THE
NEW UNIVERSAL
SINGLE MICROSCOPE,

Invented, Made and Sold by
GEORGE ADAMS
at Tycho Brahe's Head in Fleet Street,
LONDON.

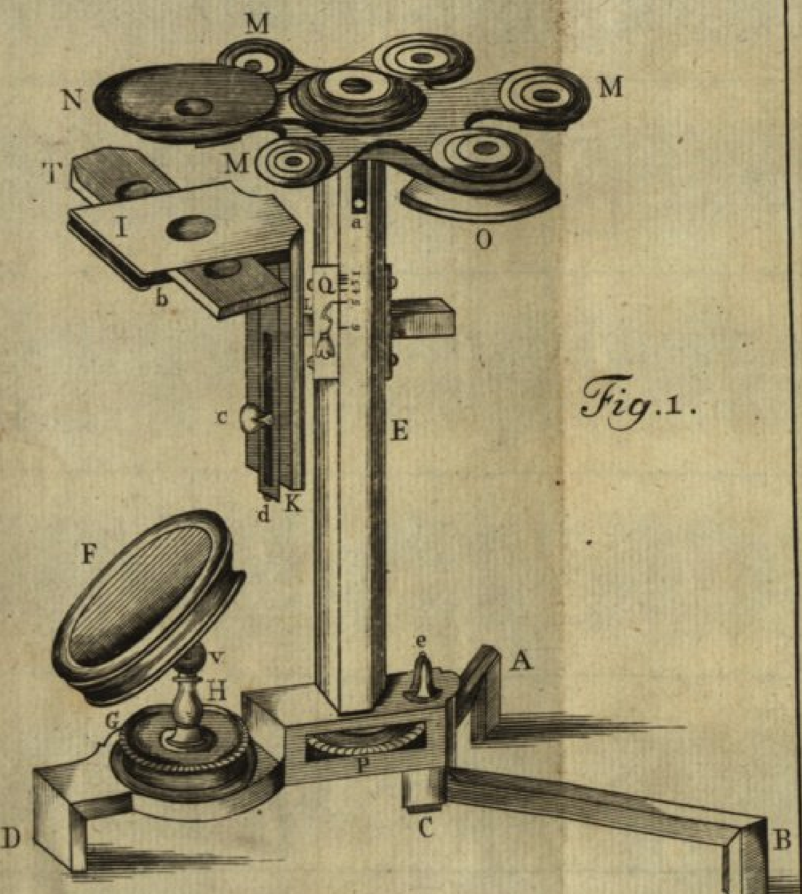

Fig. 1.

Micrographia Illustrata,

O R,

The Knowledge of the MICROSCOPE *Explain'd*:

Together with an ACCOUNT of

A *New Invented*

UNIVERSAL, Single *or* Double,

MICROSCOPE,

Either of which is capable of being applied to an Improv'd

SOLAR APPARATUS.

This TREATISE contains a Description of the Nature, Uses, and Magnifying Powers of MICROSCOPES in general; together with full Directions how to prepare, apply, and examine, as well as preserve, all Sorts of minute Objects:

Also an ACCOUNT of

The principal MICROSCOPICAL DISCOVERIES, that have hitherto been mentioned by the most celebrated AUTHORS, together with a great Variety of new Experiments and Observations.

The WHOLE being, as it were,

A NATURAL HISTORY of a Multitude of Aerial, Terrestrial, and Aquatick Animals, Seeds, Plants, *&c.*

To which is added,

A TRANSLATION of Mr. JOBLOTT's Observations on the Animalcula, that are found in many different Sorts of Infusions;

A N D

A very particular ACCOUNT of that surprising Phænomenon, *The Fresh Water Polype*, translated from the *French* Treatise of Mr. *Trembley*.

This WORK is compiled for the Assistance of those, who are desirous of surveying the extensive Beauties of the minute Creation;

And is illustrated with 65 Copper-Plates, curiously engrav'd, which contain above 560 Pictures of MICROSCOPIC OBJECTS.

By *GEORGE ADAMS*,

Mathematical, Philosophical, and Optical Instrument-Maker, at *Tycho Brahe's Head*, in *Fleet-Street*.

The Second Edition.

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MDCCXLVII.

INTRODUCTION.

THE Study of Nature, or in other Words, a ſerious Contemplation of the Works of God, is certainly one of the moſt pleaſing and uſeful, as well as moſt extenſive Kinds of Knowledge. It is indeed the great, and proper Object of our rational Faculties; for ſurely we cannot employ our Reaſon better, than in endeavouring to make ourſelves acquainted with the glorious Works of that Being, to whoſe Goodneſs we owe it.

Natural Philoſophy is now ſo greatly improv'd in all its ſeveral Branches, that few Perſons, who have had the Happineſs of a liberal Education, are wholly unacquainted with the Value of it. But ſtill the Generality of Mankind are guilty of one very great Miſtake, for they are apt to form an abſolute Judgment of the Works of Nature, from outward Appearances only; and ſo imagine, that the moſt grand and magnificent Parts of the Creation, are

always

always most perfect, and for that Reason most worthy of our Regard. The Splendour of the Sun is visible to every Eye, and we need only look upwards in order to be convinced, that nothing less than infinite Power and Wisdom, could first create the Universe. What, but an Almighty Hand, could raise such a glorious Canopy as that of the Heavens, so richly adorned with Stars? Or stretch out such a spacious Area, as this terraqueous Globe on which we tread, and sail; and which is furnish'd with every Thing that is necessary for our Support or Happiness? And indeed these great Truths are so very obvious to the lowest Capacities, that few Persons pretend to dispute them; but then it must likewise be own'd, that Men are generally apt to confine their Attention to the most shining Parts of Philosophy, and so treat every Thing else with Coolness and Indifference, and even some Degree of Contempt. But surely a true Philosopher is one, who diligently pursues the Study of Nature, in all its several Branches; who can behold with Admiration her noblest Productions, and yet view with Pleasure the smallest of her Works; in short one, who thinks every thing excellent, that owes its Formation to her skilful Hand. Nor is this a forced and imaginary Description, but a real Character; and we need only take a transient View of some of those Creatures, with which all Parts of the Earth are so plentifully stored, in order to be convinced of the Justness of it. For whether we regard their Elegance, and Beauty; or consider their Fitness to answer those Purposes, for which they were designed; in both these Respects we shall find,

