Part of a Grain of † Sand. The Bodies of them are roundiſh, ſomewhat flat before, but ending ſharp behind, with Tails exceedingly tranſparent, five or ſix times longer, and about five times more ſlender than their Bodies. They move themſelves along by the violent Agitation of their Tails, in various Bendings, after the Manner that Eels or Serpents ſwim; and, ſometimes, their Tails are moved thus eight or ten times in getting forwards the Diameter of a Hair.

Their Shape and Form is ſhewn Fig. VII.

It is wonderful to conſider the Minuteneſs of theſe little Animals, and particularly the amazing Slenderneſs of their Tails: which muſt, notwithſtanding, be furniſh'd with as many Joints as the Tails of larger Creatures, ſince they are able to move them with great

† *Arcan. Nat.* Tom. II. Part II. p. 61, 69, 286.

Agility:

Agility: and, beſides, every one of theſe Joints muſt be provided with its proper Muſcles, Nerves, Arteries and Veins; and alſo with Fluids circulating thro' them, and ſupplying them with Nouriſhment, Strength, and Motion. In ſhort, the Mind loſes itſelf in contemplating a Minuteneſs beyond all human Conception; tho' Reaſon tells us, it certainly muſt be. I remember Dr. POWER has a fine Paſſage to this Purpoſe in the Preface to his Experiments. "It has often "ſeem'd to me (ſays he) an ordinary Pro- "bability, and ſomething more than Fancy "(how paradoxical ſoever the Conjecture "may ſeem) to think, that the leaſt Bodies "we are able to ſee with our naked Eyes, "are but *middle Proportionals*, as it were, "betwixt the *Greateſt* and the *Smalleſt* Bo- "dies in Nature; which two Extremes lye "equally beyond the Reach of human Sen- "ſation.----For, as one ſide they are but "narrow Souls, and not worthy the Name "of *Philoſophers*, that think any Body can "be *too great*, or *too vaſt* in its Dimenſi- "ons: ſo likewiſe are they as inapprehen- "ſive, and of the ſame Litter with the "former, that, on the other ſide, think the "Particles of Matter may be *too little*, or "that Nature is ſtinted at an Atom, and "muſt have a *Non ultra* of her Subdiviſi- "ons."

As

As the *Animalcules* in the *Semen Maſculinum* of different Creatures are not much unlike in Shape, it is alſo obſervable, that they do not differ in * Bigneſs according to the Sizes of the Creatures they are taken from; but ſeem, in this Reſpect, analogous to the *Seeds* of Trees and Plants, whoſe Size bears very little Proportion to the Bigneſs of the Trees and Plants producing them. The Seed of an Apple, for Inſtance, is ſome thouſands of times ſmaller than a Cocoa-Nut, tho' the Trees they grow on have not that Diſproportion: And the Seeds of Tobacco (whereof a thouſand † weigh not above a ſingle Grain) are leſs beyond Compariſon than many kinds of other Seeds whoſe Plants are not near ſo large as Tobacco is. Hence it comes to paſs, that *Animalcules* may be diſcovered in the *Semen* of the ſmalleſt Birds, Quadrupeds and Fiſhes, nay, and even in Inſects too. For Mr. LEEUWENHOEK aſſures us, he found a *white Matter* he had ſometimes ſqueezed from the hinder Parts of male ‡ Spiders, about the bigneſs of a Grain of Sand, to be indeed their *Semen*, by diſcovering therein prodigious Multitudes of *Animalcules*, which continued living above five Hours, but were ſo extremely minute, that he ſuppoſes a thouſand Millions of them

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* *Arc. Nat.* Tom. IV. pag. 30. † Dr. POWER's Experim. pag. 30. ‡ *Philoſoph. Tranſact.* Numb. 279.

would

would not equal the Size of a Grain of Millet. He found them likewiſe in the *Semen* of the [a] Dormouſe, in [b] Oyſters, in [c] Silkworms, in the [d] *Labella minima* or ſmall Dragon-Fly, the common [e] Fly, in the male [f] Flea, in [g] Gnats, and in ſeveral other Inſects: and, without doubt, a curious Enquirer will be able to diſcover them in abundance of Subjects yet unexamined; for Nature is uniform in all her Works, and there is good Reaſon to believe that they certainly exiſt in all the animal Part of the Creation.

Amongſt the many Species of *Animalcules* obſerved in Waters and Infuſions, there are [h] none found reſembling thoſe in *Semine:* but the Animalcules in the *Semen* of all Sorts of Creatures hitherto examined have a common and general Likeneſs to one another; with this Particularity, that they appear in continual Motion, without the leaſt Reſt or Intermiſſion, provided the Fluid be ſufficient for them to ſwim about in.

Many People have imagined, that *living Creatures* might alſo be found in the other *animal Juices:* but after the ſtricteſt and moſt careful Examination, it appears certain,

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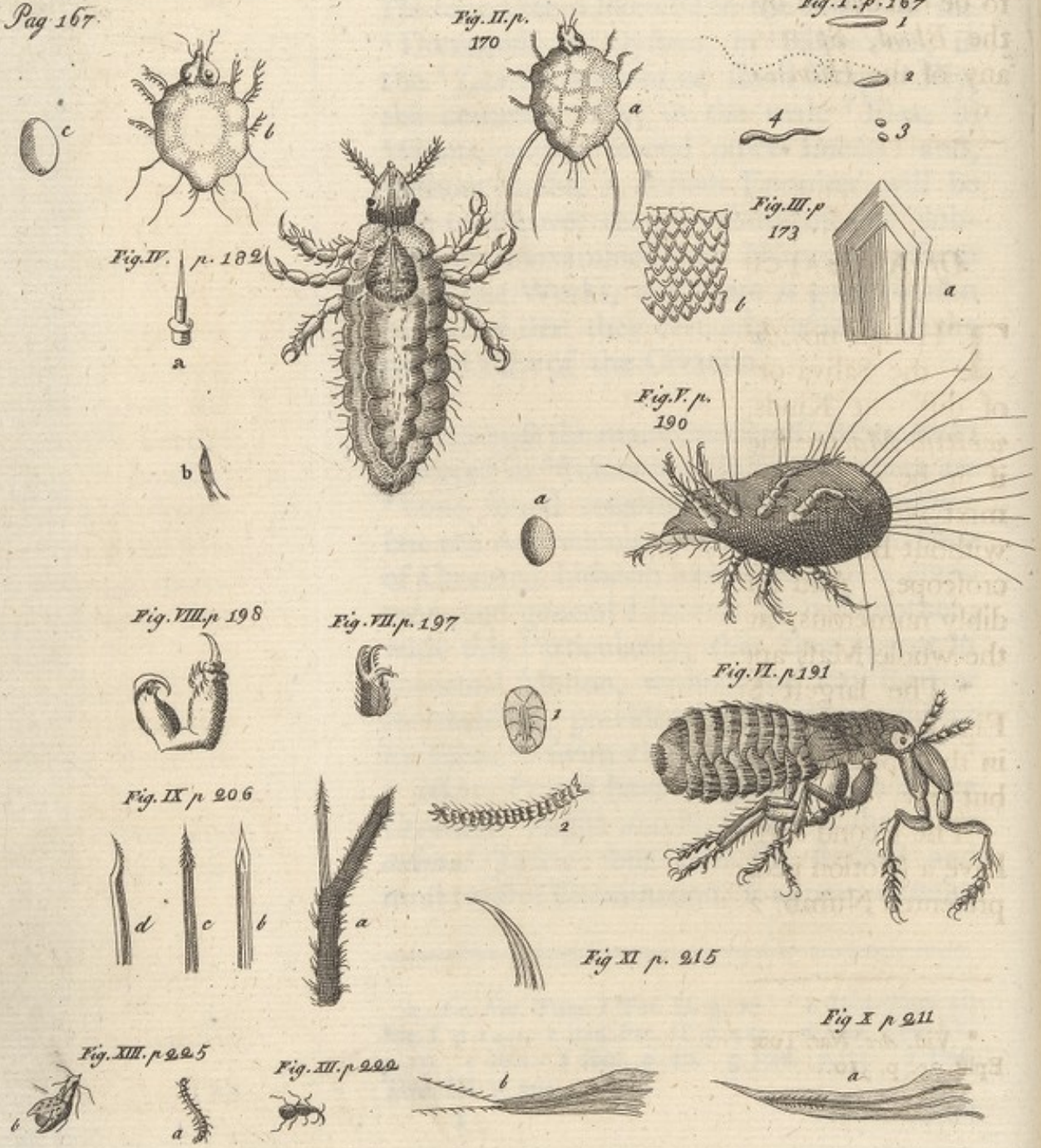
a *Arc. Nat.* Tom. I. Par. II. p. 27. b Ibid. Tom. II. Par. I. p. 144. c Ibid. Par. II. p. 422. d Ibid. Tom. IV. p. 19. e Ibid. f Ibid. p. 20. g Ibid. p. 22. h Ibid. Tom. III. p. 294.

Plate XIII

Pag 167



that nothing with the leaſt Token of Life is to be diſcovered by the beſt Glaſſes, either in the *Blood*, *Spittle*, *Urine*, *Gall*, *Chyle*, or any of the *Humours*, except the *Semen* only.

CHAP. XVII.

Of ANIMALCULES *in the* TEETH.

THough no *Animalcules* can be found in the Saliva or Spittle, great Numbers, of different Kinds, may diſcovered in the *whitiſh Matter* ſticking between the Teeth: if it be picked out with a Pin or Needle, mixt with a little Rain Water and Spittle without Bubbles, and applied before the Microſcope. And ſometimes they are ſo incredibly numerous, and ſo full of Motion, that the whole Maſs appears alive.

* The largeſt Sort (ſhewn Plate XIII. Fig I. Numb. 1.) move along very ſwiftly in the Spittle or Water; of theſe there are but few.

The ſecond Sort are more numerous, and have a Motion peculiar to themſelves, as repreſented Numb. 2.

* Vid. *Arc. Nat.* Tom. IV. p. 40. Again, Tom. IV. Epiſt. 75. p. 310.

The

The third Sort are roundiſh, and ſo minute, that a Grain of coarſe Sand would equal a Million of them in Bigneſs: they move ſo ſwiftly, and in ſuch Multitudes, that they ſeem like Swarms of Gnats or Flies, and the exact Shape of them is not eaſy to be diſtinguiſhed.

Some or all of theſe three Kinds may be found, pretty conſtantly, in the *Matter* taken from between the Teeth of Men, Women, or Children; eſpecially from between the Grinders, even though they waſh their Teeth continually, and clean them with the utmoſt Care: but from the Teeth of People that are more careleſs, the ſaid Matter affords another Sort of Animalcules, in the Shape of Eels or Worms, as pictured Numb. 4. Theſe move themſelves backwards, or forwards, with great Bendings of the Body; and force their Way through the minuter *Animalcules* every where around them, with the ſame Eaſe as a large Butterfly would break through a ſwarm of Gnats. There are likewiſe, in this Matter from the Teeth, other Sorts of *Animalcules*, whoſe Motions are ſo extreamly languid, that without long Attention they cannot be diſtinguiſhed to be alive.

Obſervation. They all dye if Vinegar be applied to them; whence it ſeems reaſonable to conclude, that waſhing the Teeth and Gums with Vinegar may be a Means of preſerving them from theſe minute Creatures.

CHAP.

CHAP. XVIII.

Of the ITCH.

THE *Microſcope* has diſcovered, what without it could ſcarce have been imagined, that the Diſtemper we call the *Itch*, is owing to little Inſects under the *Cuticula*, whoſe continual Bitings cauſe an ouzing of Serum from the *Cutis*, and produce thoſe Puſtules or watry Bladders whereby this Diſeaſe is known. This was found out by Doctor BONONIO, * who obſerving that itchy People frequently pull out of their ſcabby Skin little Bladders of Water, with the Point of a Pin, and crack them on their Nails like Fleas, he determined to examine what theſe Bladders might really be. Wherefore picking out with a fine Needle a little Puſtule from a Place ſcabbed over, and where there was a ſevere Itching, he ſqueezed a thin Matter from it, and perceived a very ſmall white Globule ſcarcely diſcernable, which, applying to the Microſcope, he found to be a very *minute Animal*, in Shape reſembling a Tortoiſe, of a whitiſh Colour, but darker on the Back than elſewhere, with ſome long and thick Hairs, iſſuing from it, very nimble in its Motion, having ſix Legs, a ſharp Head,

* *Philoſ. Tranſact.* Numb. 283.

and

and two little Horns; being in Shape as repreſented by the two Pictures. Fig. II. a. b. Plate XIII.

This Experiment was repeated on itchy Perſons of all Ages, Sexes and Complexions, and at all Seaſons of the Year, and he conſtantly found the ſame *Animalcules* in moſt of the watry Puſtules: and though by reaſon of their Minuteneſs and Colour, (which is the ſame as the Skin) it is difficult to diſcern theſe Creatures on the Surface of the Body, yet he ſometimes ſaw them upon the Joints of the Fingers in the little Furrows of the *Cuticula*, where they firſt begin to enter with their ſharp Heads, gnawing and working in their Bodies, till they are got quite under the *Cuticula*, where they burrow from Place to Place, cauſe a troubleſome and grievous Itching, and force the infected Perſon to ſcratch, which only ſerves to increaſe the Malady; for, by breaking the little Puſtules and ſome ſmall Blood-Veſſels, Scabs, cruſty Sores, and ſuch like foul Symptoms enſue: whilſt theſe miſchievous *Animalcules* eſcape the Nails by their Minuteneſs, and diſperſe themſelves the farther.

Frequently obſerving theſe *Animalcules*, he perceived one of them drop a little oblong white Egg, almoſt tranſparent, from the hinder Part of its Body: and afterwards he ſaw many of the ſame Sort of Eggs; which proves them generated like other Creatures from

from a Male and Female, though he was never able to distinguish the Sex of any he examined.

The Figure of the Egg is shewn c.

We may hence account how this Distemper comes to be so very catching, since these *Animalcules* by simple Contact can easily pass from one Person to another, having not only a swift Motion, but clinging to every thing they touch, and crawling as well upon the Surface of the Body as under the outward Skin: and a few being once lodged, they multiply apace by the Eggs they lay. The Infection may also be propagated in a like manner by Sheets, Towels, Handkerchiefs, or Gloves, used by itchy People; since these *Animalcules* may easily be harboured in such things, and will live out of the Body two or three Days.

The Discovery of these *Animalcules* shews the Reason likewise why this Distemper is never to be cured by internal Medicines: but requires lixivial Washes, Baths, or Ointments, made up with *Salts*, *Sulphurs*, *Vitriols*, *Mercury*, *Precipitate*, *Sublimate*, or such kinds of penetrating and corroding Remedies as can powerfully kill these Vermin in the Skin. And if, sometimes, we find the Disease returns upon us in a little while after we supposed it quite cured by Unction, it is no great Wonder; since, tho' the Oint-

ment may deſtroy all the living *Animalcules*, it may not probably kill their Young Ones in the Eggs laid in Neſts in the Skin; which, coming to hatch, may renew the Diſtemper. For this Reaſon, it is adviſable to continue the Anointing for ſome Days, even after the Cure ſeems perfected.

CHAP. XIX.

Of SCALES *on the* Human Skin.

THE *Cuticula*, *Scarf-Skin*, or *outward Covering* of the Body, is remarkable for its *Scales* and for its *Pores*.

Its Scales are a Diſcovery of the *Microſcope*; for being ſo minute that * two hundred of them may be covered with a Grain of Sand, they could never be diſcerned by the naked Eye. They are placed as on Fiſhes, † three deep; *i. e.* each Scale is ſo far covered by two others, that only a third Part thereof appears: which lying over one another, may be the Cauſe why the Skin of the Body appears ‡ white; for about the Mouth and Lips, where they only juſt meet together, and do not fold over, the Blood-

* Vid. *Arc. Nat.* Tom. I. Par. II. p. 208. Again, Tom. IV. p. 46. † Ibid. p. 47. ‡ Ibid. p. 51.

Veſſels

Veſſels are ſeen through, and the Parts look red. The perſpirable Matter is ſuppoſed to iſſue between theſe Scales (which lye over the Pores or excretory Veſſels through which the watry and oily Humours perſpire) and may find Vent in an hundred Places round the Edges of each Scale *: ſo that if a Grain of Sand can cover two hundred Scales, it will be able to cover twenty thouſand Places where Perſpiration may iſſue forth.

A Piece of Skin taken from between the Fingers, from the Forehead, Neck, Arms, or any other ſoft Part of the Body, which is not hairy, ſerves beſt to ſhew the Scales; for where the Skin is callous, they are glewed as it were together.

They are generally of five Sides, as in the Picture, Fig. III. *a*.

Their Diſpoſition on the Skin is ſhewn Fig. III. *b*.

If they are ſcraped off with a Pen-knife, put into a Drop of Water, and ſo applied to the Microſcope, they will be ſeen to good Advantage.

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* *Arcan. Nat.* Tom. IV. p. 48.

CHAP. XX.

The PORES *of the* Skin.

EVERY Part of the human Skin is full of *excretory Ducts* or *Pores*, which emit ſuperfluous Humours, continually, from the Maſs of the circulating Fluid.

In order to view the *Pores*, cut a Slice of the upper Skin with a ſharp Razor as thin as poſſible: then immediately cut a ſecond Slice from the ſame Place, which apply to the Microſcope, and in a Piece not larger than a ‡ Grain of Sand can cover, innumerable *Pores* will be perceived, as plainly as little Holes pricked by a fine Needle may be diſcerned if it be held up againſt the Sun. The Scales of the outer Skin prevent any diſtinct View of the *Pores*, unleſs they are ſcraped away with a Penknife, or cut off in the above Manner; but if a Piece of the Skin between the Fingers, or in the Palms of the Hands, be ſo prepared, and then examined, the Light will be ſeen very pleaſantly through the *Pores*.

Mr. LEEUWENHOEK endeavours to give ſome ſlight Notion of the incredible Num-

‡ *Arcan. Nat.* Tom. III. p. 409. 412.

ber of *Pores* in a human Body. He † supposes there are one hundred and twenty such *Pores* in a Line one tenth of an Inch long; however, to keep within Compass, he reckons only one hundred. An Inch in length will then contain a thousand in a Row, and a Foot twelve thousand. According to this Computation, a Foot square must have in it an hundred and forty four Millions: and supposing the Superficies of a middle-sized Man to be fourteen Feet square, there will be in his Skin two thousand and sixteen Millions of *Pores*.

To acquire some clearer Idea still of this prodigious Number of *Pores* by our Conception of Time, let us reckon with * MERSENNUS, that each Hour consists of sixty Minutes, and each Minute of sixty Seconds, or sixty Pulsations of an Artery: in one Hour there will then be three thousand and six hundred Pulses; in twenty-four Hours eighty-six thousand and four hundred; and in a Year thirty-one Millions five hundred and thirty-six thousand. But there are about sixty-four times as many *Pores* in the Surface of a Man's Skin, and therefore he must live sixty-four Years, e'er he will have had a Pulsation for every *Pore* in his Skin.

† *Arcan. Nat.* Tom. III. p. 413.
* Ibid. p. 413.

Dr. NATHANIEL GREW obſerves, that the * *Pores* through which we perſpire are more particularly remarkable in the Hands and Feet; for if the Hand be well waſhed with Soap, and examined with but an indifferent Glaſs, in the Palm, or upon the Ends and firſt Joints of the Thumb and Fingers, innumerable little Ridges parallel to each other, of equal Bigneſs and Diſtance will be found. Upon which Ridges the *Pores* may be perceived by a very good Eye, lying in Rows, even without a Glaſs: but, viewed through a good Glaſs, every *Pore* ſeems like a little Fountain, with the Sweat ſtanding therein as clear as Rock-Water; and, if wiped away, it will be found immediately to ſpring up again.

When we conſider the Multitude of Orifices all over the Skin, it is reaſonable to imagine, that minute Animals, as Fleas, Lice, Gnats, *&c.* do not with their ſlender Inſtruments make new Perforations, but rather thruſt or inſinuate them into the Veſſels of the Skin, and ſuck out the Blood or what other Humour is their proper Aliment.

† *Philoſoph. Tranſactions*, Numb. 159.

CHAP.

CHAP. XXI.

Of the LOUSE.

THE *Louſe* has ſo tranſparent a Shell or Skin, that we are able to diſcover more of what paſſes within its Body, than in moſt other living Creatures; which renders it a delightful Object for the Microſcope.

It has naturally three † Diviſions, *viz.* The Head, the Breaſt, and the Belly or Tail-part.—In the Head appear two fine black Eyes, with a Horn that has five Joints, and is ſurrounded with Hairs, ſtanding before each Eye; from the End of the Noſe or Snout there is a pointed projecting Part, ſerving for a Sheath or Caſe to a Sucker, or Piercer, which the Creature thruſts into the Skin, to draw out the Blood or Humours it feeds on, as it has no Mouth that opens. This Piercer or Sucker is judged to be * ſeven hundred times ſlenderer than a Hair; is contained in another Caſe within the firſt, and can be thruſt out or drawn in at Pleaſure.

The Breaſt is marked very prettily in the Middle, the Skin thereof tranſparent, and

† *Vid.* SWAMMERDAM Hiſt. Gener. des Inſectes. p. 174.
* Vid. *Arc. Nat.* Tom. II. p. 74.

full of little Pits. From the under Part of it proceed ſix Legs, each having five Joints, their Skin reſembling Shagreen, except towards the Ends, where it appears ſmoother. Each Leg terminates in two hooked Claws of unequal Length and Size, which it uſes as we would a Thumb and middle Finger. There are † Hairs between theſe Claws, as well as over all the Legs.

On the Back of the Tail-part we may diſcern ſome * Ring-like Diviſions, abundance of Hairs, and a ſort of Marks that look like the Strokes of a Rod on one that has been whipt. The Skin of the Belly ſeems like Shagreen, and towards the lower End is clear and full of little Pits; at the Extremity of the Tail are two little ſemicircular Parts, covered all over with Hairs, which ſerve to conceal the Anus.

When the *Louſe* moves its Legs, the Motion of the Muſcles (which all unite in an oblong dark Spot in the Middle of its Breaſt) may be diſtinguiſhed perfectly: and ſo may the Motion of the Muſcles in the Head be, when it moves its Horns. The Motion of the Muſcles is alſo viſible in the ſeveral Articulations of the Legs. We may likewiſe ſee the various Ramifications of the

† *Vide* SWAMMERD. p. 175.
* Vide *Philoſoph. Tranſ.* Numb. 102.

Veins

Veins and Arteries (which are white) with the Pulſe regularly beating in the Arteries. But the moſt ſurpriſing of all is the periſtaltic Motion of the Inteſtines, continued from the Stomach along all the Guts down to the Anus.

If a *Louſe*, when very hungry, be placed on the Back of the Hand, it will thruſt its Sucker into the Skin, and the Blood may be ſeen paſſing in a fine Stream to the Fore-Part of the Head; where, falling into a roundiſh Cavity, it paſſes again, in a like Stream, to another circular Receptacle in the Middle of the Head; from thence through a ſmaller Veſſel to the Breaſt; and then to a Gut that reaches to the hinder Part of the Body, where in a Curve it turns a little upwards.——In the Breaſt and Gut the Blood is without Intermiſſion moved with great Force, eſpecially in the Gut, and that with ſuch a ſtrong Propulſion downwards and ſuch a Contraction of the Gut as is amazing: which continual and ſtrong Action of the Stomach and Bowels upon the Food of this Creature, to further its Digeſtion, is worthy to be conſidered.——In the upper Part of the crooked aſcending Gut juſt mentioned, the propelled Blood ſtands ſtill, and ſeems to undergo a Separation: ſome of it becoming clear and wateriſh, while certain

little

little black Particles pass downwards to the Anus †.

If a *Louse* be placed on its Back *, two bloody darkish Spots appear; the larger in the Middle of the Body, and the lesser towards the Tail. In the larger Spot a white Film or Bladder contracts and dilates upwards and downwards from the Head towards the Tail; the Pulse of which is followed by a Pulse of the dark bloody Spot, in or over which the white Bladder seems to lye. This Motion of Systole and Diastole, is seen best when the *Louse* grows weak. The white pulsing Bladder seems to be the Heart, for on pricking it the *Louse* instantly dies. In a large *Louse* the Pulsation may be seen in the Back, but the white Film not without turning the Belly upwards. The lower darkish Spot Dr. HARVEY conjectur'd to be the Excrements in the Guts.

Lice are not *Hermaphrodites*, as has erroneously been imagined, but Male and Female. Mr. LEEUWENHOEK discovered that the Males have ‡ Stings in their Tails, but the Females none: and supposes the smarting Pain they sometimes give arises from their Stinging, when made uneasy by Pres-

† Vid. *Philosoph. Transact.* Numb. 102.
* *Vid.* Dr. POWER's Observ. 9.
‡ *Arc. Nat.* Tom. II. p. 77.

sure

ſure or otherwiſe; ſince, if roughly handled, they may be ſeen to thruſt out their Stings; and as he felt little Pain or Uneaſineſs from the Sucker or Piercer, tho' ſeven or eight were feeding on his Hand at once. The Females lay Eggs or Nitts, whence *young Lice* come forth, perfect in all their Members, and undergo no farther Change but an Increaſe of Size.

Mr. LEEUWENHOEK being deſirous to learn the Proportion and Time of their Increaſe, put two * Females into a black Stocking, which he wore both Night and Day; and found that in ſix Days one of them had laid fifty Eggs, and upon diſſecting it ſaw as many more in the Ovary; whence he concludes, that in twelve Days it would have laid an hundred Eggs. Theſe Eggs hatching in ſix Days (which he found to be their natural Time) would probably produce fifty Males and as many Females: and theſe Females coming to full Growth in eighteen Days, might each of them be ſuppoſed, after twelve Days more, to lay alſo an hundred Eggs; which Eggs in ſix Days farther (the Time required to hatch them) might produce a young Brood of five thouſand †. So that, in eight Weeks, a *Louſe* may ſee five thouſand of its own Deſcendants; an

* Ibid. pag. 78.
† *Arc. Nat.* Tom. I. pag. 78.

Increaſe hardly credible, were it not proved by Experience.

A *Louſe* may be diſſected eaſily in a ſmall Drop of Water, upon a Slip of Glaſs that can be applied to the *Microſcope*; but without Water the Parts are very difficult to divide, and when ſeparated ſhrivel and dry up immediately. Thus, five or ſix Eggs of a full Size and ready to be laid may be found in the Ovary of a Female, with ſixty or ſeventy of different Sizes, but all much more minute, as the Eggs are in the Ovary of a Hen. In the Male the Penis is remarkable, and alſo the Teſtes, whereof it has a double Pair; the Sting likewiſe deſerves a curious Examination. Theſe Creatures avoid the Light as much as poſſible, and are impatient of Cold. The Females, if faſting, appear very white, and even after feeding ſeem leſs red than the Males, the Blood not appearing ſo plainly through their Veſſels, from the Multitude of their Eggs.

The Picture of the *common Louſe* is given Plate XIII. Fig. IV.

Its Piercer or Sucker is ſhewn by *a*.

The Sting of the Male by *b*.

There's another Kind of *Louſe*, found about uncleanly People, which from its Shape is called the *Crab-Louſe*. The Vermin adhering to and feeding on the Bodies of different Animals, though much unlike

like in Form and Size, are also commonly called *Lice*. Of these there are numberless Species, several whereof we are obliged to *Seignior* REDI for giving us the Drawings of, at the End of his Treatise *de Generatione Insectorum*, whence Mr. ALBIN has taken them into his *Book of Spiders*: but few of these have been sufficiently examined by the *Microscope*, and there are great Varieties of other Kinds that are yet quite unknown.

Even Insects are infested with Vermin that feed on them and torment them. A Sort of Beetle known by the Name of the *Lousy Beetle*, is remarkable for Numbers of little Creatures that run about it nimbly from Place to Place, but will not be shaken off. Some other Beetles have Lice also, but of different Kinds.

The *Earwig* is troubled frequently with minute Insects, especially just under the setting on its Head. They are white and shining like Mites, but much smaller: they are round-backed, flat-bellied, and have long Legs, particularly the two foremost. The same has not been observed on any other Animal.

Snails of all Kinds, but chiefly the large ones without Shells, have many little Insects, extreamly nimble, that live and feed upon them.

Numbers of little *red Lice*, with a very small Head, and in Shape resembling a Tortoise,

toiſe, are often to be ſeen about the Legs of Spiders. Whilſt the Spider lives they cling cloſely to it, but if it dies they leave it.

Whitiſh Lice are frequently to be diſcovered running very nimbly on Humble-Bees: I have ſeen them frequently on Ants: many Kinds are diſcoverable on Fiſhes; KIRCHER ſays, he has found Lice on Fleas; and, probably, very few Creatures are free from them.

As ſome may be deſirous to know what Kinds of *Lice* * SEIGNIOR REDI has obſerved and given *Drawings* of, the following Liſt is inſerted to ſatisfy their Curioſity. Lice found on the Hawk *three Sorts:* on the large Pigeon, the Turtle-Dove, the Hen, the Starling, the Crane. On the Moor-Hen *three Sorts.* On the Magpye, the Heron, the leſſer Heron, the Swan, the Turkiſh Duck, the Sea-Mew, the ſmaller Swan: on the wild Gooſe *two Sorts:* on the Teal, the Kaſtrel, the Peacock, the white Peacock, the Capon, the Crow, the white Starling: on Sweet-meats and Drugs: on Men, *two Sorts, viz.* the *common Louſe* and the *Crab-Louſe:* on the Goat, the Camel, the † Aſs, the African Ram, the African Hen; on the Stag *two Sorts,* and on the ‡ Tiger.

CHAP.

* REDI calls the Vermin on Beaſts *Pediculi* or *Lice,* thoſe on Birds *Pulices* or *Fleas.* He ſays every Kind of Bird has its particular Sort of *Fleas,* different from thoſe of other Birds: That all when firſt hatched are white, but gradually acquire a Colour like the Feathers they live among: yet remain tranſparent

CHAP. XXII.

Of the WOOD-LOUSE.

THERE's a little Animal, in Shape and Colour like a Louſe, that runs ſwiftly by Starts or Stops, and is commonly found on the Leaves and Covers of Books, or amongſt rotten Wood: 'tis called a *Wood-Louſe*, or *Wood-Mite*, and is known almoſt to every Body. The Eyes of this Creature are of a golden Colour, and can be drawn in or thruſt out at Pleaſure; the periſtaltic Motion of the Bowels appears in it diſtinctly, and what is ſtill more wonderful, a Motion of the Brain is ſeen.

I take this to be the Animal Mr. DERHAM calls the *Pediculus pulſatorius* or *Death-Watch*, (in *Phil. Tranſact.* Numb. 291.) where he ſays, the *Pediculus Pulſatorius*, and the *Scarabæus ſonicephalus* are the only two Inſects that make regular clicking Noiſes like the Beat of a Pocket Watch.

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tranſparent enough for a good *Microſcope* to diſcover the Motions of their Inteſtines: That the *Crane* has a white Sort, marked as it were with *Arabic* Characters: and that their Size is not proportioned to the Birds they breed upon, for the little *Black-bird* has *Fleas* as large as the *Swan*.

† ARISTOTLE in his *Hiſtory of Animals*, and PLINY, on his Authority, aſſerts, that *Aſſes* and *Sheep* are free from Vermin: but REDI proves they are both miſtaken as to the *Aſs*; and as to *Sheep* every Shepherd Boy is able to confute them.

‡ The *Louſe* of the *Lion* reſembles that of the *Tiger* in Shape, but is larger, and of a brighter red. Vid. REDI *Experim. circa Gener. Inſect.* pag. 312. & ſeq.

CHAP.

CHAP. XXIII.

Of MITES.

BY *Mites* are commonly underſtood the minute Creatures found in great Abundance on Cheeſe that is decaying. To the naked Eye they appear like moving Particles of Duſt; but the *Microſcope* diſcovers them to be Animals, perfect in all their Members, having as regular a Figure, and performing all the neceſſary Offices of Life, in as orderly a Manner, as Creatures that exceed them many Millions of times in Bulk.

They are cruſtaceous * Animals, and uſually tranſparent. The principal Parts of them are, the Head, the Neck, and Body. The Head is ſmall in Proportion to the Body, with a ſharp Snout, and a Mouth that opens and ſhuts like a Mole's. They have two little Eyes, and are extreamly quick-ſighted; for if you touch them once with a Pin or other Inſtrument, you'll perceive how readily they avoid a ſecond Touch. Some have ſix Legs, and others eight; which proves them of different Sorts, tho' in every Reſpect beſides they appear alike. Each Leg has ſix Joints, ſurrounded with Hairs, and two little

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* Vid. POWER's Obſerv. HOOK's Microgr. p. 214.

Claws

Claws at the Extremity thereof, which can eaſily take up any Thing. The hinder Part of the Body is plump and bulky, and ends in an oval Form, with a few exceeding long Hairs iſſuing therefrom. Other Parts of the Body and Head are alſo thinly beſet with long Hairs.

Theſe Creatures are Male and Female. The Female lays Eggs; whence (as in Lice and Spiders) the young ones iſſue forth with all their Members perfect, though moſt exceedingly minute: but, notwithſtanding their Shape does not alter, they caſt their Skins ſeveral times before they attain their full Growth.

They may be kept alive many Months between two concave Glaſſes, and applied to the Microſcope at Pleaſure, and by often looking at them many curious Particulars will be diſcovered. They may thus frequently be ſeen † *in coitu*, conjoined Tail to Tail; for though the Penis of the Male be in the Middle of the Belly, it turns backwards like that of the *Rhinoceros*. The Coitus is perform'd with an incredibly ſwift Motion. Their Eggs, in warm Weather, hatch in twelve or fourteen Days; but in Winter-time and cold Weather not under ſeveral

† Vid. *Arc. Nat.* Tom. IV. p. 360.

Weeks. 'Tis not uncommon to ſee the young Ones ſtruggling to get clear of the Egg-ſhell, which ſometimes they are a Day about.

The Diameter of a *Mite*'s Egg ſeems equal to the * Diameter of the Hair of a Man's Head; and ſix hundred ſuch Hairs are about equal to the Length of an Inch. Suppoſing, then, a *Pigeon*'s Egg is three quarters of an Inch in Diameter: four hundred and fifty Diameters of a *Mite*'s Egg are but equal to the Diameter of the Egg of a *Pigeon:* and, conſequently, if their Figures be alike, we muſt conclude, that ninety one Millions, an hundred and twenty Thouſand Eggs of a *Mite* are not larger than one *Pigeon*'s Egg.

Mites are moſt voracious Animals; for they devour not only Cheeſe, but likewiſe all Sorts of dryed Fiſh or Fleſh, dryed Fruits, Grain of all Sorts, and almoſt every Thing beſide that has a certain Degree of Moiſture without being over wet: nay, they may often be obſerved preying upon one another. In eating they thruſt one Jaw forwards and the other backwards alternately, whereby they appear to grind their Food; and after they have done feeding, they ſeem to munch and chew the Cud.

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* Vid. *Philoſoph. Tranſact.* Numb. 333, & 284.

Theſe

These are the Vermin that find a Way into the Cabinets of the Curious, and eat up their fine *Butterflies* and other choice *Insects*, leaving nothing in their stead but Dust and Ruins. The only Way of preventing this, is, to keep the Drawers or Boxes continually supply'd with *Camphire*, whose hot and dry Effluvia penetrate, shrivel up, and destroy the tender Bodies of these little mischievous Plunderers.

It must however be remembered, that there are several *Species* of *Mites*, which differ in some Particulars, though their general Figure and the Nature of them be the same. For Instance,* the *Mites* in Malt-Dust and Oatmeal-Dust are nimbler than *Cheese-Mites*, and have more and longer Hairs. The *Mites* among Figs resemble Scarabs, have two Feelers at the Snout, and two very long Horns over them, with three Legs only on each Side, and are more sluggish than those in Malt. Mr. LEEUWENHOEK observed some *Mites* on Figs to have longer Hairs than he had seen on any other Sorts; and upon Examination found those Hairs were spicated, or had other little Hairs issuing from their Sides: whence he imagin'd they might be jointed at the little Distances where these Hairs come forth. He

* Vid. POWER's *Observ.* p. 10.

had alſo ſeen the like Hairs on other *Mites*, tho' very ſeldom. Mr. HOOK deſcribes a Sort of theſe Animals, which he terms † *wandring Mites*, as being to be found in every Place almoſt where they can get Food.

Happening, ſome Years ago, to look into an empty white Gallipot, I fancy'd it was duſty; but, on a nearer View, perceiving the Particles to move, I examin'd them by the *Microſcope*, and diſcovered what I had taken for Duſt to be Swarms of theſe *wandring Mites*, which were tempted and brought thither by the Smell of ſome *Caviere*, that had been in the Gallipot a few Days before.

The *Mite* is exceedingly tenacious of Life; I have kept them in my Glaſſes Months together, even without Food; and Mr. LEEUWENHOEK ſays, one he ſtuck upon a Pin before his *Microſcope* ‡ lived in that Condition eleven Weeks.

The Picture of the *Mite* is ſhewn Plate XIII. Fig. V.

One of its Eggs appears juſt by, at *a*.

† HOOK's *Microgr.* p. 205.
‡ *Arc. Nat.* Tom. IV. page 363.

CHAP.

CHAP. XXIV.

Of the FLEA.

THIS well-known little Creature is covered all over with black hard ſhelly Scales, Plates, or Diviſions, curiouſly jointed, and folded over one another, in ſuch a Manner, as to comply with all the nimble Motions and Activity of the Animal. The Scales are curiouſly poliſhed, and beſet about the Edges with long Spikes, in the moſt beautiful and regular Order poſſible. It's Neck is finely arch'd, and much reſembles the Form of a Lobſter's Tail. The Head is very extraordinary; for from the Snout-Part thereof proceed its two Fore-Legs, and between them lies the Piercer or Sucker wherewith it penetrates the Skin of other living Creatures, and draws out its Food. It has two large beautiful black Eyes, and a Pair of little Horns or Feelers. Four other Legs are join'd on at the Breaſt, ſo that it has ſix in all; which, when it leaps, fold ſhort one within another, and exerting their Spring all at the ſame Inſtant, carry the Creature to a ſurpriſing Diſtance. The Legs have many Joints, are very hairy, and terminate in two long ſharp hooked Claws, as may be ſeen Fig. VI. Plate XIII.

The *Flea*'s Piercer or Sucker is lodged between its Fore-Legs, and includes a Couple of Darts or Lancets, which, after the Piercer has made an * Entrance, are probably thruſt farther into the Fleſh, to make the Blood flow from the adjacent Parts, that it may be ſucked up; and ſeems to occaſion that round red Spot, with a Hole in the Centre of it, which we commonly call a *Flea-Bite*. This Piercer, its Sheath opening ſideways, and the two Lancets within it are very difficult to be ſeen, † unleſs the two Fore-Legs, between which they uſually are folded in and concealed from View, be cut off cloſe to the Head: for a *Flea* rarely puts out its Piercer except at the Time of feeding, but on the contrary keeps it cloſely folded inwards: the beſt Way therefore of coming at it is, by cutting off the Head firſt, and then the Fore-Legs; ſince in the Agonies of Death, it may eaſily be managed, and brought before the *Microſcope*.

Fleas are Male and Female, and lay Eggs as well as *Lice* and *Mites*; but are extreamly different in all the Progreſs of their Lives beſides, paſſing through the ſame Changes exactly as the *Silkworm* does. They depoſite their Eggs at the Roots of the Hair of Cats, Dogs,

* Vid. *Arc. Nat. detect.* Tom. IV. p. 22.
† Ibid. p. 332. *Phil. Tranſact.* Numb. 249.

and

and other Animals, ſticking them faſt thereto by a kind of glutinous Moiſture. When the Eggs hatch, not perfect *Fleas*, but little Worms or Maggots, whoſe Bodies have ſeveral annular Diviſions thinly cover'd with long Hairs, come out of them, and feed on the Juices of the Body, whereto they cloſely adhere *. Theſe Maggots are very briſk and nimble, but if touch'd, or under any Fear, roll themſelves up on a ſudden in a round Figure, and continue motionleſs for ſome Time; after which they ſlowly open themſelves and crawl away, as Caterpillars do, with a lively and ſwift Motion.

When the Time of their Change approaches, they conceal themſelves as much as poſſible; eat nothing, lie quiet, and ſeem as if dying: but if viewed with the *Microſcope*, will be found, with the Silk or Web that comes out of their Mouth, weaving a Covering or Bag round them, whoſe Inſide is as white as Paper, though without it always appears ſoil'd with Dirt. In this Bag they put on the *Chryſalis* or *Aurelia* Form, and become Milk-white: but two or three Days before they break from this Priſon, their Colour darkens, they acquire Firmneſs and Strength, and as ſoon as they iſſue from the Bag are *perfect Fleas*, and able to leap away.

* *Phil. Tranſact.* Numb. 249.

It has been discover'd, by putting the Eggs of *Fleas* in a small Glass Tube, and keeping it constantly warm in one's Bosom, that, in the Midst of Summer, they hatch in four Days: then, feeding the Maggots with dead Flies, which they suck greedily, in eleven Days they come to the full Perfection of their reptile State: when the Maggot spins its Bag, and in four Days more changes into a *Chrysalis*; after lying in which Condition nine Days, it becomes a *perfect Flea*. It is then immediately capable of Coition, and in three or four Days lays Eggs. So that in * twenty-eight Days a *Flea* may come from the Egg itself, and propagate its Kind; and their vast Increase will not seem so great a Wonder, if we consider, that from *March* to *December* there may be seven or eight Generations of them. After having laid their Eggs they soon die, as all Creatures do that undergo such like Changes.

By keeping *Fleas* in a Glass Tube corked at both Ends, but so as to admit fresh Air, their several Actions may be observed, and particularly their Way of coupling, which is performed Tail to Tail, the Female (which is much the larger) standing over the Male. They will also be seen to lay their Eggs, not all at once, but ten or twelve in a Day for

* Vid. *Arc. Nat.* Tom. IV. p. 325.

several

ſeveral Days ſucceſſively; which Eggs hatch in the ſame Order.

A Diſſection of the *Flea* may be effected after the ſame Method as that of the *Louſe*, that is, in Water: the * Stomach and Bowels, with their periſtaltic Motion may plainly be diſtinguiſhed, and alſo the † Teſtes and Penis, together with Veins and Arteries minute beyond Conception. LEEUWENHOEK affirms, that he has likewiſe diſcover'd innumerable Animalcules ſhaped like Serpents in the *Semen maſculinum* of a *Flea*.

Two Things in this Creature deſerve our Conſideration, to wit, its ſurprizing Agility, and its prodigious Strength, whereby it is enabled to leap above an hundred times its own Length: as has been proved by Experiments. What vigorous Muſcles! what a Springineſs of Fibres muſt here be! and how weak and ſluggiſh, in Proportion to its own Bulk, is the Horſe, the Camel, or the Elephant, if compared with this puny Inſect!

A Flea's *Egg* is ſhewn Plate XIII. Fig. VI. 1.

The *Worm* or *Maggot* proceeding from it Fig. VI. 2.

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* Vid. *Act. Nat.* Tom. IV. p. 20.

† Again, pag. 335.

CHAP.

CHAP. XXV.

Of SPIDERS.

EVERY Body is ſo well acquainted with the general Form of a *Spider*, even without the Aſſiſtance of a *Microſcope*, that I ſhall ſpend no Time in the Deſcription of it: but proceed to give an Account of ſome Particulars in this Animal, which are diſcoverable only by that Inſtrument.

As a Fly (the *Spider*'s natural Prey) is extreamly cautious and nimble, and comes uſually from above, it was neceſſary the *Spider* ſhould be furniſhed with a quick Sight, and an Ability of looking upwards, forwards, and ſideways at the ſame time: and the *Microſcope* ſhews, that the Number, Structure, and Diſpoſition of its Eyes are wonderfully adapted to ſerve all theſe Purpoſes.

Moſt *Spiders* have eight * Eyes: two on the top of the Head or Body (for there is no Diviſion between them, a *Spider* having no Neck) that look directly upwards; two others in Front, a little below theſe, to diſcover all that paſſes forwards: and on each ſide a couple more, one whereof points ſide-

* *N. B. Spiders* Eyes are not pearled.

ways forward, and the other ſideways backwards: ſo that it can ſee almoſt quite round it. All Kinds of them have not indeed a like Number of Eyes, for we find ten in ſome, in others only eight, ſix, or four; and in the *Field*, *Long-Legs*, or *Shepherd-Spider*, no more than two. But whatever the Number be, they are immoveable, and tranſparent: are ſituated in a moſt curious Manner, and deſerve the ſtricteſt Examination. The beſt Way of viewing them is, to cut off the Legs and Tail, and bring only the Head-part before the *Microſcope*.

All *Spiders* have eight Legs, which they employ in walking, and two Arms or ſhorter Legs near the Mouth, that aſſiſt in taking their Prey. They appear thickly beſet with Hairs, have each ſix Joints, and end with two hooked Claws, ſerrated, or having Teeth like a Saw on their Inſide, whereby they cling faſt to any thing; and at a little Diſtance from theſe Claws a ſort of Spur ſtands out, without any Teeth at all. See Fig. VII. Plate XIII.

But the dreadful Weapons wherewith the *Spider* ſeizes and kills its Prey are a Pair of ſharp crooked Claws or Forceps, (by ſome, tho' very improperly, called Stings) in the Fore-part of its Head. The *Scolopendra*, or *Indian Millepedes*, and ſeveral other Inſects have Weapons of the like Form, and

ſerving

ſerving to the ſame Purpoſe. Theſe Claws or Pincers ſtand horizontally; and are, when not made uſe of, concealed in two Caſes contrived for their Reception: into which they fold like a Claſp-knife, and there lye between two Rows of Teeth, that are likewiſe employ'd to hold faſt its Prey. This Apparatus is better ſhewn than deſcribed: See Fig. VIII.

Mr. LEEUWENHOEK informs us, † that each of theſe Claws or Pincers has a ſmall Aperture or Slit near its Point, as in a Viper's Tooth: through which he ſuppoſes a poiſonous Juice is injected into the Wound it makes, occaſioning Death to Flies and other Inſects. But Dr. MEAD, in his moſt excellent *Eſſay on Poiſons*, believes this to be a great Miſtake: having not been able to diſcern any Exit or Opening, though he viewed theſe Parts ſeveral times with a very good *Microſcope*. And he was the more confirmed in this Opinion, by examining a Claw of the great *American Spider*, deſcribed by PISO, and called *Nhamdu*, given him by Mr. PETIVER: which being above fifty times bigger than that of any *European Spider*, if there had been any Slit in it, he doubted not his Glaſs would have diſcover'd it; but yet he found it to be quite ſolid. Beſides,

† Vid. *Act. Nat.* Tom. IV. Par. II. p. 319.