find, that the ſmalleſt Creatures are perfect in their Kind, and carry about them as ſtrong Marks of infinite Wiſdom and Power, as the greateſt. How many curious Animals inhabit the Air, and what Numbers traverſe the deep Waters. The whole Earth is full of Life; there not being a ſingle Tree, Plant, or Flower, but what affords Food and Shelter to a Species of Inhabitants peculiar to itſelf. And then if we call in the Aſſiſtance of Art, what a new Scene of Wonder opens to our View? What an infinite Variety of living Creatures preſent themſelves to our Sight? Indeed their extream Minuteneſs may at firſt ſeem a juſt Argument for that low Opinion, which the Vulgar are apt to entertain of them; however, if we examine them with Cloſeneſs and Attention, we ſhall ſoon diſcover their divine Original. We ſhall then ſurvey with Admiration the wonderful Art and Mechaniſm of their Structure; wherein ſuch a Number of Veſſels, Fluids, and Movements, are collected into a ſingle Point; and That often inviſible to the naked Eye. What a Profuſion of the richeſt Ornaments, and gayeſt Colours, are frequently beſtowed upon one little Inſect; and yet there are Millions of others, that are as beautiful and wonderful in their Kind. Some are covered with ſhining Coats of Mail; others adorned with Plumes of Feathers; and all compleatly furniſh'd with thoſe Weapons, that are moſt proper for defending themſelves, as well as attacking their Enemies. In ſhort, the more we enquire into Nature, the more excellent ſhe appears, and we ſhall conſtantly find, that the Beauty of her Works will gradually riſe in Proportion to our Knowledge of them. There is no ſuch Thing as Meanneſs in *any of her Productions; ſome indeed may be more grand, and happen to ſtrike our Senſes more ſtrongly than others, but all are perfect in the higheſt Degree.*

If then a ſerious Contemplation of the Works of God, may juſtly be conſider'd as an excellent Kind of Knowledge, and worthy of our Purſuit; and if all thoſe Works, though different in Degrees of Splendour, are ſtill perfect; it is hoped, that an humble Attempt to improve, and encourage the Study of any Branch of Natural Philoſophy, will not be unacceptable to the Publick. And ſince the Knowledge of the Microſcope has always been look'd upon as no inconſiderable Branch of Natural Philoſophy, and as that Part of it has more particularly fallen within the Compaſs of the Author's Studies, he has ventured to make it the Subject of the following Treatiſe; a Subject, which has ſo often employ'd the moſt learned Men, that it can hardly ſtand in Need of an Apology for the Choice of it.

Having ſaid thus much with Regard to the Science, I ſhall now beg Leave to ſay ſomething of the Inſtrument itſelf; and then make Haſte to acquaint the Reader with what he is to expect in the following Sheets.

The Microſcope is an Inſtrument ſo curious and entertaining, and ſo generally eſteemed amongſt the learned Part of the World, that one great Reaſon of its being ſo much diſregarded by Men of Leiſure and Fortune, muſt be owing to the Difficulty of uſing ſome of thoſe, which have been hitherto invented. Beſides, many Perſons have neglected the Microſcope, from an Apprehenſion, that a good Degree of Knowledge in Opticks would be neceſſary to their Underſtanding even the experimental Part of it; where-

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as nothing more is really required, than good Eyes, good Glasses, and a well-constructed Instrument; with these Helps, a common Understanding, and a little Practice, will be sufficient to carry us through this Branch of Natural Philosophy.

Others, again, have consider'd the Microscope as an Instrument, which is perhaps capable of affording a little Amusement, or even raising our Wonder for a Moment, but is indeed of no real Service. However, this is an Objection that reflects more upon the Author of it, than the Instrument; and therefore does not seem to deserve the Ceremony of an Answer. Some also have laid aside the Microscope, after a little Use, merely from a Want of knowing what Objects to examine, and where to find them; as well as how to prepare and apply them.

I hope the Reader will find, that I have, in some Measure, surmounted all these Difficulties. For, first, I have given a clear and accurate Description of my new invented Universal Microscope; which comprehends all the several Uses of other Microscopes, in one Apparatus; a Circumstance that deserves a very particular Consideration. For Microscopes have been generally constructed so, as chiefly to excel in a single Instance; some having been adapted for viewing Opake, and others for Transparent Objects; but none capable of shewing both in the same exact Manner. I have therefore endeavoured to contrive my Universal Microscope so, as to render it capable of doing every Thing that can be expected from such a Kind of Instrument. I have likewise shewn how it may be applied to an improved Solar Apparatus; in which Application of it, there is a particular Contri-

vance

vance for confining Frogs, Mice, Bats, &c. in order to view the Circulation of the Blood in the Mesentery, and other Parts of those Animals.

Next I have proceeded to give a Description of all the different Sorts of modern Microscopes, that have been hitherto invented; so that any Gentleman, who is willing to purchase, may readily comprehend their several Uses, and by comparing them together, be enabled to form a true Judgment of their Value.

I come now to acquaint the Reader with what he is to expect in the following Sheets, and this I shall do in a very few Words.

And here I must be so ingenuous as to confess, that my Book contains rather a faithful Collection of every Thing that has hitherto been mention'd by the best Writers upon Microscopes, than Matters of my own Invention. However, I can truly say, that my sincere Endeavours have not been wanting, in order to range these Materials under their proper Heads, as well as to enlarge upon them, where it was requisite, in the most plain and intelligible Manner. I have likewise attempted a Translation of two very valuable Pieces; the one containing Mr. JOBLOT'*s Observations upon the Animalcula, that are found in many different Sorts of Infusions; the other Mr.* TREMBLEY'*s Account of the fresh Water Polype; neither of which, I believe, has hitherto appeared in our Language.*

As to the Copper-Plates, I have taken particular Care to have them copied from exceeding good Drawings, and then engraved in the very best Manner; and in order to prevent, as much as possible, any Inaccuracy, I always obſerved the following Method: When I had a Mind to make a Drawing of any Object, I placed it in my Univerſal Microſcope, and applied it to an improved Solar Apparatus; by which Means the Object was thrown upon a large Sheet of white Paper, and magnified to a Degree, that cannot be conceived by thoſe, who have never ſeen the Experiment. I then took my Pencil, and went over every Line of the Object, with all imaginable Care and Exactneſs, 'till I had finiſhed a compleat Drawing of it; and this being fixed in the Camera Obſcura, and ſo reduced, according to the ſtricteſt Rules of Perſpective, to a Size proper for my Book, I drew from it the Pattern, which was ſent to my Engravers. And indeed I have been ſo extreamly careful with Reſpect to the Copper-Plates, that no Expence has been wanting, in order to their being engraved in the very beſt Manner. It is for this Reaſon that I am obliged to raiſe the Price of my Book much higher, than I ever intended, or even deſired; however, as it is not a Matter of Choice, but abſolute Neceſſity, I hope the Publick will be ſo indulgent, as to take it into their Conſideration.

As my Microſcope has had the good Fortune to meet with a favourable Reception from many Gentlemen of Diſtinction and Learning in ENGLAND, as well as ſeveral Parts of EUROPE; I thought an accurate Deſcription of it would not be diſagreeable to thoſe, who had been pleaſed to honour me with their Cuſtom. This was my ſole Intention in ſitting down to write, but I quickly found myſelf engaged much deeper, than at firſt I deſigned; and at length began to believe, that a Collection of the moſt valuable Materials that could be met with in *the best Writers upon Microscopes, might perhaps be pleasing, as well as useful to the Publick. I was greatly assisted in this Undertaking, by being allowed a free Access to one of the finest Libraries in* ENGLAND, *belonging to a noble Personage, whose Name I am not permitted to mention, but whose Goodness upon this, and all other Occasions, I shall constantly acknowledge with the highest Respect and Gratitude. I shall only add, that I have neither so much Ambition, nor Vanity, as to presume to reckon myself among the Number of those learned Men, who have wrote upon this Subject. My Profession indeed must necessarily afford me a good deal of Insight into several Branches of Natural Philosophy, and I cannot reproach myself with having wilfully neglected any Opportunity of Improvement, but still I am fully sensible, that my Book must have many Defects; however, I rely very much upon the Candour of the Reader, and so shall beg Leave, without farther Ceremony, to throw my Mite into the publick Treasury.*

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CONTENTS.

Chap.

ERRATA.

Page 98, Line 24. for *Bindings*, read *Windings*.
Page 127, Line 16. read *Anemony*.

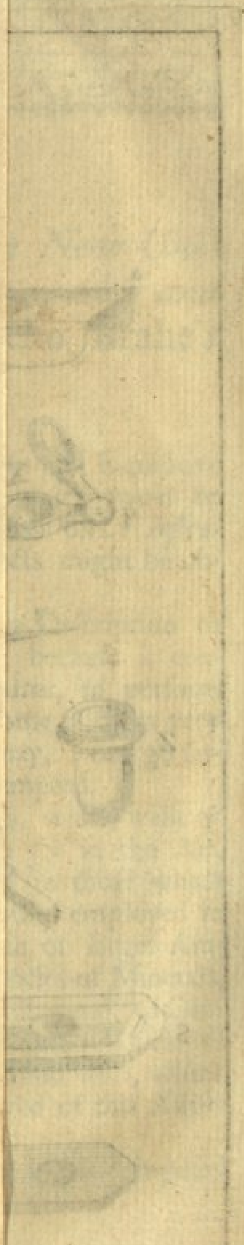
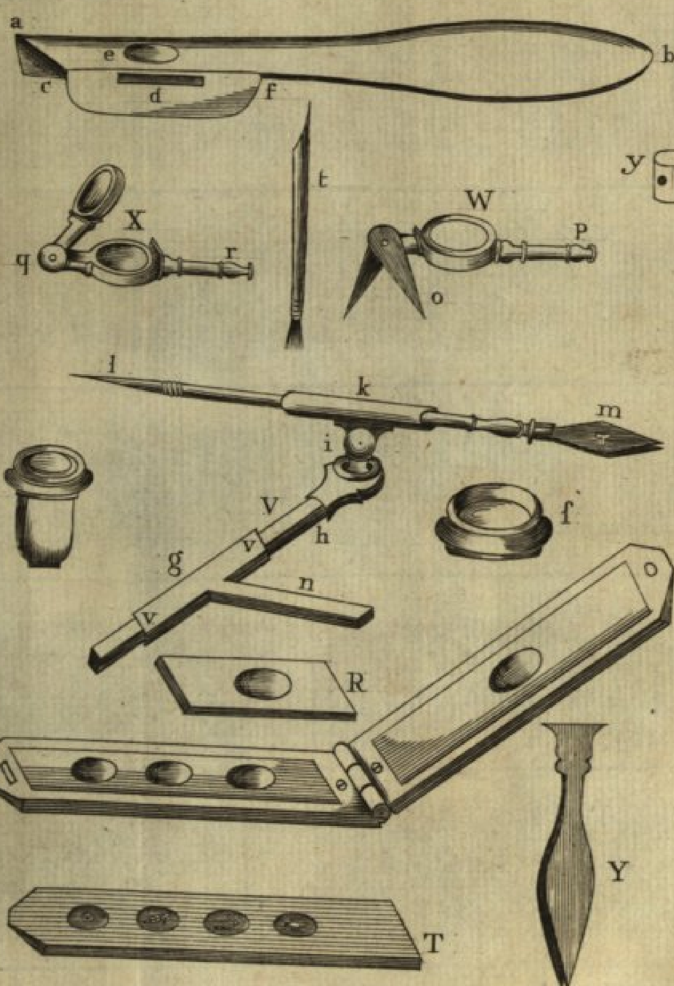


Fig. 2.



CHAP. I.

Containing the Deſcription and Uſe of a New Univerſal Single Microſcope, invented, made and ſold by GEORGE ADAMS, *at* Tycho Brahe's *Head, in* Fleet-Street, LONDON.

IT hath long been the Deſire of the Curious and Inquiſitive Part of Mankind, to have a Microſcope which would be Portable and Univerſal, that is to ſay, ONE ONLY *Inſtrument*, by which all Sorts of minute Objects might be obſerv'd.

I ſhall here preſent the Reader with a Deſcription of One, which comprehends all the wiſh'd-for Advantages, becauſe it contains a *ſufficient (tho' ſmall, yet all that's neceſſary) Apparatus*, to perform the Effects of all the various Sorts of Microſcopes, (and ſome of them very elaborate ones too) that have been heretofore invented; nay, I can go farther, and ſay alſo of ſome others that have been ſince attempted.

It is capable of obſerving all thoſe very minute Animals, which walk or crawl upon the Earth, Trees, Flowers, *&c.* thoſe which fly in the Air, and the Animalcula that ſwim in prepared Liquors, and in thoſe which have had no Preparation; it may alſo be very advantagiouſly employed in examining the Circulation of the Blood, *&c.* in the Inſide of larger Animals, and likewiſe in the Diſcoveries of the minute Particles of Minerals, Plants, *&c.* wherein may be perceived what amazing and ſtupendious Contrivances, exact and perfectly uniform Proportions, the great Author of Nature hath endowed thoſe very minute Parts of the Creation with, which are ſo extreamly ſmall, as to eſcape the beſt Eyes deprived of this Aſſiſtance of human Art.

This MICROSCOPE is made either of *Braſs* or *Silver*, and is compoſed of *ſix* double Convex *Lens's*, of different Foci.

Repreſented, as put together for Uſe in Fig. 1.

When it is firſt taken out of its Box, the two Legs A, B, are to be turn'd about upon the Joint C, till they make an equilateral Triangle with the fixed Leg D, then will the Pillar E, be ſupported in a perpendicular Poſture.

F, is an illuminating Glaſs, for reflecting the Light of the Sky, the Sun, or a Candle, upon the Object: Its Support H, is to be put into a Hole, in the Center of the round Piece G.

The Object-Bearer I, with its Springs b, and Slider K, has a ſquare Stem behind the Slider, which is to be put into a Hole at L, in the upright Pillar E.

M, M M, is a ſcollop'd Plate, which contains the ſix Magnifiers, number'd from 1 to 6, the leaſt Number being the greateſt Magnifier; in the Center, and on the Underſide of this Plate, is a ſhort Cylinder, with a ſmall Steel Pin near the End of it. This Cylinder is to be placed in the Top of the Pillar E, in ſuch a Manner that the aforeſaid Steel Pin may go into the Slit at æ.

N, a black Eye Piece, hollowed out to defend the Eye from the Side Rays of Light, under which the Magnifiers may be turn'd round at Pleaſure; ſo that in this Apparatus there is no Trouble in changing the Magnifiers, they being ſo contrived as to be ſucceſſively brought under the Eye-Piece N.