" after

" after repeated Trials he plainly saw that " nothing drop'd out at the Claws, which " were always dry, while the *Spider* bit, but " that a short white Proboscis was at the " same time thrust out of the Mouth, which " instilled a Liquor into the Wound." And he farther observes, " that the Quantity of " Liquor emitted by our common Spiders " when they kill their Prey, is visibly so " great, and the wounding Weapons so mi- " nute, that they could contain but a very " inconsiderable Portion thereof, if it were " to be discharged that way.

Spiders frequently cast their Skins, which may be found in Cobwebs, perfectly dry and transparent; and from such Skins the Forceps or Claws (for they are always shed with the Skin) may easier be separated, and examin'd with more Exactness than in a living *Spider:* for they commonly appear spread out fairly to view, and, by their Transparency every minute Part is seen with much Distinctness. But neither this Way, nor any other, have I been ever able to discern the Aperture Mr. LEEUWENHOEK speaks of.

The Contexture of the Webs of *Spiders*, and their Manner of Weaving them, are farther Discoveries of the *Microscope*; for that informs us, that the *Spider* has five little

Teats or Nipples near the Extremity of the Tail, whence a gummy Liquor proceeds, which adheres to any thing it is preſſed againſt, and being drawn out, hardens inſtantly in the Air, and becomes a String or Thread, ſtrong enough to bear five or ſix times the Weight of the *Spider*'s Body. This Thread is compoſed of ſeveral finer ones that are drawn out ſeparately, but unite together two or three Hairs Breadth diſtant from the Body of the *Spider*. The Threads are finer or coarſer according to the Bigneſs of the *Spider* that ſpins them. Mr. LEEUWENHOEK computes, that an hundred of the fineſt Threads of a *full-grown Spider* are not equal to the Diameter of the Hair of his Beard; and, conſequently, if the Threads and the Hair be round, ten thouſand ſuch Threads are not bigger than ſuch an Hair. He calculates farther, that when *young Spiders* firſt begin to ſpin, four hundred of them are not larger than One that is full grown; and, therefore, the Thread of ſuch a little *Spider* is ſmaller by four hundred times than the Thread of a full-grown One: allowing which, four Millions of a young *Spider*'s Threads are not ſo big as the ſingle Hair of a Man's Beard *.

* Vid. *Phil. Tranſ.* Numb. 272.

The

The Eggs of ſome *Spiders* are very pleaſant Objects, being round at one End and flattiſh at the other, with a Depreſſion in the Center of the flattiſh End, and a yellowiſh Circle round it. Their Colour is a blewiſh White like counterfeited Pearl; and when they hatch, the *little Spiders* come out perfectly formed, and run about very nimbly. The Female depoſits her Eggs, to the Number of five or ſix hundred, in a Bag ſtrongly compoſed of her own Web, which ſhe either carries under her Belly and guards with the greateſt Care, or elſe hides in ſome ſafe Receſs. As ſoon as the Eggs are hatch'd, the minute *Spiders* appear very agreeable in the *Microſcope*.

It has been before obſerved, that the Current of the Blood may be ſeen in the Legs and Body of this Creature; and the judicious Obſerver will diſcover many other Wonders in the Diſſection and Examination of its ſeveral Parts, which it would be tireſome for me to dwell on here. I cannot, however conclude this Head, without pointing out two or three Kinds of *Spiders* as particularly worth Notice.

There is a little *white Field Spider* with ſhort Legs, found plentifully among new Hay, whoſe Body appears like white Amber, with black Knobs, out of each where-

of

of grow Prickles like Whin-Pricks. Some have ſix, ſome eight Eyes, that may be diſtinctly ſeen, quick and lively: each Eye has a Violet-blew Pupil, clear and admirable, ſurrounded by a pale yellow Circle *.

The *wandring* or † *hunting Spider*, who ſpins no Web, but runs and leaps by Fits, has two Tufts of Feathers fixt to its fore Paws, which well deſerve being placed before the *Microſcope:* the Variety and Beauty of Colouring all over this little Creature afford likewiſe a moſt delightful View.

‡ The *Long-Legs*, *Field*, or *Shepherd-Spider* is a moſt wonderful Creature: It has two Fore-Claws at a great Diſtance from the Head, tip'd with black like a Crab's, that open and ſhut in the Manner of a Scorpion's, and are Saw-like, or indented, on the Inſide.-----Cut all the Legs from this *Spider*, and place it before the *Microſcope*, and you'll diſcover, that the Protuberance on the top of the Back is furniſh'd with two fine Jet-black Eyes.

The little *red Spider* that creeps on the Barks of Trees ſhould alſo not be neglected.

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* Dr. POWER's *Microſcop. Obſerv.* p. 13.
† HOOK's *Microgr.* pag. 200. ‡ Ibid. 14.

CHAP.

CHAP. XXVI.

Of the GNAT.

THE Production of this Creature is from an *Egg*, depoſited by its Parent upon the Waters, which firſt becomes a *Worm* or *Maggot*, then a very odd *aquatic Animal*, (deſcribed pag. 88.) and afterwards a *Gnat*.

The particular Beauties of it cannot poſſibly be diſcovered without a *Microſcope*; but by the Aſſiſtance of that Inſtrument, it appears to be adorned by Nature in a more extraordinary Manner than moſt other living Creatures are. Its Tail-part is covered over with Feathers, moſt exquiſitely diſpoſed in Rows: of different Colours, but yet perfectly tranſparent. The * Breaſt (which is cruſtaceous) is bedecked with little ſtiff Hairs or Briſtles, inſtead of Feathers; and from thence ſix hairy Legs proceed, with ſix Joints to each, and at the End two little Claws. The Feet are all over feather'd in a Manner reſembling the Scales of Fiſhes, with abundance of little black Hairs amongſt them appearing ſtubborn like Hogs Briſtles. Its Wings are encompaſſed with a Furbelow of long Feathers: and the Veins or Ribs that

* SWAMMERD. Hiſt. general. des Inſect. p. 108.

ſerve to ſtrengthen them are alſo either feathered or ſcaled. Between theſe Ribs an exceeding thin tranſparent Membrane is extended, full of little black ſharp-pointed Hairs, that are ranged every where with the utmoſt Regularity. But as there are † different Sorts of Gnats, their Wings are alſo very different, ſome having a Border of long Feathers, others of ſhort ones, and others none at all: the Rib-work of the Wings, likewiſe, in ſome is feathered, in ſome ſcaled, and in ſome beſet with Prickles.

But the moſt wonderful Part of this Creature is its Head: as it contains the Horns, the Sting or Sucker, and the Eyes. The Horns of the *bruſh-horn'd* or *Male Gnat* are a moſt charming Object: it has two Pair, one whereof is ſurrounded, at little Diſtances, with long Hairs, iſſuing out circularly: each Circle leſſening more than other as it ſtands nearer the Extremity of the Horns: and the whole, together, exactly repreſenting the Figure of the Plant called *Equiſetum* or *Horſe-Tail*. The other Pair are longer and much thicker than the foregoing, and hairy from End to End. In the *great belly'd* or *Female Gnat*, the firſt Pair of Horns, though of the

† Mr. DERHAM obſerved near forty different Species of Gnats about the Place where he lived, which was *Upminſter*, in *Eſſex*. Vid. *Phyſico-Theolog.* p. 378.

ſame

ſame Figure as the Male's, has Hairs not near ſo long, and the ſecond Pair is ſhorter than the firſt by at leaſt three Parts in four.

The *Piercer*, *Sting*, or *Sucker*, is a Caſe covered with long Scales, that lies concealed under the * *Gnat*'s Throat, when not made Uſe of. The Side opens, and four Darts are thruſt out thence, occaſionally; one whereof, (minute as it is) ſerves for a Sheath to the other three. The Sides of them are extreamly ſharp, and they are barbed or indented towards the Point, whoſe Fineneſs is inexpreſſible, and ſcarcely to be diſcerned by the greateſt Magnifier. When theſe Darts are thruſt into the Fleſh of Animals, either ſucceſſively, or in Conjunction, the Blood and Humours of the adjacent Parts muſt flow to and cauſe a Tumour about the Wound, whoſe little Orifice being cloſed up by the Compreſſion of the external Air, can afford them no Outlet. When a *Gnat* finds any tender juicy Fruits, or Liquors, ſhe ſucks up what ſhe likes, through the outer Caſe, without uſing the Darts at all: but if it is Fleſh, that reſiſts her Efforts, ſhe ſtings very ſeverely, then ſheaths her Weapons in their Scabbard, and through them ſucks up the Juices ſhe finds there. The Pain they cauſe

* Vid. *Hiſt. of Nat.* Eng. 12mo. Edit. Vol. I. p. 124.

is only while they are entering, and continues not when the *Gnat* is ſucking: nor is its Stinging out of Revenge, but from mere Neceſſity, to obtain a proper Suſtenance.

The *Gnat*'s four Darts are ſhewn Plate XIII. Fig. IX. *a. b. c. d.*

A *Gnat*'s Eyes, which form the greateſt Part of its Head, are pearled, or compoſed of many Rows of little ſemicircular Protuberances ranged with the utmoſt Exactitude. What theſe Protuberances are, and the Purpoſes whereto they ſerve, will be explained when we come to treat of the *Eyes* of *Inſects*.

The Motion of the Inteſtines may be ſeen in the tranſparent Parts of this Animal, and upon Diſſection many curious Diſcoveries may be made. Mr. LEEUWENHOEK ſays, he found in the * *Semen* of the Male numberleſs *Animalcules* ſmaller than thoſe in Fleas, and in the Female a ſurprizing Quantity of Eggs. And, indeed, the Spawn of this Inſect is amazingly great, in proportion to its Size, being ſeen floating on the Waters (though always faſtened to ſomething to prevent its ſwimming away) ſometimes above an Inch in Length, and half a quarter in Diameter; the Eggs (each of which has a little

* LEEUWENH. *Arcan. Nat.* Tom. IV. p. 22.

black

black Speck) being placed in exact Order, and kept together by a Sort of Gelly or glewy Matter, which the minute Maggots, when hatched, carry down with them to the Bottom, and thereby cement together the ſmall Particles of Earth or Sand that form their Cells or Caſes.

CHAP. XXVII.

Of the Ox-Fly, *or* Gad-Bee.

ANOTHER Creature that undergoes a like Change, is the *Ox-Fly*, *Dun-Fly*, or *Gad-Bee*, an Inſect very troubleſome to Cows and Horſes.

This, like the Gnat, has a long Proboſcis, with a ſharp Dart or Darts ſheathed therein. The Uſe of theſe Darts is to penetrate the Fleſh of Animals, and feed on their Blood; whereas the Proboſcis can only ſerve to ſuck the Juices, Honies, or Dews, from Fruits, Flowers, or the Leaves of Plants: and Providence ſeems to have kindly furniſhed it with this twofold Inſtrument, that if one Sort of Proviſion fails, it may be able to ſubſiſt on the other. It is worth Enquiry whether *Lice*, *Fleas*, *Houſe-Bugs*, &c. are not alſo provided for the ſame Purpoſes.

The Eggs of this Inſect are depoſited in the Waters, and produce an extraordinary Kind of little *Worm* or *Maggot*, the Extremity of whoſe Tail is incircled with moveable Hairs, which, being expanded on the Surface of the Water, enable it to float along, † as in Plate VII. Fig. XIII. *a*. When it would deſcend towards the Bottom, theſe Hairs are made to approach each other in an oval Form, and incloſe a little Bubble of Air; by means whereof it is able to riſe again: and if this Bubble eſcapes, as ſometimes it will, the Inſect immediately ſqueezes out of its own Body another like Bubble to ſupply the Place thereof. The *Maggot*, as deſcending, is ſhewn, Fig. XIII. *b*. Its Snout has three Diviſions, whence three little pointed Bodies are thruſt out, in continual Motion, like the Tongues of Serpents.

Theſe *Maggots* are frequently to be met with in Water taken from the Surface of Ditches. The Motion of their Inteſtines are perfectly ſingular and diſtinguiſhable, and they are Objects well deſerving our particular Obſervation.

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† Vid. SWAMMERD. *Hiſt. Generale des Inſectes*, p. 148.

CHAP.

CHAP. XXVIII.

Of the STINGS *of* INSECTS.

THE *ſharp* and *penetrating Inſtruments* wherewith the Tails of Bees, Waſps, Hornets, Ants, and ſome other Inſects are armed, I diſtinguiſh by the Name of *Stings:* being Weapons given them by Nature to defend themſelves and offend their Enemies; whereas the *Trunk* or *Proboſcis* which Gnats, Fleas, Lice, and many other Kinds carry in their Mouth, though it may be equally ſharp, is not intended as an Inſtrument of Revenge, but for procuring and ſucking in their Food; and, therefore, when ſuch Creatures bite or ſting us, as we term it, we muſt not imagine they do ſo out of Anger, but from Neceſſity. Squeeze or ſtrike a Bee or Waſp, it inſtantly puts forth its *Sting*, but no Provocation can urge a Gnat or Flea to bite: on the contrary, when diſturbed or hurt they draw in their *Proboſcis* inſtead of thruſting it out, and never make Uſe of it but when they think themſelves perfectly ſafe and quiet. There is beſides, this farther Difference; a *Sting injects* a venomous Liquor into the Wound it makes, but a *Proboſcis ſucks* or *draws out* the Blood and Humours from it.

As the Structure and Contrivance of moſt Stings are nearly alike, by deſcribing one the reſt will be underſtood: I ſhall, therefore, give a brief Account of the *Sting* of a *Bee*, as diſcovered by the *Microſcope*.

CHAP. XXIX.

Of a Bee's *Sting.*

THE *Sting* of a *Bee* is a horny Sheath or Scabbard that includes two bearded Darts. This Sheath ends in a ſharp Point: near the Extremity whereof a Slit opens, through which, at the Time of ſtinging, two *bearded Darts* are protruded beyond the End of the Sheath; one whereof being a little longer than the other, fixes its Beard firſt; but the other inſtantly following, they penetrate, alternately, deeper and deeper, taking hold of the Fleſh with their Hooks, till the whole Sting becomes buried in the Wound; and then a venomous Juice is injected, thro' the ſame Sheath, from a little Bag at the Root of the Sting, which occaſions an acute Pain, and a Swelling of the Part, continuing ſometimes ſeveral Days. This is beſt prevented, by enlarging the Wound immediately to give it ſome Diſcharge.

The

The two Darts lye within the Sting as in Plate XIII. Fig. X. *a*.

When thruſt out they appear as in Fig. X. *b*.

Mr. DERHAM ſays, he counted, in the *Sting* of a *Waſp*, eight Beards on the Side of each Dart, ſomewhat like the Beards of Fiſh-Hooks, and I have obſerved the ſame Number in that of a *Bee*. When theſe Beards are ſtruck deep in the Fleſh, if the wounded Perſon ſtarts before the *Bee* can diſengage them, ſhe leaves her *Sting* behind ſticking in the Wound: but if he has Patience to ſtand quiet, till ſhe brings the Hooks cloſe down to the Side of the Darts, ſhe withdraws her Weapon, and the Wound becomes much leſs painful. A Waſp is not ſo liable as a Bee to leave its *Sting* behind, the Beards of it being rather ſhorter, and the Animal ſtronger and more nimble *.

To view the *Sting* of a *Bee* by the *Microſcope*, cut off the End of its Tail, and then touching it with a Pin or Needle, it will thruſt out the *Sting* and *Darts*, which may be ſnipt off with a Pair of Sciſſars and kept for Obſervation. Alſo, if you catch a *Bee* in a Leather Glove, its *Sting* will be

* Vid. DERHAM's *Phyſ. Theol.* p. 241. *Spect. de la Nat.* Dial. VI.

left

left therein, being unable to disengage its Hooks from Leather: and when it is quite dead, which it will not be till after several Hours, you may by Care and Gentleness extract it with its Darts and Hooks. By squeezing the Tail, pulling out the Sting, and pressing it at the Bottom, you may likewise force up the Darts; but without some Practice this will be a little difficult.

The Bag containing the poisonous Juice may easily be found at the Bottom of the *Sting*, and examin'd, being commonly pulled out with it: and, by letting the *Bee* strike its *Sting* upon some hard Body, enough of the said Juice may be obtained to put upon a Slip of Glass, in order to view the *Salts*, floating therein at first, and afterwards shooting into Crystals.

CHAP. XXX.

Of the STING *of a* SCORPION.

HOW far the *Sting* of a *Scorpion* is of a like Structure with that of a *Bee* I never had the Opportunity of examining, as none of them are brought alive to *England*; but the Curious that go abroad into hot Countries, where they are produced, would do well to observe, particularly, whether a Dart

or

or Darts are not ſheathed in the horny Sting at the Extremity of their Tail.

The Opinions of Authors are very different as to this Creature's having or not having any Opening in its *Sting*, through which a Poiſon iſſues into the Wound it makes. GALEN ſays, there is none: PLINY, TERTULLIAN, ELIAN, ALDROVAND and others aſſert, on the contrary, that there is. But I think this Matter is ſet in the trueſt Light by *Seignor* REDI, that diligent Naturaliſt, who took the Pains to examine *Scorpions* brought from TUNIS, from EGYPT, and from ITALY, in order to diſcover this Aperture, with two of the beſt *Microſcopes* in the *Muſæum* of the *Grand Duke* of TUSCANY, one whereof was made at ROME, and the other in ENGLAND: but, though theſe Glaſſes were excellent, he was unable to diſcern the leaſt Perforation. However, not ſatisfied with only viewing them, he endeavoured, by Preſſure, to ſqueeze from the Cavity of the *Sting* any Liquor it might contain; but he found it ſo hard and horny, that Squeezing could have no Effect. He, moreover, cauſed a *Scorpion* to ſtrike on a Plate of Iron, but no Moiſture appeared thereon; ſo that he began to conclude GALEN's Opinion right; when he diſcovered, accidentally, an exceeding ſmall and almoſt inviſible Drop of *white Liquor* upon the *Sting*;

Sting *; which convinced him that ELIAN ſays true, where he aſſerts, that the Perforation in a *Scorpion*'s *Sting* is ſmall beyond the Poſſibility of being ſeen. And ſuch a Drop he frequently ſaw afterwards, in the Progreſs of his Experiments, on the *Stings* of ſeveral *Scorpions*, at the Time of their Striking: which Drop, entering the Wound, produced the moſt fatal Effects †.

What a virulent and ſurprizing Poiſon muſt this be! that, in ſo very minute a Quantity, can contaminate the whole Maſs of the Fluids, and bring on ſudden Death, not only in Man and other ſmaller Creatures, but even in Lions, Camels and Elephants, as we are aſſured it will! How ſubtile, how penetrating, how diviſible, muſt the component Particles of this little Speck of Venom be! and how ſtrong a Proof it affords, that the greateſt Changes imaginable may be wrought in the human Body, by the Admixture of different Liquors with the Blood, even in the ſmalleſt Quantities!

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* Vid. REDI *de Gener. Inſect.* p. 127.

† Mr. LEEUWENHOEK diſcovered an Opening on each Side of the *Sting* for the Emiſſion of this Poiſon; which he ſuppoſes is not diſcharged till the *Sting* is buried in the Wound. Vid. *Arc. Nat.* Tom. II. p. 167.

CHAP. XXXI.

Of the POISON *of a* VIPER.

THE Miſchief done by the *Viper*, or any other Serpent, is not effected by means of a Sting, (for what is darted out of its Mouth, and by the vulgar ſuppoſed a Sting, is nothing but the Tongue of the Animal, and perfectly harmleſs :) but its *Teeth* are the dreadful Weapons wherein the Poiſon lies, and its *Bite* is all we need to fear.

Dr. MEAD, in his moſt valuable Eſſay on the *Poiſon of the Viper*, has deſcribed theſe Teeth and their Poiſon ſo much better than it is poſſible for me to do, that I ſhall beg Leave to borrow the chief I have to ſay from him.

The poiſonous *Fangs* or great *Teeth* are crooked and bent : they are hollow from the Root a conſiderable Way up, not to the very Point, (which is ſolid and ſharp to penetrate the better) but to within a little Diſtance of it : as may be ſeen by ſplitting a Tooth through the Middle. This Cavity ends in a viſible Slit reſembling a Nip or Cut of a Pen. See Plate XIII. Fig. XI. The Poiſon is ejected through this Slit from a Bag at the Root of the Teeth, into which it is diſcharg'd by a Duct juſt behind the Orbit of the Eye, from

from a conglomerated Gland that ſeparates it from the Blood.

The venomous Juice of the *Viper* may be got by enraging it till it bites on ſomething ſolid. This Juice the Doctor put carefully on a Glaſs Plate, and examined it by the *Microſcope*. Upon the firſt Sight he could diſcover nothing but a Parcel of ſmall Salts nimbly floating in the Liquor: but in a very ſhort Time the Appearance was changed, and thoſe ſaline Particles were now ſhot out as it were into Cryſtals of an incredible Tenuity or Sharpneſs, with ſomething like Knots, here and there, from which they ſeemed to proceed: ſo that the whole Texture did in a manner repreſent a Spider's Web, though infinitely finer and more minute; and yet withal, ſo rigid were theſe pellucid Spicula or Darts, that they remained unaltered upon his Glaſs for ſeveral Months. And, by conſidering the neceſſary Effects of ſuch Spicula in the Blood, this learned Phyſician accounts very reaſonably for all the Symptoms uſually ſucceeding the Bite of this Animal.

GALEN ſays, the *Mountebanks* of his Time uſed, with ſome kind of Paſte, to ſtop the Perforations in the Teeth of *Vipers*, whereby they kept in the Venom; and then would ſuffer themſelves to be bit, pretending their Antidotes prevented any ill Effects.

CHAP.

CHAP. XXXII.

Of the SNAIL.

THE * *Snail* has four Eyes, at the End of optic Nerves, ſheathed in her Horns, which ſhe can draw in, or thruſt out, turn, or direct, as ſhe finds moſt convenient.

When the Horns are out, cut off nimbly the Extremity of one of them, and, placing it before the *Microſcope*, you may diſcover the black Spot at the End to be really a *Semiglobular Eye*.

The Diſſection of this Animal is very curious; for the *Microſcope* does not only ſhew the Heart, beating, juſt againſt a round Hole near the Neck, which ſeems the Place of Reſpiration; but alſo the Liver, Spleen, Stomach, Veins, Arteries, Guts, Mouth and Teeth. The Guts are green, from the Creature's eating Herbs, and branched all over with fine capillary white Veins. The Mouth is like a Hare's or Rabbet's, with four or ſix *Needle-Teeth* reſembling thoſe of *Leeches*, and of a Subſtance like Horn.

Snails are all *Hermaphrodites*, having both Sexes united in each Individual. They lay their Eggs with great Care in the Earth;

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* *Vide* POWER's *Obſerv.* p. 38. LISTER *Exerc. Anatom. Cochl.*—*Spect. de la Nature*, Dial. XI.

and

and the Young Ones come out, when hatched, with Shells compleatly formed, and of a Minuteneſs proportionable to their own Size. Theſe little Shells enlarge, as the *Snails* advance in Growth, by the Addition of new Circles, of which Circles they always continue to be the Center.

Cutting off a *Snail*'s Head, a *little Stone* appears, † which from its diuretic Quality is of ſingular Service in gravelly Diſorders. Immediately under this *Stone* the beating *Heart* is ſeen, with its *Auricles*, which are membranous; all of a white Colour, as are alſo the Veſſels iſſuing therefrom. This *little Stone* ſeems intended to ſerve inſtead of a Breaſt-Bone, which moſt other Creatures have.