O, is a reflecting Speculum of Silver, or other Metal, highly poliſhed; which when an opake Object is to be viewed, muſt be placed under the Eye-Piece N. By which Means, the Light thrown upon it from the Mirrour F, will be by it collected and reflected back again upon that Surface of the Object next the Eye; which will then be ſo ſtrongly illuminated, as to be examined with Eaſe and Pleaſure.

This removes the Inconvenience of having the dark Side of an Object next the Eye, that having been hitherto an unſurmountable Obſtruction to the making Obſervations on opake Objects, with any conſiderable Degree of Exactneſs. For in all other modern Contrivances generally known, when a large Magnifier is uſed, the Nearneſs of the Inſtrument to the Object, unavoidably overſhadows it ſo much, that its Appearance is render'd obſcure and indiſtinct; although many Ways have been tried to throw Light upon an Object from the Sun, the Sky, or a Candle, by a Convex Lens, placed on the Side thereof, yet this refracted Light falls on the Object ſo obliquely, that it rather ſerves to give a confuſed Glare, than to afford a clear and perfect View.

P, is an adjuſting Screw, by the turning of which an Object placed between the Object carrying Plate I, and Springs b, is readily raiſed or depreſſed; until it is brought into the exact Focus of the Magnifier.

1, 2, 3, 4, 5, 6, are Marks on the Pillar E, to ſhew the reſpective Diſtances of the Object from the Magnifiers, according as each Glaſs magnifies more or leſs. — For Inſtance, if you uſe the 5th Magnifier,

firſt

firſt place it under the Eye-Piece N, and then with your Finger and Thumb turn the Screw P, till the Finger of the Hand which is engraved on the Sliding-Piece Q, points to the Mark 5 on the Pillar; then will the Object be very near its exact Diſtance from the Magnifier; ſo that by a Turn or two of the Screw P, either backwards or forwards, to be found by Trial, you may ſoon fit it exactly to your Eye.

The Object carrying Plate I, and Steel Springs b, are capable of holding Ivory Sliders; or other Contrivances of different Thickneſſes, by unſcrewing the little Screw c, and with your Nail preſſing down the Slider K, by the Button d, the Steel Springs will then be ſo ſeparated from the Plate I, as to receive any other Part of the Apparatus; and may be there made faſt by tightening the Screw c.

e, A Nut, by the ſcrewing of which, the Joint C may be tightned, if at any Time it ſhould wear eaſy.

The Plate numbered Fig. 2. *repreſents the Apparatus belonging to the Univerſal Single Microſcope*, Fig. 1. *and alſo to the Univerſal Double Microſcope, repreſented by* Fig. 3. Whereof,

a, b, f, Is a Contrivance to confine a ſmall Fiſh, by putting its Tail under a Spring on the Inſide at c, and tying the Body of the Fiſh to the long Part b, f, the two extreme Ends of the Tail, may be drawn through the Slits d, d, on each Side, that the Middle of the Tail may lie flat: Then put the End æ of this Fiſh-pan between the Object carrying Plate I, and Springs b, of Fig. 1, or Fig. 3, (they being firſt opened to a proper Thickneſs to receive it,) in ſuch a Manner, that the Hole e, under which the Tail of the Fiſh is placed, may lie nearly under the Center of the Hole f, in the Object carrying Plate I. In this Poſition, the Magnifiers may be all ſucceſſively turned over the Object: And the Circulation of the Blood examined from the leaſt to the greateſt Magnifier, with Eaſe and Pleaſure. It may alſo be ſeen in the Webb between the Toes of a Frog's hind Foot, which is to be placed under the Spring at c, and its Body tied with a Tape to the Part b, f.

R, is a Piece of Glaſs to be placed as Occaſion requires, either upon the Surface of the Object carrying Plate I, or between it and the Springs b; its Uſe is to hold any accidental Object that may offer; ſuch as the Animalcules in Fluids, (which may be very commodiouſly examined in this Manner) Duſts, Cryſtals of Salts, the Farina of Vegetables, *&c.*

S, S, A jointed Slider, containing two flat Glaſſes, with Cavities ſunk in them, deſigned for confining any ſmall Object without cruſhing or deſtroying it; ſuch as Aquatics, or any other live Inſects, as Fleas, Buggs, Lice, *&c.* and is alſo to be placed between the Object carrying Plate I, and Springs b, which muſt be ſet wider to receive it as before directed.

T, is an Ivory Slider with four Holes, wherein to place different Objects between two Pieces of *Muſcovy* Talcs, and is alſo to be applied between the

the Object carrying Plate I, and Springs b, ſee Fig. 1, with the Ivory Slider T, applied to it.

V with its Socket g, ſliding Steel Bar h, Joint i, and its ſpringing Tube k, through which runs a Steel Wire; one End whereof terminates in a ſharp Point l, and the other hath a Pair of Plyers m, ſoldered to it: The Joint i having a twofold Motion for the readily placing the Parts of an opake Object before the Magnifier.

The Point or Plyers, are to be thruſt into, or take up, and hold any Inſect or Object; either of them may be turned under the Magnifier, as beſt ſuits the Purpoſe.

When this Apparatus is uſed, the ſquare Stem n, of the Socket g, muſt be put on to the Pillar E, at the Hole L, Fig. 1, and 3, (the Object Plate I, with its Springs b and Slider K being firſt removed,) it is repreſented as applied to the Microſcope at Figure 3.

W is a round Object Plate, one Side black and the other white, for rendring Objects the more viſible, by placing them if black upon the white, and if white upon the black Side. A Steel Spring o turns on each Side to make any Object faſt, and a hollow Pipe p iſſues from the Object Plate which may be ſcrew'd upon the ſliding Wier's Point l. y is another black and white Object-Plate, to be ſtuck on the aforeſaid Wires Point for opake Objects.

X is a ſmall Braſs Box, with a Joint at q and a Glaſs on each Side, its Uſe is to confine any living opake Object for Examination. This Box alſo hath a Pipe r, to ſcrew over the End of the ſliding Wire l.

Y, a Pair of Plyers or Forceps, to take up any Object, and manage it with Conveniency.

Z, a ſmall Ivory Box, with Iſinglaſs, to be placed when wanted, in any of the Ivory Sliders.

ſ, Is a ſeventh Magnifier, ſet in Ivory, to be held in the Hand or laid in the black Eye-piece N, for viewing any large Object.

t, A little Hair-Bruſh or Pencil, wherewith to wipe any Duſt from off the Glaſſes, or to take up any ſmall Drop of Liquid one would examine, and to put it upon the Glaſs R.

When a tranſparent Object is to be examined, thruſt the Ivory Slider which contains the Objects, between the Object carrying Plate I, and the Steel Springs (they being firſt opened to receive the Thickneſs of the Slider) and obſerve always to put that Side of the Slider where the Braſs Rings are, fartheſt from your Eye: Then turn the Magnifier you intend to uſe under the Eye-piece N, and ſet the Finger of the Hand on the ſliding Piece Q, to the Mark anſwering the Number of the Magnifier.

The Microſcope being placed on a Table near the Window, direct the Mirrour F towards the Sky, and then looking through the Eye-piece N upon the Object, placed next under the Plate I, turn the illuminating Glaſs

F, ſo about upon its Support H, and Joint v, till the Light is reflected upwards to the Object.

If it ſhould then happen not to be at its due Diſtance from the Magnifier, turn the Screw P at the ſame Time you are looking at the Object, till it be made to fit your Eye; which you will then know by its appearing perfectly diſtinct and clear.

I muſt here obſerve that the Screw P is to be turned as your Hands and Arms are reſting upon the Table, which is a Conveniency to be met with in no other Microſcope. All others requiring the Obſerver to raiſe his Body and Arms in adjuſting the Object to fit his Sight; which is not only very troubleſome but tireſome too; eſpecially if it requires any conſiderable Attention. Whereas in this new univerſal Microſcope a leaning Poſture is ſufficient, and conſequently the eaſieſt of all others for microſcopick Obſervations.

When an opake Object is to be view'd, place the reflecting Speculum O exactly under the Eye-piece N; Fig. 1, and fix your Object either on the Point of the Sliding Wire l, in the Plyers m, in the Braſs hollow Box X, or on the Object Plate W, as may be moſt convenient according to the Nature of it; then apply this whole Apparatus mark'd V, to the Microſcope, by putting its Stem n into the Hole L of the Pillar E: The Object carrying Plate being firſt removed. See Fig. 3. where this Apparatus is applied to the Microſcope. The Microſcope being placed upon a Table near the Window, direct the illuminating Glaſs to the Light, ſo as to throw it upon the Speculum O, then looking through the Eye-Piece N, and that Magnifier you judge fitteſt for the Object you would examine; by the Aſſiſtance of the Steel Bar h, ſliding in its Socket g, the Point and Plyers ſliding in their ſpringing Socket k, together with the double Motion of the Joint i. The Object may be turn'd about, rais'd or depreſs'd, brought nearer to the Magnifier, or put farther from it, till you hit the true focal Diſtance, and the Light be reflected ſtrongly on the Object from the Speculum O. The Screw P, will alſo greatly aſſiſt in adjuſting the Object to fit your Sight. In this Manner an opake Object will be ſhewn ſurprizingly diſtinct and clear.

It is always beſt to view an Object at firſt with one of the leaſt Magnifiers, by which Means, you may examine the whole, or a large Part thereof at once, and then gradually to inſpect the ſeveral particular Parts, by ſucceſſively turning the larger Magnifiers, under the Eye-Piece N, and thereby gain a true Idea of the Whole and all its Parts. Altho' the greateſt Magnifiers can ſhew but a very ſmall Portion of an Object at once: Yet by gently moving the Slider that contains the Object, and ſometimes gently turning the Magnifier backwards or forwards within the Limits of the Hole in the Eye-Piece N, or if it be an opake Object by ſliding the Steel Bar h backwards or forwards in its Socket g, the Eye will regularly

larly ſurvey it all: And if any Part ſhould be out of Diſtance, it may be eaſily rectified by turning the Screw P, one Way or the other.

In uſing the firſt Magnifier in the Single Microſcope, the Object is requir'd to be brought ſo near the Glaſs, as almoſt to touch it; therefore particular Care muſt be taken not to ſcratch it by rubbing the Slider, *&c.* againſt it; a few Turns of the Screw P will eaſily prevent it, and give it Room.

The Objects may be changed in the Sliders for any other you think proper, by taking out the Braſs Rings which keep in the Glaſſes where the Objects lie, with the Point of a Penknife; and if you turn the Slider, the Talcs will fall out: After which you may put what you pleaſe between them, and replace the Rings.

CHAP. II.

Containing the Deſcription and Uſe of a New Univerſal Double Microſcope, invented and made by GEORGE ADAMS, *at* Tycho Brahe's *Head, in* Fleet-Street, LONDON.

THIS Microſcope is compoſed of three double convex Lens's, two of which are placed in the Body thereof at a and b, and the Magnifier at g, ſix of which belong to this Microſcope, and are fixed in a ſcollop'd Plate M, M, M, moveable about a Center at f, by which Means either of them may be readily turn'd under the other two Glaſſes, as at g, whereby the Trouble of ſearching out for different Magnifiers is remov'd.

The Body of the Microſcope is ſupported by the Arm T, having a circular Collar, whereinto it may be ſcrewed, or from whence it may be eaſily taken; this Arm proceeds from the upper Part of the ſliding Socket T, f.

The aforeſaid Socket T, f, together with the ſcollop'd Plate M M M, and the Body of the Microſcope; may be moved up or down the ſquare Bar R S, which is divided into as many Parts (1, 2, 3, 4, 5, 6.) as there are Magnifiers of different Foci; ſo that the Diſtance of the Object from the Object-Glaſs may be found without any Trouble, by ſetting the Finger of the Hand engrav'd upon the Socket, to the correſpondent Number of the Magnifier (then, under the Body of the Microſcope) on the Bar R S, and fixing it there by Help of the Screw *b*. But as it is ſcarce exactly enough determined this Way, the Object may be brought nearer to, or removed farther from the Magnifier at Diſcretion, by a Turn or two of the Screw P. Remembering at the ſame Time, the upper Hand is ſet to any Number

Number on the ſquare Bar, to place the Index on the Piece Q, to the Flower-de-luce on the upright Pillar E.

O, is a reflecting Speculum highly poliſhed, which muſt be placed at R, when an opake Object is to be viewed, on which a direct Light becomes reflected from the aforeſaid Speculum.

The ſquare Bar R S, fits into the Top of the upright Pillar E, and may be made faſt thereto by the Screw at æ.

The Object-Bearer I, Ivory Slider, illuminating Glaſs F, with its Support H, and round Piece G, and the Apparatus V, with its Nippers and ſliding Wire, *&c.* having been ſufficiently deſcribed in the foregoing Chapter, I ſhall refer the Reader to that for the Uſes thereof, and alſo for a Deſcription of the Apparatus, which is exactly the ſame as that repreſented in Fig. 2. and its Uſes and Application to this Univerſal Double Microſcope, the very ſame as in the foregoing Univerſal Single One.

I have alſo adapted to either of theſe two New Microſcopes, a particular Apparatus for confining Frogs, Mice, Bats, *&c.* in order for viewing the Circulation of the Blood in the Meſentery, or any of the tranſparent Skins, which will by and by be fully deſcribed.

It remains therefore only to ſhew how theſe two New Microſcopes are beſt illuminated by Candle-Light, which is by letting the Rays of Light tranſmitted from the Candle, firſt paſs through a Glaſs Globe *, filled with Water before they fall on the illuminating Glaſs F, and if that ſhould prove too glaring, as it ſometimes does, interpoſe between the Globe and Microſcope, a Piece of thin oil'd Paper, by which Means moſt Sorts of Objects may be view'd as well by Night, as in the Day-Time.