It is very remarkable that *Snails* diſcharge their Excrements at an Opening in the Neck, that they breathe there, and that both their Male and Female Parts of Generation are ſituated near the ſame Place. The Male Part is very long, and in Shape reſembles the *Penis* of a Whale.

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† *Vide* SWAMMERDAM *Hiſt. Gener. des Inſectes*, p. 77.

CHAP.

CHAP. XXXIII.

Of the common FLY.

THE common *Fly* is adorned with Beauties not to be conceived without a *Microſcope*. It is ſtudded from Head to Tail with Silver and Black, and its Body is all over beſet with Briſtles pointing towards the Tail. The Head of it contains two large Eyes, encircled with Borders of Silver Hairs; a wide Mouth, with an hairy Trunk or Inſtrument to take in its Food: a Pair of ſhort Horns, ſeveral ſtiff black Briſtles, and many other Particulars diſcoverable by the *Microſcope* *. Its Trunk conſiſts of two Parts, folding over one another, and ſheathed in the Mouth. The Extremity thereof is ſharp like a Knife, for the Separation of any thing. The two Parts can alſo be formed, occaſionally, into a Pair of Lips for taking up proper Quantities of Food, and by the *Fly*'s ſucking in the Air, they become a kind of Pump, to draw up the Juices of Fruits or other Liquors.

Some *Flies* are much lighter coloured and more tranſparent than others, and in ſuch the Motion of the Guts may be ſeen very

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* *Spectacle de la Nat.* Dial. VII.

 diſtinctly,

distinctly, working from the Stomach towards the Anus; and also the Motion of the Lungs, contracting and dilating themselves alternately. Upon opening a *Fly*, numberless Veins may likewise be discovered, dispersed over the Surface of its Intestines: for the Veins being blackish, and the Intestines white, they are plainly visible by the *Microscope*, though two hundred thousand times slenderer than the Hair of a Man's Beard. According to Mr.‡ LEEUWENHOEK, the Diameter of four hundred and fifty such minute Veins were about equal to the Diameter of a single Hair of his Beard; and consequently, two hundred thousand of them put together would be about the Bigness of such an Hair.

In most kinds of *Flies*, the Female is furnished with a moveable Tube at the End of her Tail, by extending of which she can convey her Eggs into convenient Holes and Receptacles, either in Flesh, or such other Matters as may afford the Young Ones proper Nourishment. From the Eggs come forth minute Worms or Maggots, which after feeding for a while, in a voracious Manner, arriving at their full Growth, become transformed into little brown *Aurelias*;

‡ *Arc. Nat.* Tom. II. p. 77.

whence,

whence, after ſome time longer, they iſſue perfect Flies.

It would be endleſs to enumerate the different Sorts of *Flies*, which may continually be met with in the Meadows, Woods and Gardens; and impoſſible to deſcribe their various Plumes and Decorations, ſurpaſſing all the Magnificence and Luxury of Dreſs in the Courts of the greateſt Princes. Every curious Obſerver will find them out himſelf, and, with Amazement and Adoration, lift up his Eyes from the *Creature* to the CREATOR.

CHAP. XXXIV.

Of the WEEVIL, *or* CORN-BEETLE.

THE *Weevil* and the *Wolf* are two kinds of ſmall Inſects that do abundance of Miſchief to many Sorts of Grain, by eating into them and devouring all their Subſtance.

The *Weevil* is ſomewhat bigger than a large Louſe, of the Scarab Kind, with two pretty, jointed, tufted Horns, and a Trunk or Piercer projecting from the Fore-part of its Head. At the End of the Trunk (which is very long in Proportion to its Body) are a ſort of Forceps or ſharp Teeth, wherewith it gnaws its Way into the Heart of the

Grain, either to ſeek its Food or depoſit its Eggs there.

By keeping theſe Creatures in Glaſs Tubes, with ſome few Grains of Wheat, their Copulation has been diſcovered, and likewiſe their Manner of Generation, which is thus.——* The Female perforates a Grain of Wheat, and therein depoſits a ſingle oblong Egg, or two Eggs at moſt, (a Grain of Wheat being unable to maintain above one or two of the young Brood when hatch'd) and this ſhe does to five or ſix Grains every Day for ſeveral Days together. Theſe Eggs, not above the Size of a Grain of Sand, in about ſeven Days produce an odd ſort of *white Maggot*, which wriggles its Body pretty much, but is ſcarce able to move from Place to Place, as indeed it has no occaſion, being happily lodged by its Parent where it has Food enough. This *Maggot* turns into an *Aurelia*, which in about fourteen Days comes out a *perfect Weevil*.

As many People are unacquainted with the *Weevil*, a Picture of it is given Plate XIII. Fig. XII.

Weevils when in the Egg, or not come to their perfect State, are often devoured by Mites.

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† *Vide* LEEUWEN. Epiſt. de ſexto *Auguſti* 1687. ad Reg. Societ.

CHAP.

CHAP. XXXV.

Of the WOLF.

THE *Wolf* is a little white *Worm* or *Maggot* that infeſts Granaries and Corn-chambers, and unleſs proper Care be taken, will do unſpeakable Damage.--- I call it a *Worm* or *Maggot*, becauſe under that Form it does the Miſchief, though in its perfect State it is really a ſmall *Moth*, whoſe Wings are white, ſpotted with black Spots.

This little *Maggot* has ſix Legs; and, as it creeps along, there iſſues from its Mouth an exceeding fine Thread or Web, by which it faſtens itſelf to every thing it touches, ſo that it cannot fall. Its Mouth is armed with a pair of reddiſh Forceps or biting Inſtruments, wherewith it gnaws its Way, not only into Wheat and other Grain, but perforates even wooden Beams, Boxes, Books, and almoſt any thing it meets with.

Towards the End of Summer, this pernicious Vermin (in Corn-Chambers infeſted with them) may be ſeen crawling up the Walls in great Numbers, in ſearch of proper Places where they may abide in Safety during their Continuance in their *Aurelia* State: for when the Time of undergoing a Change into that State approaches, they for-

ſake their Food, and the little Cells they had formed of hollowed Grains of Corn, clotted together by means of the Web coming from their Mouths, and wander about till they find ſome Wooden Beam, or other Body to their Mind, into which they gnaw Holes with their ſharp Fangs, capable of concealing them: and there, enveloping themſelves in a Covering of their own Spinning, ſoon become metamorphoſed into dark-coloured *Aurelias* *.

Theſe *Aurelias* continue all the Winter unactive and harmleſs: but about *April* or *May*, as the Weather grows warm, they are transformed a-new, and come forth *Moths* of the Kind above deſcribed. They may then be ſeen in great Numbers taking little Flights, or creeping along the Walls; and, as they eat nothing in their Fly-State, are at that Time not miſchievous. But they ſoon copulate and lay Eggs (ſhaped like Hen's Eggs, but not larger than a Grain of Sand) each Female ſixty or ſeventy, which, by means of a Tube at the End of her Tail, ſhe thruſts or inſinuates into the little Wrinkles, Hollows, or Crevices of the Corn; where, in about ſixteen Days, they hatch, and then the *Plague* begins: for the minute *Worms* or *Maggots* immediately perforate the Grain

* Vid. LEEUWEN. *Experiment. & Contempl.* Epiſt. 71.

they

they were hatched upon, eat out the very Heart of it, and with their *Webs* cement other Grains thereto, which they likewiſe ſcoop out and devour, leaving nothing but Huſks, and Duſt, and ſuch a quantity of their Dung, as ſhews them to be more voracious Inſects than the *Weevil*.

The watchful Obſerver has two Opportunities of deſtroying this Vermin, if they happen to be got among his Corn. One is, when they forſake their Food and aſcend the Walls, which they will ſometimes almoſt cover: the other, when they appear in the *Moth State*. At both theſe Times they may be cruſhed to Death againſt the Walls in great Numbers by clapping Sacks upon them. But they may ſtill be exterminated more effectually, if cloſing up all the Doors and Windows, the Corn-Chamber be filled with the Fumes of *Brimſtone*, by leaving it burning on a Pan of Charcoal, without giving it any Vent, for twenty four Hours. Great Caution, however, muſt be uſed, to open the Windows and Doors, and let all the Fumes be intirely gone, before any Body enters the Place afterwards, for Fear of Suffocation. The Fumes of *Sulphur* are in no wiſe hurtful to the Corn, or give it any Taſte.

The Picture of the *Wolf* in its Reptile State, (when it goes by that Name) is ſhewn Plate XIII. Fig. XIII. *a*.

Its Appearance when transformed into a *Moth* is seen Fig. XIII. *b*.

Old Corn is less subject to these devouring Insects than Corn that is new; for its Skin being more hard and dry, it is much more difficult for the *little Maggots* when first hatch'd to penetrate *.

CHAP. XXXVI.

Of the pearled Eyes *of* † Insects.

THE *Eyes* of *Insects* are amazing Pieces of Mechanism, whose Structure and Disposition, without the Assistance of the *Microscope*, would for ever have been unknown to us.----*Beetles*, *Dragon-flies*, *Bees*, *Wasps*, *Ants*, *common Flies*, *Butterflies*, and many other *Insects* have two Crescents, or immoveable Caps, composing the greatest Part of the Head, and containing a prodigious Number of little *Hemispheres* or round *Protuberances*, placed with the utmost Regularity and Exactness in Lines crossing each other, and resembling Lattice-Work. These

* I call this Insect the *Wolf* from the *Latin* Name *Lupus*; given, I suppose, for its Voraciousness.

† Vide *Spectacle de la Nature*, Dial. VIII. Hook's *Microg.* p. 180. Leeuw. *Arcan. Nat.* Tom. II. Part II. p. 41. Again, p. 424. Derham's *Phys. Theol.* p. 364.

are

are a Collection of *Eyes*, so perfectly smooth and polished, that like so many Mirrors they reflect the Images of all outward Objects. One may see the Figure of a Candle multiplied almost to Infinity on their Surfaces, shifting its Beams into each Eye, according to the Motion given it by the Observer's Hands: and as other Creatures are obliged to turn their Eyes to Objects, this Sort have some or other of their Eyes always ready directed towards Objects, on whatever side they present themselves. In short, all these little *Hemispheres* are *real Eyes*, having in the middle of each a minute transparent *Lens* and *Pupil*, through which Objects appear topsy-turvy as through a convex Glass: This becomes also a *small Telescope* when there is a just focal Distance between it and the *Lens* of the *Microscope*. It is also reasonable to believe, that every *Lens* has a distinct Branch of the Optic Nerves administring to it: and yet, that Objects are not multiplied, or appear otherwise than single, any more than they do to us, who see not an Object double though we have two Eyes.

Every Man almost that has seen a *Microscope* has been entertained with a View of these *minute Eyes*, and yet very few perhaps have well consider'd either the Nature or the Number of them. Mr. Hook computed fourteen thousand *Hemispheres* in the

two Eyes of a *Drone*, *viz.* seven thousand in each Eye. Mr. LEEUWENHOEK reckoned six thousand two hundred thirty-six in a *Silk-Worm*'s two Eyes, when in its Fly-state: three thousand one hundred eighty one in each Eye of a *Beetle:* and eight thousand in the two Eyes of a *common Fly.* The *Libella*, *Adder-Bolt*, or *Dragon-Fly*, is the most remarkable of all the Insects we know for its large and fine *pearled Eyes*; which even with a common Reading-Glass appear like the Skin we call Shagreen. Mr. LEEUWENHOEK reckons in each Eye of this Creature, twelve thousand five hundred forty four *Lenses*, or, in both, twenty-five thousand eighty-eight; placed in an hexangular Position, each *Lens* having six others round it; which is also the Order most common in other Eyes. He likewise observed in the Center of each *Lens* a minute transparent Spot, brighter than the rest, and supposed to be the *Pupil* through which the Rays of Light are transmitted upon the *Retina*. This Spot had three Circles surrounding it, and seemed seven times less than the Diameter of the whole *Lens*. We see here, in each of these exceedingly minute *lenticular Surfaces*, as much Accuracy in the Figure and Polish, and as much Contrivance and Beauty as in the Eye of a Whale or an Elephant: and how delicate, how exquisitely delicate must the Filaments of the *Retina* be which

serve

ſerve to each of theſe, ſince the whole Picture of Objects painted thereon, muſt be Millions of times leſs than the Images of them pictured on the human Eye!

If we cut off the *Eye* of a *Dragon Fly*, of a *Drone*, or of a *common Fly*, and with a Pencil and ſome clean Water waſh out all the Veſſels, thoſe Veſſels may be examin'd by the *Microſcope*, and the Numbers of them will appear wonderful and ſurprizing; and then, if the outward Covering be dryed carefully, ſo as not to ſhrink, it will be rightly prepared for making Experiments with the *Microſcope*: and, upon viewing it, we ſhall perfectly diſtinguiſh the numerous *Protuberances* or *Hemiſpheres*, divided from one another, with a ſmall Light iſſuing between them, and ſix Sides to each. Mr. LEEUWENHOEK having prepared an Eye in this Manner, placed it a little farther from his *Microſcope* than when he would examine an Object: ſo as to leave a right and exact *focal Diſtance* between it and the *Lens* of his *Microſcope*; and then, looking thro' both, in the Manner of a *Teleſcope*, at the Steeple of a Church, which was two hundred ninety and nine Feet high, and ſeven hundred fifty Feet from the Place where he ſtood, he could plainly ſee, thro' every little *Lens*, the whole Steeple, inverted, tho' not larger than the Point of a fine Needle: and then,

direct-

directing his View to a neighbouring Houſe, he ſaw, through abundance of the little *Hemiſpheres*, not only the Front of the Houſe, but likewiſe the Doors and Windows; and was able to diſcern diſtinctly whether the Windows were ſhut or open.

There can be no doubt, that *Lice*, *Mites*, and multitudes of other *Animalcules*, much ſmaller ſtill than they, have Eyes contrived and faſhion'd, to diſcern Objects ſome thouſands of times leſs than themſelves: for ſo the minute Particles they feed on, and many other Things neceſſary for them to diſtinguiſh and know perfectly, muſt certainly be.— What a Power then of magnifying are ſuch Eyes endued with! and what extraordinary Diſcoveries might be made, were it poſſible to obtain Glaſſes through which *we* could ſee as *they* do!

CHAP. XXXVII.

Of the Antennæ, Feelers, *or* Horns *of* Insects.

THE *Horns* of *Inſects* have been thought by many deſigned only to clean their Eyes, by wiping off any Duſt that may fall thereon: but as we conſtantly obſerve them perform-

performing that Office with their Fore-legs, 'tis certain their *Horns* must be intended for some other Purpose. And since they are perpetually feeling before them with their *Antennæ* as they walk along *, Mr. DERHAM very reasonably imagines them absolutely necessary to search out and find their Way. For as their Eyes are immoveable, so that no Time is required for their turning them to Objects, there is no necessity that the *Retina*, or *optic Nerve*, should, occasionally, be brought nearer to, or removed farther from the *Cornea*, as it is in other Animals; which would require Time: but their *Cornea* and *Optic Nerve* being always at one and the same Distance, and fitted only to see distant Objects; they would be insensible of, and apt to run their Heads against Bodies very near them, were they not assisted by their *Feelers*.

And that this, rather than wiping the Eyes, is the chief Use of the *Feelers*, is farther manifest from the *Antennæ* of the *Flesh-Fly*, and many other Insects, which are short and strait, and uncapable of being bent down to, or extended over the Eyes: as also from others enormously long, such as those of the *Capricorni* or *Goat Chafers*, the *Cadew Fly*, and divers others both *Beetles* and Flies.

* DERHAM's *Phys. Theol.* p. 365.

The

The lamellated *Antennæ* of some, the clavellated of others, the Topknots or Tufts like *Dandelion* Seeds, the branched, the feathered, and divers other Forms of Horns of the *Beetle*, *Butterfly*, *Moth*, *Gnat*, and many Kinds beside, are surprizingly beautiful when viewed through a *Microscope*. And, in some, these *Antennæ* distinguish the Sexes; for in the *Gnat-kind* all those with Tufts, Feathers, or Brush-Horns (of which there are great Varieties) are *Males:* those with short single-shafted Horns are *Females.*

CHAP. XXXVIII.

Of the Wings *of* Insects.

THERE is such infinite Variety in the Contexture, Formation, Disposition and Ornaments of the *Wings* of *Insects*, according to their different Wants and Ways of Life, that nothing but a curious Observation can make us have any true Conception of it. Some Wings are filmy, as those of *Dragon-flies*; others are stuck over with short Bristles, as in *Flesh-flies*; some are Films covered with short Feathers, like the Tiles of a House, as in *Butter-flies* and *Moths*; others have divided Wings, as the *grey* and *white feathered*

feathered-Moth. The Wings of many sorts of *Gnats* are adorned with Rows of Feathers along their Ridges, and Borders of Feathers round their Edge. Some, again, have Hairs, and others Hooks, placed with the greatest Regularity and Order. All of the Scarab Kind have *Elytra*, or *Cases*, into which their Wings are folded and preserved until they want to employ them. Some of these Cases reach almost to the Extremity of the Tail, as in most Kinds of *Beetles*; and others are very short, as in the *Earwig*. Many of them are likewise extreamly beautiful when brought before the *Microscope*.

All these Kinds of *Wings* have certain bony Parts or Ribs, that give them Strength, along the Sides of which run large Blood-Vessels, branching out into numberless Divisions, and conveying Nourishment to the intermediate Parts: for though no Circulation can be discerned in them, it being probably extreamly slow, we can scarce doubt that there must be continually a Supply of Juices to the Quills, Hairs, or Bristles, wherewith they are armed or ornamented.

As to Motion, *Wings* that are filmy move faster than those covered with Feathers. Mr. Hook observes, that in the Wings of some minute Flies there are many Hundreds, if not Thousands of Vibrations in a Second, and supposes them the swiftest Vibrations in the World;

World: whence he reflects very ingeniously, on the Quickness of the Animal Spirits, that serve to supply this Motion.

Those conversant in *Microscopes* need not be informed, that the beautiful Colours on the Wings of Butterflies and Moths are owing to elegant minute *Feathers*, ending in *Quills*, and placed with great Exactness in orderly Rows; as, when rubbed off, the Holes they come from shew: but few, it may be, have much observed the great Variety of their Make, not only in Moths and Butterflies of different Sorts, but even in those taken from different Parts of the same Wing; insomuch that it is pretty difficult to find any two of them exactly alike.

Rub these *Feathers* gently off, with the End of your Finger, or Pen-knife; and, breathing, upon a single *Talc* in one of your *Sliders*, apply it to the Feathers which seem only like a fine Dust, and they will immediately adhere to it: then placing it before the *Microscope*, if they are not perfect, or lye not to your Mind, wipe them off, and put on others in the same Manner, till you get those you like: then cover them with another *Talc*, and fasten it down with a Wire, that you may preserve them for future Examination. Look at them with the *third* or *fourth*, then with the *second*, and at last with the *greatest Magnifier*.

The

The Wing of a *Midge* is a moſt curious Object, and ſo indeed is every Part of that minute Inſect. The Wing of the little *Plume Moth* is compoſed of ſeveral diſtinct Quills, like thoſe of Birds. There are alſo Wings folded up in the little Caſes on the Backs of *Earwigs*, very pretty to examine. But no more need be ſaid of Wings, ſince every Body muſt be ſenſible the great Variety of them is an endleſs Subject of Enquiry and Admiration.

CHAP. XXXIX.

Of the Ballances *or* Poiſes *of* Inſects.

MOST Inſects having but two Wings, are provided with a little *Ball* or *Bladder* under each, ſet at the Top of a ſlender Foot-ſtalk, which is moveable every Way at Pleaſure. With theſe they *ballance* themſelves in Flight as a *Rope-Dancer* does with his Pole leaded at each End; and if one of them be cut off, the Creature flies for a while very awkardly, as if over-heavy on one Side, and falls at laſt to the Ground. Theſe Bladders being hollow may ſerve likewiſe to produce the Noiſe many Sorts of *Flies* make, by ſtriking their Wings againſt them, and be a Means of finding out one another. In ſome

Creatures they ſtand alone, but the whole Fly-Tribe have little Covers or Shields under which they lye and move. Inſects that have four Wings ballance themſelves with the two leſſer Ones, and, as they want not, have none of theſe little Poiſes. The *Microſcope* may probably find out ſtill farther Beauties, Contrivances and Uſes for them than have been yet diſcovered.

CHAP. XL.

Of the SCALES *of* FISHES.

THE *Scales* or *outſide Coverings* of *Fiſhes* are formed with ſurprizing Beauty and Regularity; and in different Kinds of them, exhibit an endleſs Variety in Figure and Contexture. Some are longiſh, ſome round, ſome triangular, ſome ſquare, and ſome or other of all Shapes we can well imagine. Some, again, are armed with ſharp Prickles, as thoſe of the *Pearch*, *Soal*, &c. Others have ſmooth Edges, as of the *Cod-Fiſh*, *Carp*, *Tench*, &c. There is likewiſe a great Variety even in the ſame Fiſh; for the Scales taken from the Belly, the Back, the Sides, the Head, and all the other Parts are very different from one another. And, indeed, for Variety, Beauty, Regularity, and the Order of

of their Arrangement, the Scales of Fiſhes bear a near Reſemblance to the Feathers on the Bodies and Wings of Moths and Butterflies.

Theſe *Scales* are not ſuppoſed to be ſhed every Year †, nor during the whole Life of the Fiſh; but to have an annual Addition of a new *Scale*, growing over and extending every Way beyond the Edges of the former, in proportion to the Fiſh's Growth; ſomewhat in the ſame Manner as the Wood of Trees enlarges yearly by the Addition of a new Circle next the Bark. And as the Age of a Tree may be known by the Number of Ringlets its Trunk is made up of, ſo in Fiſhes the Number of Plates compoſing their *Scales* denote to us their Age. It is alſo probable, that as there is a Time of Year when Trees ceaſe to grow, or have any farther Addition to their Bulk, the ſame Thing happens to the *Scales* in Fiſhes; and that, afterwards, at another Time of Year, a new Addition, Increaſe or Growth begins. Somewhat like this in Birds and Beaſts their Feathers and Hairs demonſtrate.

Mr. LEEUWENHOEK took ſome *Scales* from an extraordinary large *Carp*, forty-two Inches and a half long, and thirty-three and a Quarter in the Round, *Rynland* Meaſure,

† Vid. LEEUWEN. Epiſt. Phyſiol. *Epiſt.* 24. Maii 1716.

which were as broad as a Dollar. Theſe he macerated in warm Water to make them cut the eaſier: and then cutting obliquely through one of them, beginning with the firſt formed and very little *Scale* in the Center, he, by his *Microſcope*, plainly diſtinguiſhed forty *Lamellæ* or *Scales*, glewed as it were over one another; whence he concluded that the Fiſh was forty Years of Age *.

It has generally been imagined that an *Eel* has got no *Scales*; but if its Slime be wiped clean away, and the Skin be examined by a *Microſcope*, it will be found covered with exceeding ſmall *Scales*, ranged in a very orderly and pretty Manner: and I believe few Fiſhes, unleſs ſuch as have Shells, are to be found without *Scales*.

The Way of preparing *Scales*, is to take them off carefully with a Pair of Nippers, waſh them very clean, and place them in a ſmooth Paper, between the Leaves of a Book, to make them dry flat, and prevent their ſhrivelling up. Then place them between your Talcs in Sliders, and keep them for Examination.