Either of the foregoing new invented Univerſal Microſcopes, may be applied to the ſolar Apparatus, and may be had at my Shop ſeparate or together. They are very portable, and neatly packed up in ſmall Caſes.

After having given a Deſcription of the new invented Univerſal Microſcope, in both its Forms, that is to ſay, either ſingle or double; it is convenient to ſay ſomething concerning the Uſes thereof. And here I muſt inform the Reader, that my Curioſity and Deſire of rendering this Inſtrument as perfect as poſſible, hath engaged me to find out Methods, which might fully ſatisfy thoſe who are willing and deſirous of prying into the minute Receſſes of Nature, and repeat the Experiments and Obſervations related in the following Natural Hiſtory.

In order therefore to obſerve Flies, and other Inſects of the like Bulk, ſtick them upon the ſliding Wires Point, or pinch ſome Part of them between the Nippers, and apply them under the reflecting Speculum O.

I have already ſhewn that Lice, Fleas, Ants, and other Animals of the ſame Size may be obſerved alive, by being confined between the two

* For the Want of a Jeweller's Globe, a common globular Decanter, filled with clear Water, will anſwer the ſame End.

Glaſſes

Glaſſes S, S, Fig. 2. They may alſo be pinch'd by the Breach between the Nippers m of the Apparatus V, Fig. 2. by which Means you will have the Pleaſure of obſerving all the external Parts of their Bodies, and may ſometimes ſee other Animals running too and fro upon them, which feed on and torment them; theſe are called Lice of the Louſe, and Fleas of the Flea. They may alſo be placed between two *Muſcovy* Talcs, as at T, Fig. 2. in an Ivory Slider.

Mites of Cheeſe, and their Eggs, Lice of Birds, and the Inſects which infeſt Pears, Apples, *&c.* may be fixed upon the black and white Object-Plate, with a little Gum-Water, if they are opake, or if tranſparent, they may be ſtuck to the Object-carrying Glaſs R, Fig. 2. with Gum Water; by which Means you may examine them with the greateſt Magnifier, and with Satisfaction and Delight view their internal Structure and the Periſtaltick Motion of their Bowels, *&c.*

All the other Sorts of little crawling Animals, which are ſo very ſmall that one can hardly touch them without deſtroying their Lives, are beſt glewed as it were upon the Point of a fine ſewing Needle, dipped in Turpentine. (The Needle being firſt made faſt to the End of a ſhort Bit of Stick by Way of Handle to it) If you do but juſt touch the Back or Side of any one of theſe minute Animals therewith, it will ſtick ſo faſt thereto, as not to be able to remove itſelf; by which Means they may be examined with Eaſe and Pleaſure. The ſewing Needle muſt be held between the Nippers m, of the Apparatus V, Fig. 2. and ſo placed before the Magnifier, either of Fig. 1, or 3. any Part of the Animal may be turn'd before the microſcopick Lens, by twiſting the Handle of the ſewing Needle, as you find Occaſion.

Hairs, Wings of Flies, ſmall Feathers of Birds, *&c.* are beſt perceived, and eaſieſt examined, when placed between two *Muſcovy* Talcs, in an Ivory Slider.

All Sorts of inanimate Objects, ſuch as Grains of Sand, Seeds of Plants, Farina of Flowers, *&c.* may be commodiouſly examined, upon the Object-carrying Glaſs R, Fig. 2. if they are tranſparent; or if they are opake, ſtrew them lightly on one of the black and white Object Plates W or y, and apply them to the Microſcope, under the reflecting Speculum o.

To preſerve any of theſe tranſparent Objects, place them in an Ivory Slider, between two *Muſcovy* Talcs, and the opake ones being thinly ſtrewed upon ſome of thoſe Holly Slips of different Colours (hereafter deſcribed in Chap. 10.) the Slips being firſt wetted with Gum-Water.

In the Manner laſt mentioned, Objects of a larger Size may be preſerved, ſuch as the Heads and ſcaly Wings, *&c.* of curiouſly colour'd Flies, and may be conveniently placed before the Microſcope, by pinching the End, or any other Part of the Slip between the Nippers *m*, of the Apparatus V, Fig. 2.

To examine the Animalcula in Fluids, thruſt the Point of an Hair Pencil,

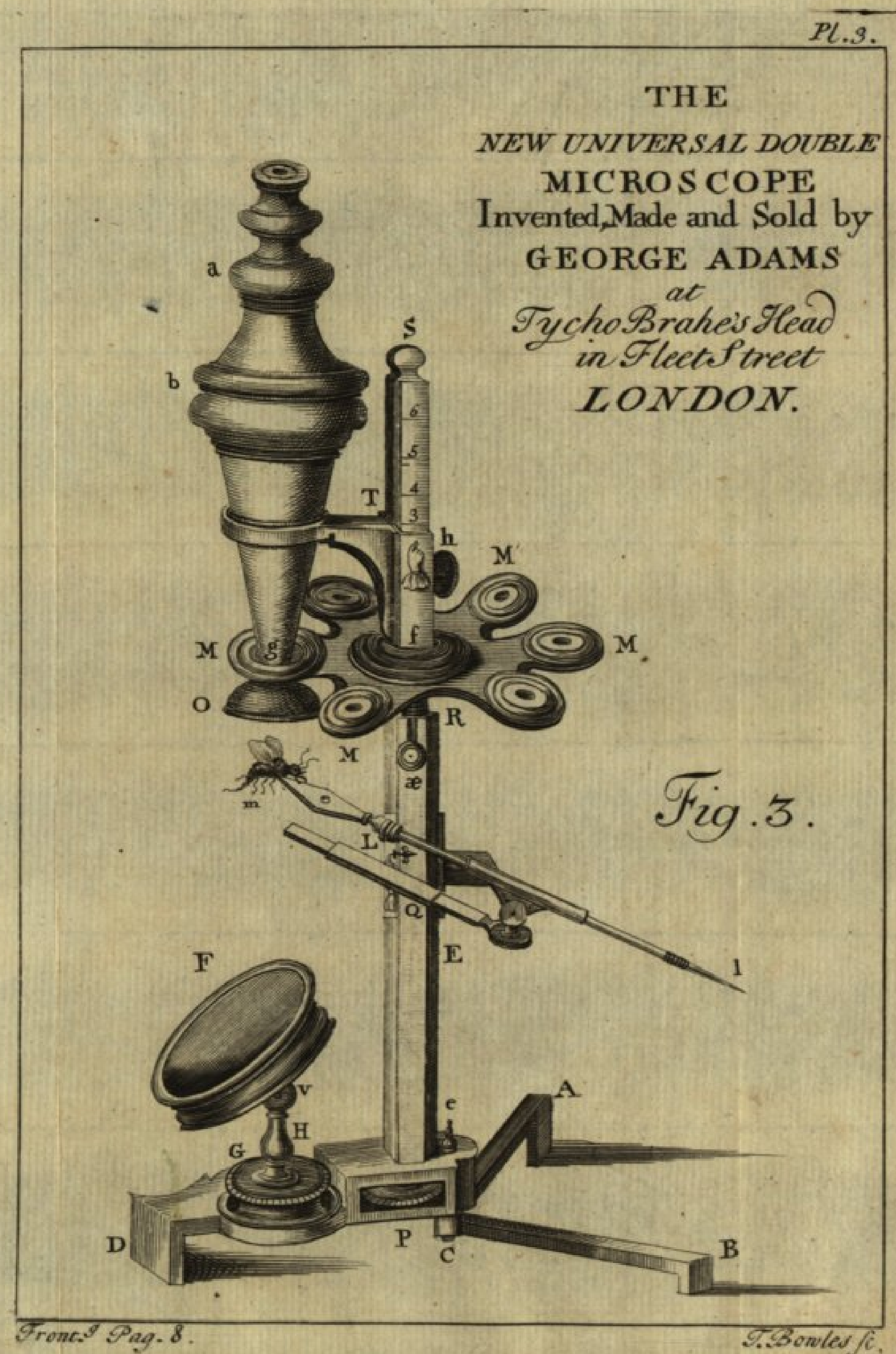

Pl. 3.
THE
NEW UNIVERSAL DOUBLE
MICROSCOPE
Invented, Made and Sold by
GEORGE ADAMS
at
Tycho Brahe's Head
in Fleet Street
LONDON.
Fig. 3.
Front. Pag. 8.
T. Bowles sc.

Fig. 4.

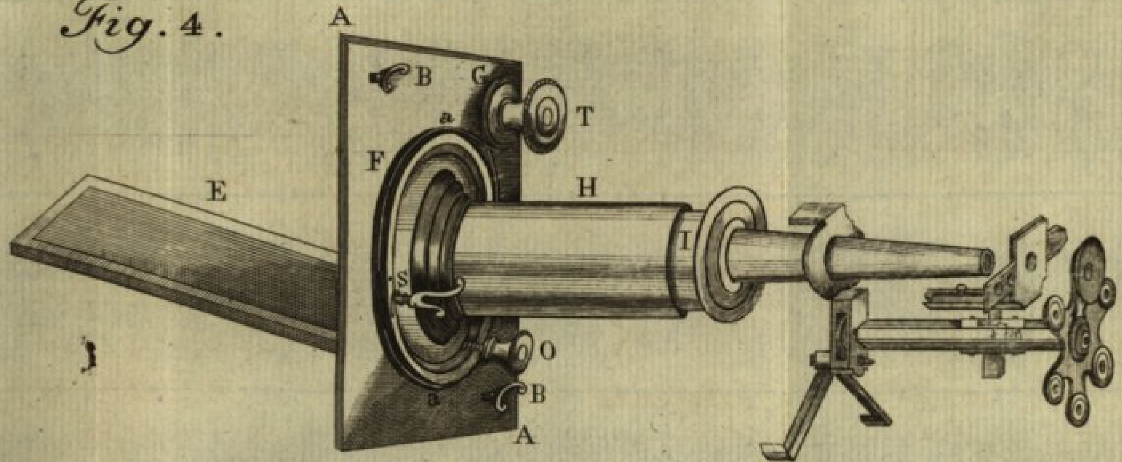
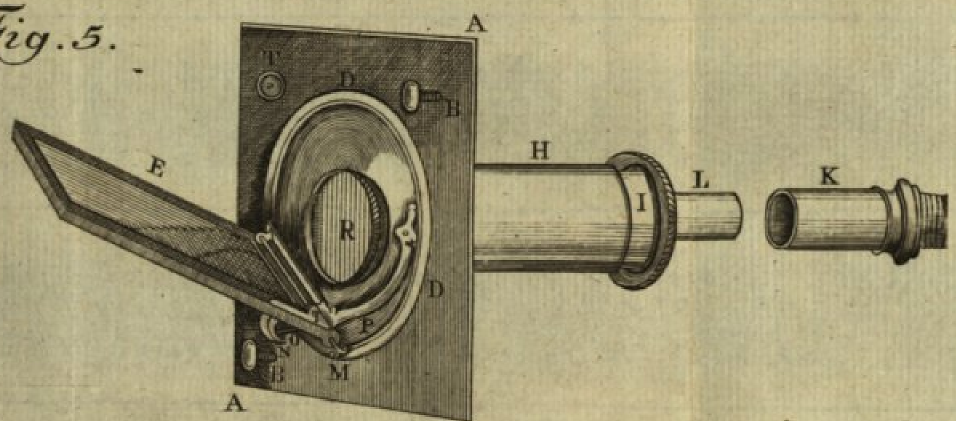


Fig. 5.



cil, or rather the Point of a Pin about one Tenth of an Inch under the Surface of the Liquor, and near the Sides of the Veſſel, that a little of it may may be taken up and placed in the Hollow of the Object-carrying Glaſs R, Fig. 2. which ſhould be no more than to form a Drop about $\frac{1}{10}$ of an Inch in Diameter, and that will be a Kind of Lake or Pond, in which you may diſcover a ſurprizing Quantity of extremely minute fiſh-like Animalcula of different Sizes, Figures, and Motions.

I have already ſhewn how to apply the Tail of a ſmall Fiſh, and the Foot of a Frog, to the Fiſh-Pan a, b, f, Fig. 2. in order to ſhew the Circulation of the Blood. And ſhall by and by explain another Method which I have contrived, for viewing the Circulation of that Purple Tide in Animals of a larger Size.

The Eaſe and Readineſs with which every minute Object may be applied to this Inſtrument, hath render'd it the moſt univerſal and commodious of any other of the preſent Sorts, for by this one Inſtrument, all the particular Uſes of every other Sort are obtained with leſs Trouble, and conſequently more Satisfaction to the Obſerver.

CHAP. III.

Of the Improved Solar, or Camera Obſcura Microſcope.

THIS moſt ſurpriſing Contrivance, is compoſed of a Looking-Glaſs, a Tube, and the *Univerſal Microſcrope*, Fig. 1, or 3, and as it depends entirely on the Sun-ſhine, is to be uſed in a Chamber, from whence all the Light muſt be excluded, except what paſſes through the aforeſaid Tube.—A Picture of the whole Apparatus put together, is ſhewn Fig. 4. and the other Side of the Solar Apparatus by itſelf, Fig. 5.

Whereof A, A, in both the Figures, is a ſquare Braſs Plate, thro' which two Screws B, B, paſs; their Screw-Nuts are ſeen at B, B, Fig. 4. and the Head of their Screw Pins at B, B, Fig. 5. A large Hole, $4\frac{3}{4}$ Inches Diameter, muſt be cut in the Window-Shutter, which is ſomewhat bigger than the Circle D D, Fig. 5. And then applying the ſquare Plate thereto, bore thro' it two other ſmall Holes, anſwerable to thoſe in the Plate at B and B. Put the Screw-Pins thro' theſe laſt made Holes in the Shutter, and with their Nuts, ſcrew the ſquare Plate faſt thereto, the Looking-Glaſs being without the Window.