The *Snake*, the *Viper*, the *Slow-worm*, the *Lizard*, the *Eft*, *&c.* afford a further Variety of *Scales*.

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† *Arc. Nat.* Tom. III. p. 214.

CHAP.

CHAP. XLI.

Of the OYSTER.

IN the clear Liquor of an *Oyſter* many little round living *Animalcules* have been found, whoſe Bodies being conjoin'd formed ſpherical Figures with Tails, not changing their Place but by ſinking towards the Bottom, as being heavier than the Fluid: Theſe were ſeen ſometimes ſeparating, and preſently afterwards coming together and joining themſelves again. In other Oyſters *Animalcules* of the ſame Kind were found, not conjoined, but ſwimming by one another, whence they ſeemed in a more perfect State, and were ſuppoſed by Mr. LEEUWENHOEK to be the *Animalcules* in the *Row* or *Semen* of the *Oyſter* *.

A *Female Oyſter* being opened, incredible Multitudes of minute *Embryo-Oyſters* cover'd with little Shells perfectly tranſparent were plainly ſeen therein, ſwimming along ſlowly: in another they were found of a browniſh Colour without any apparent Life or Motion. Monſieur JOBLOT kept the Water running from *Oyſters* three Days, and it appeared full of young *Oyſters* that ſwam a-

* *Arc. Nat.* Tom. II. Par. I. p. 52. Again, p. 145.

bout nimbly, and increaſed in Bigneſs daily. A Mixture of Wine, or the very Vapour of Vinegar killed them.

In the Month of *Auguſt* Oyſters are ſuppoſed to breed, becauſe young Ones are then found in them. Mr. LEEUWENHOEK opened an Oyſter on the fourth of *Auguſt*, and took out of it a prodigious Number of minute *Oyſters*, all alive, and ſwimming briſkly in the Liquor, by the Means of certain exceeding ſmall Organs extending a little Way beyond their Shells, which he calls their Beards. In theſe little *Oyſters* he could diſtinguiſh the joining of the Shells, and perceived ſome that were dead, with their Shells gaping, and as like large *Oyſters* in Form, as one Egg is like another.

As for the Size of theſe *Embryo-Oyſters*, he computes, that one hundred and twenty of them in a Row would extend an Inch; and, conſequently, that a globular Body whoſe Diameter is an Inch, would, if they were alſo round, be equal to one Million ſeven hundred and twenty-eight thouſand of them *. He reckons three or four Thouſand are in one *Oyſter*, and found many of the *Embryo-Oyſters* among the Beards, ſome faſtened thereto by ſlender Filaments, and

* Vid. *Arc. Nat.* Tom. IV. p. 513.

others

others lying loose. He likewise found other *Animalcules* in the Liquor five hundred times smaller than *Embryo-Oysters*.

CHAP. XLII.

Of the LIGHT *on* OYSTERS.

IT is not very uncommon to see on the Shells of Oysters, when in the Dark, a *shining Matter* or *blewish Light* like the Flame of Brimstone, which sticks to the Fingers when touched, and continues shining or giving Light a considerable Time, though without any sensible Heat *. Monsr. AUXAUT observed this *shining Matter* with a *Microscope*, and discovered it to consist of three Sorts of *Animalcules*. The first whitish, having twenty-four or twenty-five Legs on each Side, forked; a black Speck on one Part of the Head; the Back like an *Eel* with the Skin strip'd off. The second Sort red, resembling the common *Glow-worm*, with Folds on its Back, but Legs like the former, a Nose like a Dog's, and one Eye in the Head. The third Sort speckled, a Head like a *Soal*, with many Tufts of whitish Hairs on the Sides thereof. He saw also some much larger, and greyish, having a great

* Vid. *Phil. Trans.* Numb. 12.

Head, two Horns like a Snail's, and ſix or eight whitiſh Feet: but theſe ſhined not.

As the Bodies of Lobſters and ſome other Kinds of Fiſhes, tainted Fleſh, rotten Wood, and other Subſtances are ſometimes found to ſhine with a Light reſembling the foregoing, may it not probably proceed from the ſame Cauſe, *viz.* from *Animalcules?* Some have alſo ſuppoſed, that the *Ignis Fatuus, Will-in-a-Wiſp*, or *Jack-a-Lanthorn*, is nothing elſe but a Swarm of minute flying Inſects, that emit Light around them in the Manner Glow-worms do: and indeed the Motions, and ſeveral other Circumſtances of this Sort of Fire, (if I may ſo term it) ſeem favourable to ſuch Opinion.

The curious will judge it proper to examine this Matter carefully, and to them it is ſubmitted.

CHAP. XLIII.

Of the MUSCLE.

I Have obſerved already, in the 127*th Page* of this Treatiſe, that a *Muſcle* is a moſt delightful Object for the *Microſcope*; and that in the tranſparent Membrane, adhering on either Side to the Fore-part of each Shell, the

the Blood may be ſeen circulating through an amazing Number of Veſſels, even in the ſmalleſt Particle of it that can be applied for Examination.

Mr. LEEUWENHOEK, in ſeveral that he diſſected, diſcovered Numbers of *Eggs* or *Embryo-Muſcles* in the *Ovarium*, appearing as plainly as if he had ſeen them with the naked Eye, lying with their ſharp Ends faſtened to the Strings or Veſſels whereby they receive Nouriſhment. Theſe minute *Eggs* or *Embryo-Muſcles*, are, in due Time, laid or placed by the Parent, in a very regular and cloſe Order, on the Outſide of the Shell: where, by means of a glewy Matter, they adhere very faſt, and continually increaſe in Size and Strength, till becoming perfect *Muſcles*, they fall off and ſhift for themſelves, leaving the Holes where they were placed behind them. This abundance of *Muſcle-Shells* viewed by the *Microſcope* can ſhew. Sometimes two or three thouſand of theſe Eggs adhere to the Shell of one Muſcle; but 'tis not certain they were all fixed there by the Muſcle itſelf, for they frequently place their Eggs on one another's Shells. The fringed Egg of the Muſcle, which Mr. LEEUWENHOEK calls the Beard, has in every the minuteſt Part of it ſuch a Variety of Motions, as is unconceivable: for being compoſed of longiſh Fibres, each Fibre has on both Sides a vaſt many moving Particles,

ticles, which one would almoſt imagine to be *Animalcules* †.

The Threads or Strings, which we term the Beard, are compoſed of a Glew which the Muſcle applies by the Help of its Trunk to ſome fixed Body and draws out as a Spider does its Web, thereby faſtening itſelf, that it may not be waſhed away. If Muſcles be put into Salt and Water, we may have the Pleaſure of ſeeing them perform this Work, and faſten themſelves to the Sides or Bottom of the Veſſel we place them in.

Cockles, Scallops, Limpets, Perriwinkles, and Abundance of other Shell-Fiſh, are Objects that have as yet been very ſlightly examined by the *Microſcope*; and, therefore, the ſerious Enquirer into Nature's ſecret Operations may here be certain of diſcovering Beauties which at preſent he can have no Conception of.

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† *Philoſ. Tranſact.* Numb. 336. *Art. Nat.* Tom. II. p. 19. &c. Tom. IV. p. 423. &c.

CHAP.

CHAP. XLIV.

Of HAIRS.

THE *Hairs* of Animals are very different in their Appearance before the *Microscope*, and can furnish out a great Variety of pleasing Observations. MALPIGHI discovered them to be tubular, that is, composed of a Number of extreamly minute Tubes or Pipes, in his Examination of a Horse's Main and Tail, and in the Bristles of a Boar. These Tubes were most distinguishable near the End of the Hairs, where they appeared more open: and he sometimes could reckon above twenty of them. In the Hedge-Hog's Prickles, which are of the Nature of Hairs, he perceived these Tubes very plainly, together with elegant medullary Valves and Cells.

There are also in the *Hairs* of many Animals, in some transverse, in others spiral Lines, somewhat of a darker Colour, running from Bottom to Top in a very pretty Manner. A * Mouse's Hairs are of this Sort, they appear as it were in Joints like the Back-bone, are not smooth but jagged on the Sides, and terminate in the sharpest Point imaginable. Hairs taken from a

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* Vid. *Arcan. Nat.* Tom. III. p. 47.

Mouse's

Mouſe's Belly are leaſt opake, and fitteſt for the Microſcope.

The *Hairs* of Men, Horſes, Sheep, Hogs, *&c.* are compoſed of ſmall, long, tubular Fibres or ſmaller Hairs, encompaſſed with a Rind or Bark; from which Structure a Split Hair appears like a Stick ſhivered with beating. They have Roots of different Shapes in different Animals, become lengthened by Propulſion, and are thicker towards the Middle than at either End.

Hairs of *Indian* Deer are perforated from Side to Side: our *Engliſh* ones ſeem covered with a kind of ſcaly Bark. The Whiſkers of a Cat, cut tranſverſly, have ſomewhat in the Middle like the Pith of Elder. * The Quills of Porcupines or Hedge-Hogs have alſo a whitiſh Pith in a ſtar-like Form: and a human Hair cut in the ſame Manner ſhews a Variety of Veſſels in very regular Figures.

Hairs taken from the Head, the Eyebrows, the Noſtrils, the Beard, the Hand, and other Parts of the Body, appear unlike, as well in the Roots as in the Hairs themſelves, and vary as Plants do of the ſame *Genus*, but of different Species.

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* HOOK's Microg. p. 157.

CHAP.

CHAP. XLV.

Of the FARINA *of* FLOWERS.

THE *Farina*, or *mealy Powder*, found on the little pendant Tops of almoſt every Flower, is ſomewhat ſo analogous to the *Semen* of Animals, that it deſerves the ſtricteſt and moſt attentive Examination.

This Powder, whoſe Colour is different in Flowers of different Kinds, was imagined, by former Ages, to be a mere excrementitious and unneceſſary Part of the Plant: but the *Microſcope* here alſo has made ſurprizing Diſcoveries, by ſhewing, that all the minute Grains of this Powder are regular, uniform and beautiful little Bodies, conſtantly of the ſame Figure and Size in Plants of the ſame Species, but in different Kinds of Plants as different as the Plants themſelves.

It was impoſſible to obſerve this Order and Configuration of the *Farinæ*, without concluding, that Providence, which never acts in vain, muſt intend a nobler Uſe for Bodies ſo regularly formed, than to be diſſipated by the Winds and loſt. This Reflection drew on farther Examination; and farther Examination, by the Help of the ſame Inſtrument, ſoon diſcovered, that this Powder is produced and preſerved with the utmoſt Care,

Care, in Veſſels wonderfully contrived to open and diſcharge it when it becomes mature: that there is likewiſe a *Piſtil*, *Seed-Veſſel*, or *Uterus* in the Center of the Flower, ready to receive the minute Grains of this Powder, as they either fall of themſelves, or are blown out of their little Cells. And Experience, founded on numberleſs Experiments, proves, that on this depends entirely the Fertility of the Seed: for if the *Farina-Veſſels* be cut away before they open and ſhed their Powder, the Seed becomes barren and unproductive.

This *Farina* is therefore judged to be the Male Seed of Plants, and every little Grain of its Powder may poſſibly contain in it a minute Plant of the Species whereto it belongs.——It is wonderful to obſerve the various Contrivances Nature employs to prevent this Powder from being unprofitably diſperſed, and to aſſiſt its Entrance into the proper *Piſtil*, *Seed-Veſſel* or *Uterus* prepared for it. The Tulip, for inſtance, which ſtands upright, has its *Piſtil* ſhorter than the *Farina-Veſſels*, that the Powder may fall directly on it: but in the Martagon, which turns downwards, the *Piſtil* is longer than the ſaid *Veſſels*, and ſwells out at its Extremity, to catch the *Farina* hanging over it, as it ſheds.

A Mind inquiſitive into Nature's hidden Beauties, will find inexpreſſible Delight in examining and conſidering the endleſs Variety diſcoverable in the *Farinæ* of numberleſs vegetable Species. In that of the Mallow, each little Grain appears to be an opake Ball with Prickles iſſuing from it on every Side. The Sun-Flower *Farina* ſeems compoſed of flat circular minute Bodies, ſharp-pointed round the Edges; the middle of them appears tranſparent, and exhibits ſome Reſemblance of the Flower it proceeds from. The Powder of the Tulip is exactly ſhaped like the Seeds of Cucumbers and Melons. The *Farina* of the Poppy appears like Pearl-Barley, with a Furrow, as in that, reaching from End to End. That of the Lilly is a great deal like the Tulip.

I'll not anticipate the Pleaſure of the Curious, or take up their Time in deſcribing more of theſe *Farinæ*, which every Flower they come at preſents to their Examination; but adviſe them not to neglect the Veſſels that contain it, for they will find Beauties in them alſo ſufficient to reward their Pains.

Gather your *Farina* in the midſt of a Sun-ſhiny dry Day, when all the Dew is off: be careful not to ſqueeze or preſs it, but ſhake or elſe gently bruſh it off with a ſoft Hair Pencil upon a piece of clean white Paper.

per. Then take a ſingle Talc or Iſinglaſs between your Nippers, and breathing on it, apply it inſtantly to the *Farina*, which the Moiſture of your Breath will make adhere to it. If too great a Quantity of Powder ſeems ſticking to your Iſinglaſs, gently blow off a little; if there be not enough, breath on it again, and touch the *Farina* with it as before. Then put your Glaſs into the Hole of a Slider, and apply it to the *Microſcope* to ſee if the little Grains are ſpread according to your liking, and when you find they are, cover them cautiouſly with another Talc, which faſten down with a braſs Wire; but let not the Glaſſes preſs hard upon the *Farina*, for that will deſtroy its true Figure, and repreſent it different from what it is.

A Collection of the moſt remarkable *Farinæ* thus preſerved muſt be a laſting Entertainment to thoſe who ſtudy Nature: to ſuch I alſo recommend a diligent Examination of the little Cells that contain the *Farina*, and likewiſe of the *Piſtils* or *Uteri* and other Parts of Generation in Flowers. Let them only begin with the Arch-Angel, or blind Nettle with a white Flower, or even with the common Mallow, and they will diſcover Beauties impoſſible to be deſcribed. And as every other Flower has Organs for the ſame Purpoſe, though of a different Form and Structure, here are Wonders

Wonders in abundance for the *Microſcope* to diſcover, and happy the Man who can find moſt Leiſure to explore theſe Worlds as yet unknown!

I ſhall add only one Obſervation more before I leave this Head, which is, that as the *Animalcules* in *Semine* differ not in Bigneſs according to the Size of thoſe Animals whence the *Semen* comes: ſo the *minute Grains* compoſing the *Farinæ* of Vegetables are not bigger or leſs in Proportion to the Size of the Plants producing them, but are often the direct contrary; as we find by the *Farina* of the little creeping Mallow, the Globules of which are larger than thoſe of the lofty gigantick Sun-flower.

CHAP. XLVI.

Of SEEDS.

EACH Seed includes a Plant: that Plant, again,
Has other Seeds, which other Plants contain:
Thoſe other Plants have all their Seeds; and, thoſe,
More Plants, again, ſucceſſively, incloſe.
Thus, ev'ry ſingle Berry that we find,
Has, really, in itſelf whole Foreſts of its Kind.
Empire and Wealth one Acorn may diſpence,
By Fleets to ſail a thouſand Ages hence:
Each Myrtle-Seed includes a thouſand Groves,
Where future Bards may warble forth their Loves.

So ADAM's Loins contain'd his large Poſterity,
All People that have been, and all that e'er ſhall be.

Amazing Thought! what Mortal can conceive.
Such wond'rous Smallneſs!——Yet, we muſt believe
What Reaſon tells: for Reaſon's piercing Eye
Diſcerns thoſe Truths our Senſes can't deſcry.

I hope to be excuſed for borrowing the Lines above from a little *Poem* of my own, called the *Univerſe*, publiſhed ſome Years ago; as they contain a Suppoſition, which, however chimerical it may appear at firſt, will, if duely conſidered, be found, perhaps not only poſſible, but even highly probable. MALPIGHI, LEEUWENHOEK, HOOKE, GREW, and ſeveral others bear Witneſs, that the *Microſcope* has diſcover'd minute Plants not only in the larger Seeds, ſuch as the Walnut, Cheſnut, Acorn, Beech-nut, Seed of the Lime, Cotton-ſeeds, Peaſe, *&c.* but alſo in the ſmaller of Rhadiſh, Hemp, Chervil, Scurvy-graſs, Muſtard, and multitudes of other Seeds. About two Years ago, I likewiſe had the Honour to preſent the Diſſection of a Seed of the *Gramen tremulum*, or *trembling Graſs*, with an Account thereof to the *Royal Society*, wherein a perfect Plant appeared, with its Root, ſending forth two Branches, from each of which ſeveral Leaves or Blades of Graſs proceeded. Thus far our Sight aſſiſted by the *Microſcope* is able to diſcover: and as that Inſtrument convinces

convinces us that Nature in her Operations is in no wise confined to our Conceptions of Bigness, but acts as freely in the minute Fabrick of a Mite, as in the bulky Compass of a Whale or Elephant: nay, that she rather seems to wanton in her Skill, by giving a greater Number of Limbs, and more numerous Ornaments to the minute Creatures than to the larger ones. When these Things, I say, are seen, and reflected on, it is easy to conceive the rest.

Most Kinds of Seeds must be prepared, in order to discover the minute Plants they contain, by steeping them in warm Water till their Coats can be separated and their seminal Leaves opened without Laceration: tho' some few Sorts may better be dissected dry. But Seeds even without any Preparation are exceeding pretty Objects, and afford infinite Varieties of Figure, Colour and Decoration.

The Seeds of Strawberries rise out of the Pulp of the Fruit, and appear themselves like Strawberries when viewed.

Poppy Seeds (and what we call Maw-Seeds, which come from *Germany*, and are produced by a Kind of Poppy) in Shape resemble little Kidneys, but have Furrows or Ridges on their Surfaces curiously disposed with regular Sides and Angles. From these Seeds a Dust may be shaken, that looks agreeable enough when brought before the

Microſcope; having nearly the ſame Appearance as the Surfaces of the Seeds, with the Advantage of being tranſparent. This Duſt is really the fine Membranes that lay between the Seeds; which, by the Preſſure of the Seeds againſt them, have received Marks correſponding to the Ridges or Furrows on the Seeds themſelves.

Seeds of the leſſer Moonwort, of Tobacco, Lettice, Thyme, Chervil, Parſley, and a thouſand others, afford a delightful Entertainment.

The Ancients imagin'd the capillary Plants and many other Kinds to produce no Seeds at all, and their Miſtake could never have been rectified by the naked Eye: but the *Microſcope* has diſcovered, that all the ſeveral Species of Fern, Harts-Tongue, Maiden-Hair, *&c.* are ſo far from being barren in this Reſpect, that they are amazingly fruitful: that the Seed-Veſſels are on the Backs of the Leaves, and that the Duſt which flies off when we meddle with them, is nothing but their minute Seeds. Theſe Seed-Veſſels appear to the naked Eye like a black or brown Scurf on the Backſide of the Leaf; but, when viewed by the *Microſcope*, reſemble little circular Tubes, divided into many Cells, containing Seeds. When the Seed is ripe, the Veſſels fly open with a Spring, and ſpirt the Seeds out on every Side, in the Form of Duſt: and if at that Seaſon ſome of the Leaves are put in a Paper Cone, and

that

that be held to the Ear, the Seed-Veſſels may be heard to burſt with a conſiderable Noiſe. Some of theſe minute Veſſels contain at leaſt an hundred Seeds, inviſible to the naked Eye.

It would be tedious to enumerate the Beauties of Seeds, ſince every tranſient Obſerver muſt be ſenſible of their great Variety: but I believe I ſhall be excuſed, if I take Notice of the Powder or Seed of the *Fungus Pulverulentus* or *Puff-Ball*, which, when cruſh'd, ſeems to the naked Eye like a Smoke or Vapour; but when examined by one of the greateſt Magnifiers (for elſe it cannot be diſtinguiſhed) it appears to be infinite Numbers of little Globules, of an Orange Colour, ſomewhat tranſparent, whoſe Axis is not above the fiftieth Part of the Diameter of a Hair: ſo that a Cube of a Hair's Breadth Diameter would be equal to an hundred and twenty-five thouſand of them. This was the Powder of a *Fungus* bigger than two Fiſts; but in another Sort the Size of a ſmall Apple, the Globules were of a darker Colour, and had each a little Stalk or Tail *. Theſe are, evidently, ſo many *minute Puff-Balls*, furniſhed with Stalks or Tails to penetrate eaſily into the Ground: and the Miſchief they do

* Vide *Philoſoph. Tranſact.* Numb. 284. and DERHAM's *Phyſ. Theol.* p. 418.

the Eyes is probably owing to their ſharp Stalks that prick and wound them *.

CHAP. XLVII.

Of LEAVES.

THE *Leaves* of Trees or Plants are full of innumerable Veins and Ramifications, that convey the perſpirable Juices to the Pores, for their Diſcharge. Whether or no there be any Circulation in them is ſtill a Matter of Doubt; but as their Juices, when let out, immediately break, coagulate, and become a ſtiff Jelly, it ſeems probable there may be ſome Circulation which prevents the ſame Effect in the Veſſels. The ſudden ſhrinking, cloſing, and opening of Flowers, the raiſing and ſinking the Heads of Poppies, *&c.* the vermicular Motions of the Veins of Plants when expoſed to the Air, ſeem alſo to imply ſomewhat like Senſation. The *Microſcope* may perhaps be of Service to diſcover much more on theſe Subjects than we yet know.

* A *Puff-Ball* being burſt near the Eyes of a Boy of 12 Years old, by an unlucky Play-fellow, and the Duſt thereof flying into them, occaſioned ſuch Swelling, Inflammation, and intenſe Pain, with a continual Diſcharge of Water, that he could not open them for ſeveral Days; and did not recover his Sight in leſs than a Fortnight, tho' all the Remedies that could be thought on were applied. Vide JOH. MUY's *Prax. chirur. ration.* Obſerv. I.

Mr. LEEUWENHOEK tearing to Pieces a Leaf of the Species of *Box* called *Palma Cereris*, that he might examine it the better, computed one Side of it to be furniſhed with an hundred ſeventy two thouſand and ninety Pores: and as the other Side muſt have as many, the whole Number of Pores in a ſingle Leaf of *Box* will be three hundred forty four thouſand one hundred and eighty.

The Leaves of *Rue* ſeem full of Holes like a Honey-comb; all the Kinds of *St. John's Wort* appear likewiſe ſtuck full of Pin-Holes to the naked Eye; but the Microſcope ſhews, that the Places where thoſe Holes ſeem to be, are really covered with an exceeding thin and white Membrane.

The Backſide of the Herb *Mercury* looks as if rough-caſt with Silver, and the Ribs full of white round tranſparent Balls, like numberleſs Grapes, faſtened by ſlender Footſtalks.

A *Sage Leaf* appears like Rug or Shag, full of Knots taſſel'd with ſilver Thrums, and embelliſhed with fine round cryſtal Beads or Pendants faſtened by little Footſtalks.

The Backſide of a *Roſe Leaf*, but eſpecially of *Sweet Briar*, looks diaper'd with Silver *.

Every Body knows that the Leaves of *Stinging Nettles* are thick ſet with ſharp

* Dr. POWER's *Microſcop. Obſervat.*

Prickles, that penetrate the Skin when touched, and occaſion Pain, Heat, and Swelling: which Symptoms were imagined, formerly, to enſue from the Prickles being left in the Wounds they make. But the *Microſcope* diſcovers ſomething much more wonderful in this common Vegetable, and ſhews that its Prickles are formed and act in the ſame manner as the Stings of living Animals. For every one of them is found to be a rigid hollow Body, terminating in the moſt acute Point imaginable, with an Opening near its End. * At the Bottom of this Cavity lies a minute Veſſel or Bag, containing a limpid Liquor, which, upon the leaſt touching of the Prickle, is ſquirted through the little Outlet; and, if it enters the Skin, produces the Miſchiefs before-mentioned by the Pungency of its Salts. Hence it comes to paſs, that when the Leaves of *Nettles* are conſiderably dried by the Heat of the Sun, they ſting but very little: whereas ſuch as are green and juicy produce violent Pain and Inflammation. But the quite contrary to this would happen, if the Symptoms were only owing to the Breaking of the Prickles in the Fleſh: ſince, when dry, they muſt be more brittle, as well as more rigid, than when they abound with Juice.

* HOOK's *Microgr.* p. 142. *Arc. Nat.* Tom I. Par. III. pag. 107.

Quere,

Quere, Are there any Valves in the Veſſels of Vegetables, as in thoſe of Animals, to let the Juices paſs, but hinder their Return?

CHAP. XLVIII.

Of SALTS *in General.*

IT is I think agreed, that all Bodies have their *Salts*; from whoſe different Configurations and Impreſſions many wonderful Changes are effected both in Solids and Fluids, in things animate and inanimate. Saline Particles ſtriking upon the Nerves of Animals excite the Senſations of Taſte and Smell; and as their Forms and Degrees of Impulſe are almoſt infinitely diverſified, the Senſibility of Pain or Pleaſure ariſing therefrom muſt be varied almoſt infinitely, according to the greater or leſs Delicacy of the Organs they ſtrike upon.—It is therefore of great Conſequence to diſcover what we can about them.

The *Microſcope* ſhews, that *Vinegar* owes its Pungency to Multitudes of floating oblong quadrangular Salts, each of which, tapering from its Middle, has two exquiſitely

ſharp Ends. Theſe Salts being inexpreſſibly minute, can hardly be diſcovered, unleſs a Drop or two of Vinegar be expoſed for ſome Hours to the Air, that the more watry Part may evaporate, before we attempt to view them.

Their Shape appears, Plate XIV. Fig. I.

If *Crabs Eyes* are infuſed in *Vinegar*, after the Effervescence is over, the Shapes of the *Salts* will be found quite altered; their ſharp Points ſeem broken off, and they appear in different ſquare-like Forms, as at Fig. II.

In Wines of ſeveral Kinds the *Salts* are diſtinguiſhable, of various Figures, many of them reſembling thoſe in *Vinegar*, but with Ends much more obtuſe: ſome are ſhaped like a Boat, ſome like a Spindle, others like a Weaver's Shuttle, and others ſquare: there are alſo infinite Varieties of other Forms.

The Salts of Sugar candy'd are ſhewn Fig. III.

Vegetable Salts are to be extracted by burning the Wood, Stalks, or Leaves of any Tree, or Plant; throwing the Aſhes into Water; then filtering, and ſetting the Liquor to cryſtallize in a cold Place. Their Oils alſo, when examined, preſent abundance of Salts.

The *Salts* of Minerals or Metals are to be come at, by quenching them, when red hot, in Water, then filtering, evaporating, and cryſtallizing.

Pretty

Pag. 20

F.

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Pretty

Fig. I. p. 260.

Fig. II. p. 260.

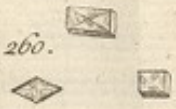

Fig. III. p. 260.

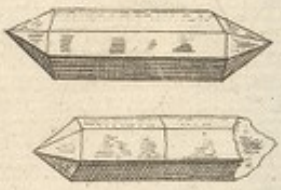

Fig. IV. p. 263.

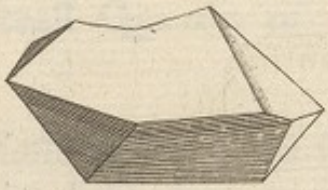

Fig. V. p. 263.

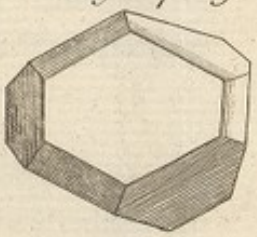

Fig. VI. p. 263.

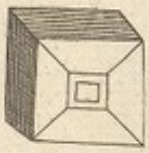

Fig. VII.

VII. p. 264.

Fig. VIII. p. 265.

1. 2. 3. 4. 5. 6. 7.

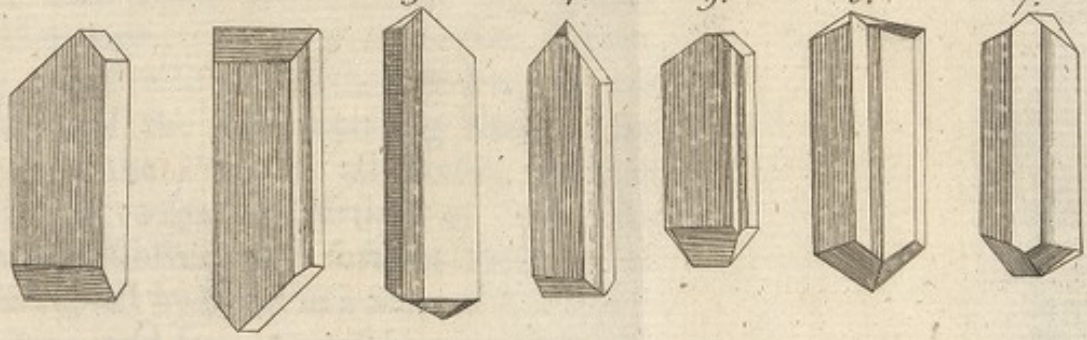

Fig. IX. p. 265.

Fig. X. p. 265.

Fig. XI.

XI. p. 265.

26

Pretty *Salts* for Obſervation are, Pot-aſh, *Engliſh* and *Ruſſian*: Salt of Wormwood, Camphire, Salt of Tartar, Salt Armoniac, Salt of Hartſhorn, Salt of Amber, *&c.* They ſhould be examined firſt in their dry or cryſtallized State, and afterwards diſſolved in a very ſmall Quantity of ſome tranſparent Fluid.

The *Salts* found in all Bodies when ſeparated by Fire, ſeem as ſo many *Pegs* or *Nails**, penetrating their Pores, and faſtening their Parts together: but as *Pegs* or *Nails* when too large, or too numerous, ſerve only to ſplit or rend aſunder; *Salts*, by the ſame Means, oftentimes break, ſeparate and diſſolve, inſtead of joining and making faſt. They indeed are meerly Inſtruments, and can no more act upon or force themſelves into Bodies, than Nails can without the Stroke of a Hammer; but they are either driven on by the Preſſure of other Bodies, or by the Spring of the Air impelling them. As *Salts* enter the Pores of all Bodies, *Water* inſinuates between the Particles of *Salt*: ſeparates or diſſolves, and ſuſtains them in its Interſtices, till by being in a State of Reſt they precipitate, and form themſelves into Maſſes. By this diſſolving Power, *Water* becomes the

* Vide *Spectacle de la Nat.* Dial. XXVI.

Vehicle

Vehicle of *Salts*, and conveys them into the Pores of Bodies, where it leaves them to execute their proper Office.

Moſt ſorts of *Animal* and *Vegetable Salts* are likewiſe, probably, diſſolved by the Juices of the Stomach, before they enter the Blood, or they would occaſion great Miſchiefs: and the Difficulty of diſſolving ſome *mineral Salts*, or breaking off their Points in the ſame Manner, may be the Reaſon of their dreadful Effects.

CHAP. XLIX.

Of SALTS *in Mineral Waters.*

THE *Microſcope* may be of great Service to determine by ocular Examination, what Kinds of *Salts* our medicinal Springs are charged with; whence to form a Judgment in what Caſes their Waters may be drank to Advantage.

The four Kinds of *foſſile Salts*, beſt known, are, according to Dr. † LISTER, *Vitriol*, *Alum*, *Salt-petre*, and *Sea-Salt*: whereto he adds a fifth, leſs known, though more

---

† *Vide* LISTER de Fontibus Medicatis Angliæ.

common

common than any, *viz. Calcarious Salt*, or *Nitre*.

Green Vitriol is produced from the Iron *Pyrites*. When mature and perfect, its Cryſtals are always pointed at each End, and conſiſt of ten Planes with unequal Sides: that is, the four middle Planes are Pentagons, and each of the ſharp Ends is made up of three triangular Planes, as *Plate* XIV. *Fig.* 4.

Alum burnt, diſſolved in Water, and ſtrained, affords Cryſtals whoſe Top and Bottom are two ſexangular Planes, the Sides round which appear compoſed of three Planes that are likewiſe ſexangular, and three double quadrangular ones, placed alternately. So that every perfect Cryſtal conſiſts of eleven Planes, *viz.* five ſexangular, and ſix quadrangular, *Fig.* V.

The Water of our Inland *Salt-Springs* affords Cryſtals of an exact cubical Form, one Side or Plane whereof ſeems to have a particular Clearneſs in the Middle, as if ſome Deficiency were in that Place; but the other five Sides are white and ſolid. See *Fig.* VI.

Sal Gem, diſſolved, ſhoots into the like cubic Cryſtals.

Sea-Water boiled to Dryneſs, and its *Salt* diſſolved again in a little Spring Water, gives Cryſtals alſo that are cubical, but remarkably different from thoſe laſt deſcribed: for in the *Cryſtals* of *Sea-Salt*, all the Angles of the Cube are ſeemingly cut off, and the Corners

Corners left triangular: (See Fig. XI. XI.) whereas the *Salts* of our *Inland-Springs* have all their Corners ſharp and perfect, as *Fig.* VI.

Nitre, or *Salt-petre*, throws itſelf into long ſlender ſexangular Cryſtals, whoſe Sides are Parallelograms. One End conſtantly terminates either in a pyramid-like Point, or elſe in a ſharp Edge, according to the Poſition of the Sides of two unequal Planes. The other End is always rough, and appears as if broken. *Fig.* VII. VII.

The moſt general, though leaſt noted of all the *foſſile Salts* amongſt us, is a Kind of *Wall* or *calcarious Nitre*, or *Lime-Salt*, which may be collected from the Mortar of ancient Walls; and is, as Dr. LISTER ſuppoſes, what a great Part of the Earth and Mountains conſiſt of*. Its Cryſtals are ſlender and long, the Sides of them four unequal Parallelograms: their Point at one End is formed of two Planes with triangular Sides; the other End terminates in two quadrangular

* We are well aſſured, that in *France*, it is the common Practice, for thoſe who have the Superintendency of the King's *Salt-petre* Works, to amaſs vaſt Quantities of the Mortar and Rubbiſh taken from old Buildings: whence, by proper Management, they extract abundance of this *calcarious Nitre*. And when they have got all they can from it, by letting it lie together for ſome Years, it becomes impregnated anew, and affords almoſt as much as it did at firſt.

Planes: though both Ends are ſeldom to be found unbroken.---Of this Salt ſome is ſeen with five Sides, and all the other Varieties may be found in it which are ſhewn *Fig.* VIII. 1. 2. 3. 4. 5. 6. 7.

Unripe, or imperfect *Vitriol*, is a white Salt, whoſe Cryſtals are Cubic Rhomboides: as *Fig.* IX.

The Cryſtals of our Inland *Salt-Springs*, not yet arrived at Maturity and Perfection, are formed like *Fig.* X.

The Particles of each of theſe particular *Salts*, either in falling one upon another, or uniting on one common Baſe, form themſelves into Maſſes, which are invariable, and always of the ſame regular Figure: but it is beſt to examine them in the ſmalleſt Maſſes, their Shape being there moſt perfect and diſtinct.

CHAP. L.

Miſcellaneous DISCOVERIES *and* OBSERVATIONS.

IT has been urged by ſome in behalf of ſpontaneous Generation, that Worms are found in the human Bowels, of a Figure ſeen no where elſe; and therefore that they muſt be generated there, ſpontaneouſly, by the Slime and Heat of the Inteſtines: for if they proceed from Parents of their own Kind without

without the Body, and get into it by Accident, either in the Egg or any other State, where are thoſe Parents found?---This ſeems a very ſtrong Objection; but the *Microſcope*, I believe, can enable us to anſwer it.

Worms found in the human Body are of three Kinds, *viz.* the *Aſcarides*, or *little, ſhort, ſlender Maggots*, ſo nearly reſembling a Sort frequently met with in warm moiſt Places, under rotten Wood, *&c.* that they may reaſonably be ſuppoſed the ſame.---The *Teretes, Rotundi*, or *long round Worms*, which are evidently the Species of Earth-worms found commonly in Dunghills and Hot-Beds; whoſe Degree of Warmth is pretty equal to that of the human Bowels. And the *Lati, Faſciæ, Tape-worms* or *Joint-worms*, which are broad, flat, full of Joints, and ſometimes of a monſtrous Length, extending many Yards along the Inteſtines.---- This is the Animal ſaid to be found no where elſe: but the *Microſcope* has very happily diſcovered Worms of the ſame Figure exactly, and differing in Size only, in the Inteſtines of *Eels*, ſo fixt as not to be removed without great Difficulty, but contracting and dilating themſelves very agreeably*. They are of an incredible Length in compariſon of their Breadth, and when contracted become

* *Arcan. Nat.* Tom. IV. p. 367.

ſix

six times broader than when extended. There are *Tape-Worms* likewise in the Bowels of a *Turbut*, though shorter than those in *Eels*, and with a Head not quite the same. They are fixed to the Guts by a kind of Hooks which they have in their Mouths, and are not to be got off but by holding the Tail with one Hand, and separating the Head from the Intestines with a Needle.

Having found these *Worms* in the Intestines of *Fishes*, let us now consider how they could get there. And, 'tis probable, they are naturally Water-Animals, whose Eggs or Young Ones getting into the Stomach with the Water or the Food, become hatched or nourished there. In the same Manner they may also be introduced into the Stomach of other Animals: and their Difference of Size in one or the other, may arise from the different Degrees of Heat, and the Kinds of Nourishment they meet with.---Three other Sorts of *Worms* are also found in the Intestines of *Eels*. *Carp* are likewise subject to Worms which make them very lean, and so is the *Trout*.--- There are two Sorts of *white Worms* in the *Whiting*; and the *Microscope* may discover them perhaps in every other Kind of Fish; nor can we wonder at it, when we reflect how liable Fishes must be to swallow the Eggs or Young Ones of whatever Insects are Inhabitants of the Waters.

2. There are frequently, in the *Liver* of Sheep, *Animalcules* ſhaped like the Seed of a Gourd, or rather like a ſmall thin Myrtle-Leaf with a very ſhort Foot-ſtalk. Their Colour is whitiſh, but numberleſs branching Veſſels or minute Canals of a greeniſh Yellow are diſperſed every where about them; and a round Hole or Mouth appears near the Stalk End. Theſe Creatures are found often in the *Gall-Bladder*, and in every Part of the *Liver*; where, forming themſelves little Cells, they abide in a Liquor that is ſeemingly Blood mixt with Gall.

3. In the *Heads* of * Stags, *Worms* or *Maggots* are moſt commonly to be met with, lodged in a Cavity under the Tongue, near the *Vertebræ* where the Head joins on to the Neck. Their Shape is partly Cylindrical, being flat underneath, but rounded on the upper Side: in Colour white, with many ſemi-annular Rings beſet with darkiſh Hairs. On the Head are a Couple of exceeding ſmall white Horns, which are thruſt out or drawn in like a Snail's; and under them two minute Claws, black, hard and ſharp, exciting much Itching, and thereby great Uneaſineſs.

‡ *Vide* Redi de *Gener. Inſect.* p. 302.
* Ibid. p. 307.

They

They move along by fixing these Claws, and then dragging up their Bodies to them. The End where their Excrements are discharged has a little Opening, with two black Spots resembling a Half-Moon. Twenty or thirty are usually found in one Head, of the Size of very large Maggots.

4. Like to the foregoing, especially towards the Tail, but smaller, less vigorous, and not so hairy, are certain *Maggots* found in the * *Heads* of Sheep. Their white Bodies are mark'd across with black Lines, (particularly the largest of them:) and two black Spots at the Anus, which form a Half-Moon in the Worms of Deer, compose in these a compleat Circle. They abide most commonly in a hollow Part of the *Os Frontis* near the Insertion of the Horns, but are sometimes found even in the Nostrils, and in the Cavities round the Roots of the Horns. Sometimes too they get higher up into the Head, and make the Sheep run mad. They are less numerous than those in Deer, being seldom more than ten or fifteen.

5. Early in the Spring Season, we shall frequently find sticking to Pales of Wood, especially very old ones, and sometimes to Walls of Brick or Stone, a Sort of *little Worm*

* Vide Redi *de Gener. Insect.* p. 309.

or *Maggot*, incloſed in a Caſe about the Bigneſs of a ſmall Barley-Corn. If this Caſe be viewed with the *Microſcope*, it appears cover'd all over with a moſt delicate Sort of Moſs, intermixt with fine Sand or Earth. At the ſharpeſt End there's a little Hole through which the Excrements are diſcharged, and at the other a larger Opening, where the Creature puts out its Head, and faſtens itſelf to the Pales or Wall. The included Animal is all black, about two Lines of an Inch long, and three quarters of a Line broad. Its Body has ſeveral Ringlets folding over one another. Its Head is large, flat and poliſh'd, reſembling Tortoiſe-ſhell, with ſome Hairs iſſuing from it; and near thereto on each Side are three Legs. The Mouth is large, and in continual Motion, and from it proceeds a ſlender Thread or Web: the Eyes are black and round. This is a pretty Object, and changes I believe to ſome ſort of minute Fly, tho' I have not had an Opportunity of making the Experiment.

6. Nothing is more common, in the Beginning of Summer, than to ſee the Leaves of Peaches, Nectarines, and Cherries curled up and blighted: which Leaves on Examination are found cover'd with *little Inſects* *, ſome

* Monſ. De la Hire calls theſe *Pucerons*, or *little Fleas*, and inſtances them as Inſects that come from *walking* to *flying* without paſſing through the *Aurelia-State:* which they do by only caſting off their Skins, as a little Obſervation will ſhew.

blackiſh,

blackiſh, others green; ſome winged, and others without Wings. Theſe Creatures bring forth their Young alive and perfect, and if their Bodies be opened, ſeveral perfect Embryos will be ſeen therein.——It remains a Doubt, whence, and by what means, theſe Inſects are conveyed upon the young ſprouting Leaves, which, at the ſame Time, are always covered with a glutinous and honey-like Moiſture: but we may hope, diligent Obſervations will diſcover this Secret to us. Trees in this Condition are viſited by Multitudes of *Ants*; which hurt not the Trees, as ſome erroneouſly conjecture, but do them Service, by devouring this Vermin that infeſts them.

7. The *Ant* itſelf is an Object well worth our Notice, being a Creature of a very ſingular Structure. The Head is large, adorned with two pretty Horns, each having twelve Joints. Its Eyes are protuberant and pearled: it has Jaws ſaw-like or indented, with ſeven little Teeth that exactly tally, opening Side-ways, and able to gape very wide aſunder; by the Help whereof it is often ſeen graſping and tranſporting Bodies of three or four times its own Bulk and Weight. It is naturally divided into the Head, the Breaſt, and the Belly or Tail: each of theſe Parts joining to the other by a very ſlender Ligament. From the Breaſt-Part, three Legs come forth on either Side. The Tail is armed with a

Sting, which the Animal uſes only when provoked; but then a poiſonous Liquor is conveyed by it into the Wound, occaſioning Pain and Swelling. The whole Body is caſed over with a ſort of Armour, ſo hard as ſcarce to be penetrated by a Lancet, and thick ſet with ſhining whitiſh Briſtles. The Legs, *&c.* are alſo covered with Hairs, but much ſmaller and of a darker Colour.

Upon opening an *Ant-Hill*, we ſhall ſee them carrying in their Mouths and ſecuring with great Solicitude ſmall whitiſh Bodies, uſually call'd their Eggs. Theſe, however, are not Eggs, but *Ants* in their *Aurelia State*, each encompaſs'd with an Integument of its own ſpinning. We might have conjectur'd this from their Largeneſs in Proportion to a *perfect Ant*, but the *Microſcope* fully proves it, by diſcovering to us their real *Eggs*, of an oblong oval Figure, about the Size of a Grain of Sand*: ninety whereof would not extend the Length of an Inch, nor an hundred and ſeventy be equal in Bigneſs to one of theſe *Aurelia's* incloſed in its Caſe. Theſe minute Eggs produce *Maggots*, which after a Time ſpin themſelves Coverings, become *Aurelias*, and then *Ants*. The Parents Affection for their Young in the *Aurelia State* is ſo ſtrong, that when Danger

* Vide Leeuwen. *Epiſt.* ad Reg. Soc. 9. *Sep.* 1687.

threatens,

threatens, they instantly run away with them, and will sooner die than leave them. There are several Sorts of *Ants* differing both in Size and Colour; and towards the End of Summer many of them are seen having four Wings. These, SWAMMERDAM says are Males†.

The *French Academy* has publish'd a curious Account of *Ants*, whence I shall abstract some few Particulars. Every *Ant*'s Nest (it tells us) has a strait Hole leading into it, about the Depth of half an Inch; which, afterwards, runs sloping downwards to the publick Magazine, where the Grains they collect are stored up: and this is a different Place from that where they rest and eat. ---Their Corn being kept under Ground, would shoot and grow, did they not prevent it by biting out the *Germen* or *Bud* before they lay it up: but this they constantly do, for if their Corn be examin'd no *Bud* will be found therein, nor if sowed in the Earth will it ever vegetate. Was it, however, to lye continually in the Ground, the Moisture would occasion it to swell and rot, and make it unfit for Food. But these Inconveniencies they find means to remedy by their Vigilance and Labour in the following Manner.——

They gather very small Particles of dry Earth, which they bring out of their Holes

† Vide SWAMMERD. *Hist. Generale des Insect.* p. 183.

every Sunſhiny Day, and place them in the Heat. Every one of them brings in her Mouth a Particle of this Earth, lays it by the Hole, and then goes to fetch another: ſo that in a Quarter of an Hour a vaſt Number of ſuch ſmall Particles of dryed Earth are heaped round the Hole. Their Corn is laid upon this Earth when under Ground, and covered with the ſame. When theſe Particles of Earth are brought out, they fetch out their Corn likewiſe, and place it round this Earth, making two Heaps about the Hole, one of dry Particles of Earth, and the other of Grains of Corn. Laſt of all, they fetch out the Remainder of their dry Earth whereon the Corn was laid. They never go about this Work unleſs the Weather be clear, and the Sun very hot: but when both are favourable they perform it almoſt every Day.

The Author of this Account had found a Neſt of *Ants* in a Box of Earth, ſtanding out from a Window two Stories high; whence they made Excurſions both upwards to the Top of the Houſe, where ſome Corn lay in a Garret; and downwards into a Garden, which the Window overlook'd. The Situation of this Neſt obliged them to go up or down a great way before they could poſſibly meet with any Thing; but he found, notwithſtanding, that none of them ever returned empty, but every one brought a Grain

of

of Wheat, Rye, or Oats, a ſmall Seed, or even a Particle of dry Earth if nothing elſe could be got. Some travelled to the farther End of the Garden, and, with prodigious Labour, brought heavy Loads from thence. It requir'd four Hours, as he learned by frequent Obſervation to carry a pretty large Grain or Seed from the Middle of the Garden to the Neſt: and he computed therefrom, that an *Ant* works as hard as a Man who ſhould carry a heavy Load twelve Miles a Day.

The Pains theſe *Ants* took, to carry Grains of Corn up a Wall to the ſecond Story, climbing all the Way with their Heads downward, muſt be exceeding great. Their Wearineſs was ſhewn, by their frequent Stops at the moſt convenient Places; and ſome appear'd ſo fatigued and ſpent they could not reach their Journey's End: in which Caſe, 'twas common to ſee the ſtrongeſt *Ants*, which had carried home their Load, come down again and help them. Sometimes they were ſo unfortunate to fall down with their Burdens when juſt in Sight of Home: but when this happen'd they ſeldom loſt their Corn, but carried it up again.---- He ſaw one, he ſays, of the *ſmalleſt Ants* carrying a large Grain of Wheat with incredible Pains. When ſhe came to the Box where the Neſt was, ſhe and her Load together tumbled back to the Ground. Going down to look for her, he found ſhe had recover'd

the Grain, and was ready to climb up again. The ſame Misfortune befel her three times; but ſhe never let go her Hold, nor was diſcouraged; till at laſt, her Strength failing, ſhe was forc'd to ſtop, and another *Ant* aſſiſted her to carry home her Load to the publick Stock.

How wonderful is the Sagacity of theſe Inſects! How commendable their Care, Diligence, and Labour! How generous their Aſſiſtance of one another for the Service of the Community! How noble their publick Virtue, which is never neglected for the Sake of private Intereſt! In all theſe Things they deſerve our Notice and Imitation.— A contemplative Mind will naturally turn its Thoughts from the Condition and Government of *Ant-Hills* to that of *Nations*; and reflect, that *ſuperiour Beings* may poſſibly conſider Human Kind and all their Solicitudes and Toils, Pride, Vanity, and Ambition, with no more Regard than we do the Concerns of theſe little Creatures.

8. Among Pinks, Roſes, and Sun-flowers, there's to be found, almoſt conſtantly, a *little, long, nimble Inſect* ſmaller than a Louſe, ſometimes creeping, and ſometimes leaping. It appears in the *Microſcope* bodied like a Waſp, with ſix or ſeven annular Diviſions: it has two fair long black and yellow Wings; two Horns, each riſing from a knobbed

Root; two black Eyes, and six Legs. 'Tis so tender the least Touch kills it, but a very pretty Object.

9. A *little Insect* is constantly found in the *Froth* (or *Cuckow-Spit* as some call it) that hangs on the Leaves of Rosemary, Lavender, *&c.* It creeps first, then leaps, and at last flies. It has six Feet, with two blackish Claws at the End of each; a long *Proboscis* to suck up its Food, two Horns, and a Pair of darkish red pearled Eyes. The Tail ends in a Stump, but by its annular Divisions can be thrust out or drawn in at Pleasure.

10. There's a pretty *yellow Insect* on Sycamore Leaves, with six Legs, running very nimbly. The Eyes are red, prominent and pearled; the Horns are slit, and forked at the Ends. At first it has no Wings, but near the Shoulders are two little Protuberances, whence two long Wings come forth when it turns into a Fly or Locust. It is hairy towards the Tail.

11. A small *white oblong Insect* sticks to the Ribs on the Backsides of Rose-Tree Leaves, towards the End of Summer, which turns into a little yellow Locust that skips about the same Tree. In both States it is a pretty Object.

12. There

12. There is alſo a greeniſh *Graſshopper* or *Locuſt*, on Gooſeberry-Leaves, Sweet-Bryar, and golden Mouſe-Ear, in *April* and *May*, with four Legs, two black Eyes, a pair of curious Horns, and many other Beauties.

13. In the Water of Ditches there are frequently Numbers of *Water-Spiders*, not larger than a Grain of Sand; they are very voracious, hunting about continually for Prey: and may be ſeen by the *Microſcope* catching and devouring other minute Animalcules. Some have eight, ſome ten Legs, and *Antennæ* jointed like *Equiſetum* or Horſe-Tail.

14. Likewiſe in ſtanding Waters we may often meet with ſlender *Eels* or *Worms*, about the third of an Inch, and ſometimes more, in Length. They are full of Joints from End to End at large Diſtances from one another, have a ſharp Head like an *Eel*, a large Mouth, and two fine black Eyes. The Tail terminates in a Tuft of Hairs of a very curious Structure; the Motions of the Inteſtines are ſeen diſtinctly, and the whole Animal is a delightful Object.--- The Blood-red *Jointed Worm*, very common in ſtagnant Waters, is alſo well deſerving our Obſervation.

15. The

15. The *Crane-Fly*, called by ALDROVAND *Culex maximus*, by SWAMMERDAM *Tipula terreſtris*, and by the common People *Father-long-Legs*, affords, in every Part of it, agreeable Subjects of Examination: But the Feet are more particularly ſurprizing, for upon diſſecting them, in a Drop of Water, the fleſhy Fibres contract and diſtend, in a Manner not to be imagin'd without ſeeing it, and continue their Motions three or four Minutes. Mr. LEEUWENHOEK found it conſtantly in the Feet of this Creature, but not in thoſe of any other Inſect *. The Inteſtines are alſo very curious, conſiſting of numberleſs Veſſels and Organs, which may be ſeen as plainly by the *Microſcope*, as the Bowels of larger Animals can by the naked Eye †. The Tails both of the Male and Female are of an extraordinary Structure: that of the Female ends in a ſharp Point, wherewith ſhe perforates the Ground, and depoſites her Eggs under the Graſs, in Meadows.

16. The *Multipes*, or *Scolopendra*, has a very long ſlender Body: its Mouth is armed with a pair of ſharp Forceps, and in hot Countries (where they are of a large Size)

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* Vid. *Arc. Nat.* Tom. III. p. 119. † Tom. IV. p. 351.

its

its Bite is venomous; but our ſmaller Ones ſeem not miſchievous. One I examin'd had fifty four Joints, and from every Joint a Leg iſſued on each Side, which, with two others, at the End of the Tail, larger than the reſt, made in all one hundred and ten. When the Creature moves along, theſe Legs follow one another very regularly, making a pretty kind of Undulation, not to be deſcribed, and giving the Body a ſwifter Progreſſion than one would expect, where ſo many Feet take ſo many ſhort Steps, in turn, one after another. There are ſeveral Sorts of theſe Inſects, different in Shape, and in Number of Legs, which the Curious will be pleaſed to examine*.

17. There's an extraordinary Sort of *Caterpillar*, of a middling Size, having four Tufts of yellowiſh white Hair, like little Bruſhes, of an equal Height, ſtanding upright on its Back: below theſe, from each Side, iſſues a Bunch of dark-colour'd Hairs of different Lengths, the Extremities of which are black. Two more Bunches of the ſame Form riſe from the Head like Horns, and another ſtill from the Top of the Tail. Every Hair in theſe Bunches,

* LEEUWENHOEK ſays, the *Indian Millepes* has eight Eyes like the *Spider*. *Quere*. Have *Engliſh* Ones ſo too?

when

when viewed through the *Microſcope*, reſembles a *Peacock*'s Feather, and is a delightful Object. The Inquiſitive will find abundance more Wonders in this amazing Creature, and indeed in moſt Sorts of *Caterpillars*.

18. The *Silk-Worm* is a Creature every Part whereof, either in the *Worm* or *Fly-State*, deſerves our particular Attention: but as both MALPIGHI and LEEUWENHOEK have examined it with great Skill, and publiſhed their Obſervations with anatomical explanatory Drawings, I ſhall refer the Curious to them, and to their own Enquiries; only adviſing ſuch as ſhall engage in a farther Examination, not to neglect the *Skins* theſe Animals caſt off three Times before they begin to ſpin: for the Eyes, Mouth, Teeth, Ornaments of the Head, and many other Parts may be diſcerned better in the *caſt-off Skins* than in the real Animal. —— A due Obſervation of the Changes of this Creature, from the *Caterpillar* to the *Nymph*, *Aurelia*, or *Chryſalis*, and thence to the *Moth* or *Butterfly State*, will give a general Notion of the Changes all *Caterpillars* undergo, tho' ſome little Differences may be in the Manner. SWAMMERDAM ſays, the *Butterfly*, by a judicious Examination, may be traced and diſcerned under each

each of theſe Forms, which are only different Coverings or Dreſſes for it.

19. The Tail of the *Male Silk-Worm* being ſqueezed, *Animalcules* were found in the *Semen* * four times as long as broad: their Backs thicker than their Bellies, like the Shape of a Trout. Their Length was ſuppoſed to be about half the Diameter of a Hair.----- This I experienced myſelf, on the 8th Day of *Auguſt*, in this preſent Year 1742, when taking a *Male Silk-Worm*, that was juſt then come forth in its *Moth-State*, and giving its Tail ſeveral little gentle Squeezes, in about a Minute's Time, a ſmall Drop of a browniſh white Liquor was ſquirted briſkly from it on a Talc I held to receive it; and diluting this with a little Water warmed in my Mouth for that Purpoſe, I was very much ſurprized and pleaſed to obſerve the numberleſs *Animalcules* it contained, ſwimming about, alive and vigorous.——

N. B. Whoever would make this Experiment, muſt do it before the *Moth* has been coupled with the Female; for nothing is to be got from it afterwards, as I have found by ſeveral Trials.

20. The *Proboſcis* of a *Butter-fly*, which winds round in a ſpiral Form, like the Spring

* Vid. Leeuwen. *Arc. Nat.* Tom. I. P. II. pag. 422.

of

of a Watch, serves both for Mouth and Tongue, by entering into the Hollows of Flowers, and extracting their Dews and Juices.---The Shape and Structure of it will be found very surprizing.

21. The *Legs* and *Feet* of *Insects* are wonderful in their Structure and Contrivance, according to their different Circumstances and Necessities of Life, and afford a pleasing Variety of Objects. It is pretty to observe, not only the sharp hooked Claws, but also the skinny Palms of some Flies, *&c.* which enable them to walk on Glass and other smooth Surfaces, even with their Bodies hanging downwards, by means of the Pressure of the Atmosphere: others again have a sort of Spunges, which preserve their Claws from being broken or blunted by striking against hard Bodies, as the Claws of Cats, *&c.* are, by soft fleshy Protuberances at the Bottoms of their Feet.

22. The *Nymph* of the *Clothes-Moth*, which (from being often found scudding among Books and Papers) Mr. Hook calls the silver-coloured Book-worm, is covered with thin transparent Scales, from whose Surfaces a multiplicity of Reflections of Light make the Animal appear in Colour like a fine Pearl. It has six Legs, runs by Starts and Stops, and has three Horns at the Ex-

tremity of the Tail. As this Description is sufficient to make it known, I shall leave the Curious to examine its Beauties, and not anticipate their Pleasure. *Vide* HOOK's *Microg.* p. 208.

23. On the Leaves of Orange-Trees, Fig-Trees, Willows, and many other Trees and Plants, there are various Kinds of *minute Insects*, as yet but little known, inclosed in Tubercles or Swellings.

24. The *Eggs* of *Insects* are remarkable for their different Figure and Colour, and for the particular Regularity and Exactness wherewith they are frequently placed. We shall sometimes find a sort cemented round a Twig of the Sloe-Tree or Damson-Tree, as if fastened there by Art, and rang'd meerly for the Sake of Beauty. The Variety of them is inconceivable, and to be sought for as well in the Waters as elsewhere; as those will be convinced who will take the Pains to examine in the Spring, the Water-Cresses, Brooklime, and other Water-Plants, on the Back of whose Leaves infinite Numbers of *minute Eggs* may frequently be discovered, appearing to the naked Eye only as a Slime.

25. In Cellars, on the Corks of Bottles, there are three or four Sorts of very surprizing Insects.

26. The

26. The *Lungs* of a *Frog*, blown up and dry'd, will aſſiſt us to diſcover the true Structure of that Bowel.

27. *Cochineal*, which comes from *New Spain*, and is ſo valuable for its Uſe, in dying *Scarlet*, *Crimſon*, and *Purple*, has been aſſerted, by ſome, to be a Seed or Grain, and, by others, an Inſect: but the *Microſcope* determines theſe Diſputes, by ſhewing plainly, after ſteeping it in Water twenty-four Hours, an oval Body, Scales, Legs, and a pointed Trunk: in ſhort, the whole reſembles our *Cow-Lady*. Many Eggs may be diſcovered upon opening their Bodies, and if you burn them, let their Aſhes ſtand two or three Days in Water, then filter and evaporate, their Salts may be diſtinctly ſeen.

28. The *Feathers* of *Birds* afford Variety of Beauty, and differ greatly from one another, not only in their general Colour and Form, but in the Structure of each particular Part; as every Body muſt be ſenſible, who examines thoſe of the Oſtrich, the Peacock, the Eagle, the Swan, the Parrot, the Owl, and all the numerous Species of Birds. Their Quills too deſerve our Attention: and our Obſervations on them will be aſſiſted by reading the 36th Obſervation in Mr. HOOK's *Micrography*, p. 168. and alſo Mr. LEEUWENHOEK's *Experiments*, in the 4th Tome of his Writings, p. 323.

29. *Moſſes*

29. *Moſſes* of all Kinds are agreeable Objects, and appear, by the *Microſcope*, to be as perfect in their Leaves, Flowers and Seeds, as the largeſt Plants or Trees. Thoſe, particularly, that grow on the Rocks and Coaſts of the Sea, exhibit amazing Beauties.

30. *Spunge* is reckoned a *Plant-Animal*, and appears compoſed of minute Veſſels reſembling Veins and Arteries.

31. Decayed Fruits, moiſt Wood, damp Leather, ſtale Bread, and abundance of other Things, contract what we call *Mouldineſs*; which the *Microſcope* diſcovers to be nothing elſe but innumerable *minute Plants*, bearing Leaves, Flowers and Seeds, and increaſing in a Manner almoſt incredible: for in a very few Hours the Seeds ſpring up, arrive at full Maturity, and bring forth Seed themſelves; ſo that a Day produces ſeveral Generations of them. There are many ſorts of theſe *microſcopical Plants*, very different in Size and Appearance: Some of the Muſhroom Kind, Others reſembling Bulruſhes, and Others again bearing vaſt Quantities and great Varieties of Fruit. Other Kinds are likewiſe found in great Abundance on the Surface of Liquors; when they are what we term *Mothery*.

32. The

32. The *Air-Veſſels*, *Sap-Veſſels*, and *Pores* of *Wood* are wonderful in their Figure, Number and Diſpoſition: as plainly appears by ſhaving off the thinneſt Slices poſſible, lengthwiſe, croſswiſe, and obliquely, and bringing them to view. Fir and Cork are the readieſt for this Purpoſe: but all other Kinds of Wood, tho' with ſomewhat more Trouble, may be rendered fit to be examined.----In a Piece of Cork, no longer than the eighteenth Part of an Inch, ſixty Cells were numbered in a Row; whence it follows, that one Thouſand and eighty are in the Length of an Inch: one Million an hundred ſixty and ſix Thouſand four hundred in an Inch ſquare; and in a Cubic Inch one Thouſand two hundred fifty-nine Millions, ſeven hundred and twelve Thouſand *.

In the *Pith* of Trees and Plants, cut ſo as to become tranſparent, the Veſſels may be diſcerned diſtinctly. The *Pores* of Wood may likewiſe be ſeen advantageouſly in *Charcoal* and *Small-coal*.

33. There are many Sorts of *Sand*; ſome gathered on the Sea Shore, or, on the Shores of Rivers, and others found within Land. The Grains of each Sort differ much in Size,

* Hook's *Microg.* p. 114.

Form, and Colour: ſome are opake, others tranſparent: ſome have rough Surfaces, and others are quite ſmooth *. Theſe Varieties are very agreeable to examine by the *Microſcope*, which ſhews, in ſome of the ſhining Kinds, Grains having all Numbers of Sides and Angles, and ſo finely poliſhed, that no Diamond is more exquiſitely beautiful. On others groteſque Figures, or Repreſentations of Landſcapes, Buildings, Plants, and Animals, at once ſurprize and pleaſe.

34. In order to examine *Diamonds* with the greater Exactneſs, Mr. LEEUWENHOEK broke a ſmall one between two Hammers, and placing the Pieces before his *Microſcope*, in the Sun-ſhine, he ſaw many ſparkling Flames iſſue from them, with a continual Corruſcation, in ſome, like a faint Lightning. Then viewing them in the Shade, he obſerved, among other pretty Appearances, a little Flame that ſeemed to dart from each Particle of the Diamond: and it was a glorious Sight to behold Multitudes of ſparkling Flames, moſt of a bright Fire-Colour, and others greeniſh, flaſhing faintly and like Lightning at a Diſtance.----In other Pieces of the

* Vide *Philoſophical Tranſactions*, Numb. 289. HOOK's *Microg.* p. 80.

† Vide *Philoſoph. Tranſact.* Numb. 374.

Diamond

mond the *Lamellæ* or *Layers* composing it were very plainly to be distinguished.

35. In striking Fire with a Flint and Steel, *little Particles* of *Steel* are struck off, and melted into Globules by the Collision; as will be evident upon making the Experiment over a Sheet of white Paper, and viewing what falls into it through the *Microscope*. Mr. Hook first made the Trial, and found that a *black Particle*, no bigger than a Pin's Point, appeared like a Ball of polished Steel, and strongly reflected the Image of the Window near which he examined it *. It is also entertaining enough, to separate the melted Iron Particles from the Particles of Stone, which sometimes are vitrified; by means of a Knife that has been touched by a Loadstone.

36. Kind Nature has supply'd the *Seeds* of Dandelion, Thistles, and many other Plants with a *Down*, that serves instead of Wings to convey them to distant Places. The Figures of such *Down*, in different Plants, are very different when looked at through Glasses: some appearing plain and smooth, others rough and thorny, and others again with little Hooks or Claspers to catch hold of any

* Hook's *Microg.* p. 25, 44, 46.

thing. Peaches, Quinces, and ſome other Fruits have likewiſe a ſoft Down, which is worth examining, as well as the Hairs on many Sort of Leaves, Fruits and Seeds.

37. There's a very fine Down or Hair called *Cowage*, or *Cow-itch*, growing on a Sort of hairy Kidney Bean that comes from the *Eaſt-Indies*. The Pods, about three Inches long, reſemble a *French* Bean, and are covered with this Down or Hair, which is very ſtiff for its Bigneſs, cauſes Pain and Inflammation if rubbed on any Part, and when viewed by a *Microſcope* appears like Multitudes of Needles.

A Sort of *curling Horns*, riſing out of the Middle of ſome Carnations and Pinks are exceeding pretty Objects.

38. The *Flakes* of *falling Snow* are various in their Configuration, and extreamly beautiful, if examined before they melt: which may eaſily be done by making the Experiment in the open freezing Air. DESCARTES, Dr. GREW, Mr. HOOK, Mr. MORTON, Dr. LANGWITH, and others, have given us ſeveral of their different Star-like Forms: and Dr. STOCKE, of *Zealand*, has lately communicated to the *Royal Society* ſome new Figures unobſerved before.

The Configuration of the Particles of Dew may perhaps be likewiſe very well worth obſerving.

Plumous

Plumous Alum, Talcs of different Kinds, Aſbeſtos, Marcaſites, and all Sorts of Minerals and Foſſils, afford a Variety of agreeable and curious Objects.

Æthiops Mineral, Calomel, Mercurius dulcis, and all other Mercurial Powders, are found, when examined by the *Microſcope*, to be full of minute Globules of crude and unaltered Mercury.

Common Salt diſſolved in Water exhibits infinite Numbers of quadrangular Bodies.

Toads, Frogs, and Newts, are * killed by rubbing Salt upon their Backs: Snakes, Vipers, Rattle-ſnakes, *&c.* by drawing thro' their Skin with a Needle a Thread dipped in Oil of Tobacco; and Mercury is a mortal Poiſon to Ants.

It would be an endleſs Taſk to point out half the Objects fit to be examined by this uſeful and entertaining Inſtrument, which ſupplies us, as it were, with Eyes, infinitely more penetrating than our own: and diſcovers Wonders to us which we ſhould be unable to conceive without it. The foregoing are a few only among thoſe that are moſt curious; but every Creature, every Plant, and Fruit, and Flower, every Drop of Wa-

* Hook's *Microg.* p. 144.

ter,

ter, and every Particle of Matter, if carefully examined, will afford us new Inſtruction and Delight.

CHAP. LI.

The Works of ART *and of* NATURE *compared together and conſidered.*

BEFORE this Treatiſe is concluded, it will not perhaps be thought unprofitable, to examine ſome of the fineſt and moſt exquiſite Performances of human Art, and compare them with the Productions of Nature; as ſuch a Compariſon muſt tend towards humbling the Self-conceit and Pride of Man, by giving him a more reaſonable and modeſt Opinion of himſelf; and at the ſame Time may in ſome Degree conduce towards improving his imperfect Conceptions of the SUPREME CREATOR.

Upon examining the *Edge* of a very keen *Razor* by the *Microſcope*, it appeared as broad as the Back of a pretty thick Knife; rough, uneven, full of Notches and Furrows, and ſo far from any thing like Sharpneſs, that an Inſtrument as blunt as this ſeemed to be, would not ſerve even to cleave Wood †.

† HOOK's *Microg.*

An

An exceeding ſmall *Needle* being alſo examined, the Point thereof appeared above a Quarter of an Inch in Breadth; not round, or flat, but irregular, and unequal; and the Surface, though extreamly ſmooth and right to the naked Eye, ſeemed full of Ruggedneſs, Holes and Scratches. In ſhort, it reſembled an Iron Bar out of a Smith's Forge *.

But the *Sting of a Bee* viewed through the ſame Inſtrument, ſhewed every where a Poliſh moſt amazingly beautiful, without the leaſt Flaw, Blemiſh, or Inequality; and ended in a Point too fine to be diſcerned: yet this is only the Caſe, or Sheath, of Inſtruments much more exquiſite contained therein, as before deſcribed, Page 210.

A ſmall Piece of exceeding fine *Lawn*, appeared, from the large Diſtances and Holes between its Threads, ſomewhat like a Hurdle, or Lattice, and the Threads themſelves ſeemed coarſer than the Yarn wherewith Ropes are made for Anchors.

Some *Bruſſel*'s Lace, worth five Pounds a Yard, looked as if it were made of a thick, rough, uneven Hair-Line, entwiſted, faſtened, or clotted together in a very awkard and unartful Manner.

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* *Philoſoph. Tranſ.* Numb. 324. *Spect. de la Nat.* Eng. Edit. 12mo. Vol. I. page 8.

But a *Silkworm's Web* being examined, appeared perfectly ſmooth and ſhining, every where equal, and as much finer than any Thread the beſt Spinſter in the World can make, as the ſmalleſt Twine is finer than the thickeſt Cable. A Pod of this Silk being wound off, was found to contain nine hundred and thirty Yards: but it is proper to take Notice, that as two Threads are glewed together by the Worm through its whole Length, it makes really double the above Number, or one thouſand eight hundred and ſixty Yards: which being weighed with the utmoſt Exactneſs, were found no heavier than two Grains and a half *. What an exquiſite Fineneſs is here! and yet, this is nothing when compared with the Web of a ſmall Spider, (ſee Page 200) or even with the Silk that iſſued from the Mouth of this very Worm, when but newly hatched from the Egg.

The ſmalleſt *Dot*, *Tittle*, or Point, that can be made with a Pen, appears, when viewed by the *Microſcope*, a vaſt irregular Spot, rough, jagged, and uneven all about its Edges, and far enough from being truly round. The fineſt and minuteſt *Writing*, ſuch as the Lord's Prayer in the Compaſs of a ſilver Penny, or other like curious Per-

* Ibid. p. 50.

formance,

formance, done by the moſt able Maſter, ſeems, when brought to Examination, as ſhapeleſs, uncouth and barbarous as if written in *Runic Characters.* But the little Specks on the Wings or Bodies of Moths, Beetles, Flies, and other Inſects, are found when magnified, to be moſt accurately circular: and all the other Lines and Marks about them, appear regularly and finely drawn, to the utmoſt Poſſibility of Exactneſs.

Dr. POWER ſays, he ſaw a golden Chain at TREDESCANT'S, of three hundred Links, not more than an Inch in Length, faſtened to, and pulled away by a Flea. And I myſelf have ſeen very lately, near *Durham Yard* in the *Strand*, and have examined with my *Microſcope*, a Chaiſe, (made by one Mr. BOVERICK, a Watch-maker) having four Wheels, with all the proper Apparatus belonging to them, turning readily on their Axles: together with a Man ſitting in the Chaiſe; all formed of Ivory, and drawn along by a Flea without any ſeeming Difficulty. I weighed it with the greateſt Care I was able, and found the Chaiſe, Man and Flea were barely equal to a ſingle Grain. I weighed alſo at the ſame Time and Place, a Braſs Chain made by the ſame Hand, about two Inches long, containing two hundred Links, with a Hook at one End, and a Padlock and a Key

a Key at the other; and found it leſs than the third Part of a Grain †.

We are told, that one OSWALD NERLINGER ‡ made a Cup of a *Pepper-Corn*, which held twelve hundred other little Cups, all turned in Ivory, each of them being gilt on the Edges, and ſtanding upon a Foot: and that, ſo far from being crouded or wanting Room, the Pepper-Corn could have held four hundred more.

Theſe are ſome of the niceſt, moſt curious and ſurprizing Works of Art; but let us examine any of them with a good *Microſcope*, and we ſhall immediately be convinced, that the utmoſt Power of Art is only a Concealment of Deformity, an Impoſition upon our Want of Sight; and that our Admiration of it ariſes from our Ignorance of what it really is.

This valuable Diſcoverer of Truth will prove the moſt boaſted Performances of Art to be as ill-ſhaped, rugged, and uneven, as

---

† I have ſeen ſince my writing the above, (made by the ſame Artiſt) a Quadrille Table with a Drawer in it, an Eating-Table, a Side Board Table, a Looking Glaſs, twelve Chairs with Skeleton Backs, two Dozen Plates, Six Diſhes, a Dozen Knives, and as many Forks, twelve Spoons, two Salts, a Faame and Caſtors, together with a Gentleman, Lady, and Footman, all contained in a *Cherry-Stone*: and not filling much more than half of it.

‡ *Ephem. German.* Tom. I. Addend. ad Obſerv. 13.

if

if they were hewn with an Ax, or ſtruck out with a Mallet and Chiſſel. It will ſhew Bungling, Inequality, and Imperfection in every Part, and that the Whole is diſproportionate and monſtrous. Our fineſt Miniature Paintings appear before this Inſtrument as meer Dawbings, plaiſtered on with a Trowel, and entirely void of Beauty, either in the Drawing, or the Colouring. Our moſt ſhining Varniſhes, our ſmootheſt Poliſhings will be found to be meer Roughneſs, full of Gaps and Flaws.

Thus ſink the *Works of Art* when we become enabled to ſee what they really are!--But, on the contrary, the nearer we examine, the plainer we diſtinguiſh, the more we can diſcover of the *Works of Nature*, even in the leaſt and meaneſt of her Productions, the more ſenſible we muſt be made of the Wiſdom, Power and Greatneſs of their Author.---Let us apply the *Microſcope* where we will, nothing is to be found but Beauty and Perfection. View we the numberleſs Species of Inſects that ſwim, creep, or fly around us, what Proportion, Exactneſs, Uniformity and Symmetry ſhall we perceive in all their Organs! what a Profuſion of Colouring! Azure, Green, and Vermilion, Gold, Silver, Pearls, Rubies and Diamonds, Fringe and Embroidery on their Bodies, Wings, Heads, and every other Part! How

rich

rich the Glow! how high the Finiſhing! how inimitable the Poliſh we every where behold!----Search we yet farther, and examine the *Animalcules*, many Sorts whereof it would be impoſſible for any human Eye unaſſiſted to diſcern; thoſe breathing Atoms, ſo ſmall they are almoſt all Workmanſhip! In them too we ſhall diſcover the ſame Organs of Body, Multiplicity of Parts, Variety of Motions, Diverſity of Figures, and particular Ways of Living as in the larger Animals.----How amazingly curious muſt the Internal Structure of theſe Creatures be! The Heart, the Stomach, the Entrails, and the Brain! How minute and fine the Bones, Joints, Muſcles and Tendons! How exquiſitely delicate beyond all Conception the Arteries, Veins, and Nerves! What Multitudes of Veſſels and Circulations muſt be contained within this narrow Compaſs! And yet, all have ſufficient Room to perform their different Offices, and neither impede nor interfere with one another.

The ſame Order, Regularity and Beauty will appear likewiſe among *Vegetables* if brought to Examination. Every Stalk, Bud, Flower, or Seed, diſplays a Figure, a Proportion, a Harmony beyond the Reach of Art. There's not a Weed, not a Moſs, whoſe every Leaf does not ſhew a Multiplicity of Veſſels and Pores diſpoſed moſt curiouſly for the Conveyance of Juices to ſup-

port and nourish it, and which is not adorn'd with innumerable Graces to embellish it.

The most perfect *Works of Art* betray a Meanness, a Poverty, an Inability in the Workman; but those of *Nature* plainly prove, the Hand that form'd them was absolute Master of the Materials it wrought upon, and had Tools exactly suitable to its Design. Every Hair, Feather, or Scale, even of the meanest Insect, appears rounded, polish'd, and finish'd to the highest Pitch; and shews the abundant Riches, Munificence, and Skill of its Maker.

But some may possibly enquire, to what Purpose Providence has bestowed such an Expence of Beauty on Creatures so insignificant: and then cry out, *What is all This to us?*--- My Reply is, that the Beauty and Elegance which adorn them, are evident and convincing Proofs of their not being so insignificant as we presumptuously suppose they are: for, such Beauty must be given them, either for their own Sake, that they themselves may be delighted with it; or else, for Ours, that we may observe, in them, the amazing Power and Goodness of the Creator. If the former be the Case, we must allow them to be of Consequence in the Account of their Maker, and therefore deserving our Regard; and if the latter, it is really our Duty to take notice of and admire them. But for what-

ever Reaſon God has been pleaſed to beſtow Exiſtence on them, and to clothe them with Beauty, what he has judged worthy himſelf to create, is not, ſurely, below us to examine and conſider. The ſame Hand that form'd the Whale, the Elephant, and the Lion, has likewiſe made the Louſe, the Gnat, and the Flea.

CHAP. LII.

Some reaſonable Reflections *on* Diſcoveries *made by the* Microſcope.

THE Uſe of the *Microſcope* will naturally lead a thinking Mind to a Conſideration of *Matter*, as faſhion'd into different Figures and Sizes, whether Animate or Inanimate: It will raiſe our Reflections from a Mite to a Whale, from a Grain of Sand to the Globe whereon we live, thence to the Sun and Planets; and, perhaps, onwards ſtill to the fixt Stars and the revolving Orbs they enlighten, where we ſhall be loſt amongſt Suns and Worlds in the Immenſity and Magnificence of Nature.

Our Ideas of Matter, Space, and Duration are meerly comparative, taken from Ourſelves and Things around us, and limited to certain Bounds; beyond which, if we endeavour to extend them, they become very indiſtinct. The Beginnings and Endings, exceſſive Greatneſs or exceſſive Littleneſs of Things,

Things, are to us all Perplexity and Confusion.

"Let a Man try to conceive the different "Bulk of an Animal which is twenty, from "another which is an hundred times less "than a Mite; or to compare, in his "Thoughts, a Length of a Thousand Dia-"meters of the Earth with that of a Million, "and he will quickly find, that he has no "different Measures in his Mind adjusted to "such extraordinary Degrees of Grandeur "or Minuteness. The Understanding, in-"deed, opens an infinite Space on every "side of us; but the Imagination, after a "few faint Efforts, is immediately at a stand, "and finds itself swallowed up in the Im-"mensity of the Void that surrounds it. "Our Reason can pursue a Particle of Mat-"ter through an infinite Variety of Divisi-"ons, but the Fancy soon loses Sight of it, "and feels in itself a kind of Chasm, that "wants to be filled with Matter of a more "sensible Bulk. We can neither widen, "nor contract the Faculty to the Dimensi-"ons of either Extream. The Object is "too big for our Capacity, when we would "comprehend the Circumference of a "World; and dwindles to Nothing, when "we endeavour after the Idea of an "Atom *."

* *Spectator*, Numb. 420.

The minute Size of microscopical Animalcules, and the little Space they occupy, when compared with ourselves and the Room we fill, may possibly increase our Pride and Folly, and make us imagine ourselves of mighty consequence in the Creation. But if we carry our Thoughts upwards, and compare the Body of a Man to the Bulk of a Mountain, that Mountain to the whole Earth, the Earth to the Circle it describes round the Sun, that Circle to the Sphere of the fixt Stars, the Sphere of the fixt Stars to the Circuit of the whole Creation, and the whole Creation itself to the infinite Space that is every where diffused about it, we shall find ourselves sink to nothing.--- * "Were "the Sun with all its planetary Worlds ut- "terly extinguished and annihilated, they "would no more be missed in the Grand "Universe than a Grain of Sand upon the "Sea-shore: the Space they possess is so ex- "ceeding little, in comparison of the Whole, "that it would scarce make a Blank in the "Creation. The Chasm would be almost "imperceptible to an Eye that could take in "the whole Compass of Nature, and pass "from one End of the Creation to the "other." What then is the mightiest Mo-

* Vide *Spectator*, Numb. 565.

narch

narch that ever lived! What is the whole Race of Man!

A Mite upon a Cheese is as large and considerable, in Proportion, as a Man upon the Earth: the little Insects feeding on the Leaves of Peach-Trees and Cherry-Trees, are no ill Representation of Oxen grasing in large Pastures: and the minute Animalcules in a Drop of Water, swim about with as much Freedom as Whales do in the Ocean:——All have equal Room in Proportion to their own Bulk.

The Term or Duration of Life, in different Creatures, is likewise comparatively long or short, according to the Number, Quickness, or Slowness of Ideas, presenting themselves successively to the Mind. For, when the Ideas succeed one another swiftly, and many of them are crouded into a narrow Compass, the Time, however short it may be, will seem long, in Proportion to the Number of Ideas passing through it: on the contrary, when the Ideas are but few, and follow one another very slowly, a long Time will appear short, in Proportion to their slow Succession, and the Smallness of their Number.

"It is evident, says Mr. Lock, to any "one who will but observe what passes in "his own Mind, that there is a Train of "Ideas, which constantly succeed one ano-

" ther in his Underſtanding, as long as he " is awake. Reflection on theſe Appearan- " ces of ſeveral Ideas one after another in " our Minds, is what we call *Duration.* " For whilſt we are thinking, or whilſt we " receive ſucceſſively ſeveral Ideas in our " Minds, we know that we do exiſt: and " ſo we call the Exiſtence, or the Conti- " nuation or Exiſtence of ourſelves, or any " thing elſe commenſurate to the Succeſſion " of any Ideas in our Minds, the *Duration* " of ourſelves, or any ſuch other Thing co- " exiſting with our Thinking *."

From theſe Principles it is manifeſt, that one Day may appear as a thouſand Years, and a thouſand Years but as one Day: by which means, the Lives of all Creatures, for ought we know, may ſeem to themſelves nearly of the ſame Duration. It is at leaſt probable, that ſomething like this may really be the Caſe as to the Inhabitants of this our Earth: for as the ſame Functions or Offices of Life, *viz.* to be born, ſeek proper Suſtenance, increaſe in Bulk, arrive at full Maturity, propagate the Kind, and die, are equally performed by all; they who perform them in a few Months, Days,

* Vide Locke on *Human Underſtanding*, Chap. XIV.

or Hours,* may be supposed, from the Number and swift Succession of Ideas suited to all these Purposes, to live as long, according to

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* SWAMMERDAM has published, in *Low Dutch*, a curious Account of what he calls the *Ephemeron:* a Fly which, he tells us, lives but five Hours. This Insect is found about all the Mouths of the *Rhine*; and, according to his Drawings and Descriptions, seems to be a Species somewhat between our *May-Fly* (bred from the *Cadew-Worm*) and the *Libella* or *Dragon-Fly*. It has four Wings, two whereof are shorter than the other; a pair of small Horns, six Legs, and two very long strait Hairs issuing from the Tail. They are seen, he says, flying near the Surface of the Water, about Midsummer, for three succeeding Days, but no longer in one Season. They eat nothing; and their only Business is to generate, and drop their *Eggs* upon the Water: which *Eggs*, sinking to the Bottom produce a Kind of *Worms* or *Maggots*, that soon hollow themselves Cavities in the Clay, where they abide three Years; growing each Year about an Inch in Length. When the *Worm* is come to its full Growth, it rises to the Surface, about six o'Clock in an Evening: lays its *Eggs*, and dies about ten o'Clock the same Night.

I'm surprized that SWAMMERDAM should say, the Life of this Creature is no more than five Hours, when his own Account plainly proves that it really lives three Years: for it is certainly as much alive in the *Worm-State*, as when afterwards it becomes a Fly.——Truth should be every Body's Pursuit, and for the Sake thereof I have endeavoured to clear up the general Mistake as to this Fly, which is frequently produced, upon SWAMMERDAM's Authority, as the most remarkable Instance we know of the Shortness of Life.—But tho' this Insect happens to live much longer than was imagined, I make no Doubt, there are some among the numberless Species of Beings, whose natural Lives are as short as this was supposed to be: such too are most likely to be found amongst the very minute Kinds. For as those *exceeding small Plants*, invisible to the naked Eye, which compose what we call *Mouldiness*, spring up, bear Fruit, and dye in a few Hours; we may reasonably suppose, the Lives of some *exceedingly small Animals* to be of as short a Duration.

their own thinking, as other Creatures do, where the ſame Train of Ideas proceed more ſlowly, and take up many Years.

As the Microſcope diſcovers almoſt every Drop of Water, every Blade of Graſs, every Leaf, Flower, and Grain ſwarming with Inhabitants; all of which enjoy not only Life but Happineſs; a thinking Mind can ſcarce forbear conſidering that Part of the Scale of Beings which deſcends, from himſelf, to the loweſt of all ſenſitive Creatures, and may conſequently be brought under his Examination.* "Amongſt theſe, ſome are raiſed ſo little above dead Matter, that it is difficult to determine whether they live or no: others but one Step higher, have no other Senſe beſides Feeling and Taſte: ſome again, have the additional one of Hearing; others of Smell, and others of Sight.

It is wonderful to obſerve, by what a gradual Progreſſion the World of Life advances through a prodigious Variety of Species, before a Creature is formed that is compleat in all its Senſes: and, even, amongſt theſe, there is ſuch a different Degree of Perfection in the Senſes which one Animal enjoys beyond what appears in another, that tho' the Senſe in different Animals be diſtinguiſh'd

* Vide *Spectator*, Numb. 519.

by

by the same common Denomination, it seems almost of a different Nature. If, after this, we look into the several inward Perfections of Cunning and Sagacity, or what we generally call Instinct, we find them rising in the same Manner, imperceptibly, one above another, and receiving additional Improvements according to the Species in which they are implanted.

This Progress in Nature is so very gradual, that the whole Chasm, from a Plant to a Man, is filled up with divers Kinds of Creatures, rising one over another by such a gentle and easy Ascent, that the little Transitions and Deviations from one Species to another are almost insensible. And the intermediate Space is so well husbanded and managed, that there is scarce a Degree of Perception which does not appear in some one Part of the World of Life. Since then the Scale of Being advances by such regular Steps so high as Man, we may by Parity of Reason suppose, that it still proceeds gradually upwards thro' numberless Orders of Beings of a superior Nature to him: as there is an infinitely greater Space and Room for different Degrees of Perfection between the Supreme Being and Man, than between Man and the most despicable Insect."

Mr. Lock's Thoughts upon this Subject are very curious: "That there should, says

" he, be more Species of intelligent Creatures
" above us, than there are of sensible and
" material below us, is probable to me, from
" hence, that in all the visible and corporeal
" World, we see no Chasm, no Gaps. All
" quite down from us, the Descent is by easy
" Steps and a continued Series of Things, that
" in each Remove differ very little one from
" the other. There are Fishes that have
" Wings, and are not Strangers to the airy
" Region: and there are some Birds that are
" Inhabitants of the Water, whose Blood is
" as cold as Fish's, and their Flesh so like in
" Taste, that the Scrupulous are allowed
" them on Fish-Days. There are Animals
" so near a-kin to Birds and Beasts, that
" they are in the Middle between both.
" Amphibious Animals link the Terres-
" trial and Aquatic together: Seals live at
" Sea and at Land, and Porpoises have the
" warm Blood and Entrails of a Hog: not
" to mention what is confidently reported
" of Mermaids or Sea-Men.——There are
" some Brutes that seem to have as much
" Knowledge and Reason as some that are
" called Men; and the Animal and Vege-
" table Kingdoms are so nearly joined, that
" if you will take the lowest of one
" and the highest of the other, there will
" scarce be perceived any great Difference
" between them. And so on till we come

" to

" to the lowest and the most inorganical
" Parts of Matter, we shall find every where
" that the several Species are linked together,
" and differ but in almost insensible Degrees.
" And when we consider the infinite Power
" and Wisdom of the Maker, we have Rea-
" son to think, that it is suitable to the
" magnificent Harmony of the Universe, and
" the great Design and infinite Goodness of
" the Architect, that the Species of Creatures,
" should also, by gentle Degrees, ascend up-
" wards from us towards his infinite Perfec-
" tion; as we see they gradually descend
" from us downwards. Which if it be pro-
" bable, we have Reason then to be persua-
" ded, that there are far more Species of
" Creatures above us than there are beneath:
" we being in Degree of Perfection much
" more remote from the infinite Being of
" God, than we are from the lowest State
" of Being, or that which approaches nearest
" to Nothing."

Every Creature is confined to a certain Measure of Space, and its Observation stinted to a certain Number of Objects: but some move and act in a Sphere of a wider Circumference than that of others, according as they rise above one another in the Scale of Existence. This Earth is the Spot appointed for Man to dwell and act upon: he

ſtands foremoſt of all the Creatures here, and links together Intelligences and Brutes. The Sphere of his bodily Action is limited, confined, and narrow; but that of his Mind is vaſt, and extenſive beyond the Bounds of Matter. Form'd for the Enjoyment of intellectual Pleaſures, his Happineſs ariſes from his Knowledge; and his Knowledge increaſes in Proportion as he diſcovers and contemplates the Variety, Order, Beauty, and Perfection of the Works of Nature: whatever, therefore, can aſſiſt him in extending his Obſervations, is to be valued, as in the ſame Degree conducive to his Happineſs.

What we know at preſent, even of things the moſt near and familiar to us, is ſo little in compariſon of what we know not, that there remains a boundleſs Scope for our Enquiries and Diſcoveries; and every Step we take, ſerves to enlarge our Capacities, and give us ſtill more noble and juſt Ideas of the Power, Wiſdom, and Goodneſs of the Deity.

The Univerſe is ſo full of Wonders, that perhaps Eternity alone can be ſufficient to ſurvey and admire them all: perhaps, too, this delightful Employment may be one great Part of the Felicity of the Bleſſed. When the Soul ſhall become diveſted of Fleſh, the Pleaſures of Senſe can be no more: and if, by a con-

a continued Habit, any Longings after them shall hang about it, such Longings must create a proportionable Degree of Wretchedness, as they can never possibly be gratified. But if its principal Delight has been in the Contemplation of the Beauties of the Creation, and the Adoration of their Almighty Author, it soars, when disembodied, into the celestial Regions, duely prepared for the full Enjoyment of intellectual Happiness.

To THEE, eternal self-existing CREATOR of the UNIVERSE! whose Will is Nature's Law! Omniscient, Omnipresent, All-Bountiful and Gracious! To THEE be paid, by all thy CREATURES, Thanksgiving and Adoration, till Time shall be no more!

INDEX.

A.

Animalcules

INDEX.

Blood,

INDEX.

Cowage,

INDEX.

INDEX.

Growth

INDEX.

INDEX.

INDEX.

M.

Moſſes,

INDEX.

Old

INDEX.

Salts

Spider,

INDEX.

Wheel-

INDEX.

FINIS

BAKER

MICROSCOPE
MADE EASY

1743

Mr. LEEUWENHOEK ſays, each *Muſcular Fibre* is compoſed of many ſmaller Filaments or Fibrils; which, however minute, he could plainly diſtinguiſh to be vaſcular: for, if he cut acroſs their Length, the Light appeared through the Mouths of the Veſſels; and if he cut them ever ſo little obliquely no Light was to be ſeen †. He found alſo, that each Fibril is inveſted with a * minute membrane, which is only a Congeries of [illegible] and Nouriſhment renders [illegible] ver, to be [illegible] peculiar [illegible] branes to[illegible]d, with a [illegible]eſhes. [illegible] obſerved [illegible] Whale; [illegible]hale, the [illegible] and cloſe. [illegible] a Mouſe [illegible]oſe of an [illegible] are not [illegible]hence he [illegible] of Ani[illegible]ter or leſs [illegible]mber and Length of the Fibres ‡.

† *Phil. Tranſ.* Numb. 367.
* GORTER. *Medic. Compend.* p. 58. 59. LEEUW. *Arc.* [illegible]. Tom. III. p. 58. ‡ *Ibid.* 61.

Theſe

Theſe *fleſhy Fibres* appear through their whole Length encompaſſed with circular Wrinkles. If a Thread were twiſted about a fine Needle in a Screw-like Form, with ſpiral Circumvolutions, ſo that each Thread be diſtant from another the Diameter of the Needle, it would naturally repreſent the Manner of theſe circular Twiſtings. And this Diſpoſition is wonderfully contrived for the ready *Diſtenſion* or *Contraction* of the Fibres: for as a Cord will be diſtended or contracted *quicker*, or *ſlower*, in proportion to its Length, the ſame muſt alſo be the Caſe in *Animal Fibres*; and, therefore, on theſe Principles we may calculate how much more nimbly the Leg of a Mouſe can move than the Leg of an Ox.

The Method of viewing the *Muſcular Fibres* is, to cut carefully, and with a very ſharp Razor or Pen-knife, a Slice of dryed Fleſh or Fiſh, as thin as poſſible. Lay it on a Piece of Glaſs, and moiſten it with warm Water; which, drying ſoon away, will leave the Veſſels open and diſtinguiſhable.-----It is obſervable that the Fibres of Fiſh are larger than thoſe of Fleſh.

That the *Muſcular Fibres* are vaſcular, or made up of little hollow Veſſels, is ſuppoſed by MALPIGHIUS, BORELLI, GORTER, our own Countryman Mr. HOOKE, who ſays,