In the Middle of the ſquare Plate A A, is made a circular Hole to receive the flat Braſs Ring D, D, on one Side, and on the other Side a narrower Ring F, whoſe Edge, which projects a little beyond the Hole, is turn'd into a ſhallow Groove a a, wherein runs a ſilken Line, which by twiſting round, and then croſſing over a Braſs Pulley G, performs an eaſy Motion for turning round the flat Wheel D, D, and all the Parts thereto affixed.

H, is a Braſs Tube, that ſcrews into the Middle of the two Braſs Rings D D, and F, and becomes a Caſe for the leſſer Braſs Tube I, to be drawn backwards or forwards in.

K, is a ſhort Tube of Braſs, which fits into the Foot D of the Univerſal Microſcope, Fig. 1, or 3. the illuminating Glaſs F, and the round Piece G, being firſt taken out to make Room for its Reception. The Tube K, fits over another ſhort Tube L, which is ſolder'd to the End of the inner Tube I, and is diſtinctly ſeen in Fig. 5.

E, is a Looking-Glaſs of an oblong Figure, ſet in a Frame of poliſhed Braſs, and fixed to the broad Ring D, D, Fig. 5. by Means of a long Steel Screw M, going through a Joint at the Bottom of the Frame, and may be ſcrew'd in, or taken out at Pleaſure. At the Bottom of the Looking-Glaſs Frame, is fixed a circular Piece of Braſs N, againſt which the End of the Screw O preſſes, in order by ſcrewing it to elevate the Glaſs, which is depreſſed on its being diſcharged; by the Force of a ſtrong Spring P, acting againſt a Bracket, fixed to the Side of the Looking-Glaſs Frame.

R, a convex Lens, whoſe Focus is about 12 Inches, fixed at the outward End of the Tube H, to collect the Sun's Rays, and throw them ſtrongly upon the Object.

S, Fig. 4. is a Steel Pin, having one End of the ſilk String faſtened to it, by the Turning of which, the String may be tightened, if at any Time it ſhould be too ſlack; the other Extremity of its being tied by a Knot to the Ring F.

When this Microſcope is uſed, the Room muſt be made as dark as poſſible; for on the Darkneſs of the Room, and the Brightneſs of the Sun-ſhine, you are to expect a perfectly clear and diſtinct Image.

The Looking-Glaſs being put thro' the Hole in the Window-Shutter, and the ſquare Plate A, A, faſten'd thereto by its Screw Pins C, C, and Nuts B, B, as before directed. Screw the Tube H into the Middle of the Plate and Rings, and the double convex Lens R on its Outſide. Then adjuſt your Looking-Glaſs to the Altitude and Situation of the Sun, by Means of the Screw O, and the Silk-Line with its Pullies F and G, the firſt of theſe raiſes or depreſſes the Looking-Glaſs, and the latter by turning the Boſs T, inclines it to either Side; by which compound Motion, the Glaſs is ſo readily managed, as to be brought into a right Direction for throwing the Sun's Rays thro' the double convex Glaſs R, and Tube H, upon a Paper-Screen, placed about 5 or 6 Foot Diſtance from it; and to form thereon a round Spot of Light, which is a Proof of your Glaſs being rightly adjuſted; but this 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 perfectly round Spot of Light, but if it be on either Side of you, it may be obtained even when the Sun is in the ſouthern Tropick.

Being thus far prepared, ſcrew the Tube K into the Foot D of the *Univerſal Microſcope*, Fig. 1. or Fig. 3. and ſlip it over the ſmall End L of the inner Tube I, (all which is repreſented as done and ready for Uſe in Fig. 4.) and pull out the ſaid Tube I, more or leſs, as the Object is capable of ſuſtaining the Sun's Heat. Dead Objects may be placed within about an Inch of the Focus of the double convex Lens R, which Diſtance muſt be ſhortened for living Creatures, or they will ſoon be killed.

If the Light falls not exactly right, you may readily direct it thro' the Axis of the Microſcopick Lens; and there keep it during the Time of your Examination, by the Help of the Screw O, and Boſs T, following the Sun's Motion.

The Objects are to be managed and brought to their true focal Diſtance, by obſerving the Directions given in Chap. I. in the Deſcription of the *Univerſal Microſcope*, Fig. 1, that is, they may be placed between the Object-carrying Plate I, and Springs b, ſtuck upon the Point, or held in the Nippers, and adjuſted to their exact Focus, by the Screw P, *&c.*

The moſt uſeful Magnifiers in the ſolar Microſcope, are the 4th, 5th, or 6th.

Having taken Notice of a Screen to throw the Images of Objects upon; ſuch a Screen is uſually made of a Sheet of the largeſt Elephant Paper, ſtrain'd on a Frame, which ſlides up and down on a round mahogany Pillar, in the Manner of ſome Fire Screens. A larger Sort are compoſed of ſeveral Sheets of the ſame Paper paſted together on Cloth, and let down with a Roller from the Ceiling in the Manner of a large Map.

There are many Conveniencies in this, which no other Microſcope has, for as it ſhews Objects larger than any other Way, there is Reaſon to hope that further Diſcoveries will be made by it. Beſides this particular Property it hath, that Numbers of People may view an Object at the ſame Time, and may point to the different Parts thereof, and by diſcourſing on what they ſee, may underſtand each other better, and more probably find out the Truth, than when they are obliged to look one after another. Beſides the weakeſt Eyes may uſe it without the leaſt Straining or Fatigue. By this Means alſo, an Object may be outlined exactly, and thereby a Drawing of whatever is curious be eaſily obtained.

CHAP. IV.

The Description of the Screw-Barrel, or Mr. WILSON's *Single Pocket Microscope.*

THIS Microscope of Mr. *Wilson*'s, is an Invention of many Years standing, and was in some Measure laid aside, till Dr. *Liberkun* introduced the solar Apparatus, to which he applied it, there being no other Instrument at that Time would answer his Purpose so well; since which Time it has been revived, and esteemed the best, tho' very troublesome in most Cases.

The Body of the Microscope is represented by A B, A B, Fig. 6. made either of Silver, Brass, or Ivory.

C C, 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; on which may be placed, as Occasion requires, one of the two concave Pieces of thin Brass, with Holes of different Diameters in the Center of them, to cover the said Glass, and thereby diminish the Aperture, when the greatest Magnifiers are used.

E, 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.

F, a Piece of Wood or Brass, arched in the Manner of the said Plate, and fastened thereto.

G, The other End 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 E, intended to keep the Plates in a due Position, and counter act against the long Screw C.

I, a small turn'd Handle for the better holding the Instrument, to screw on and off at Pleasure.

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

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

M, is a flat Slip of Ivory, called a Slider, with four round Holes thro' it, wherein to place Objects between two *Muscovy* Talcs.

Six

Six 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.

There is alſo a Braſs Slider, not expreſſed in the Figure, 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 in the Glaſſes.

O, a little Hair Bruſh or Pencil, wherewith to take up and examine a ſmall Drop of Liquid.

P, is a Tube of Glaſs, to confine living Objects, ſuch as Frogs, Fiſhes, *&c.* in order to diſcover the Circulation of the Blood.

When you would view an Object, thruſt the Ivory Slider in which the ſaid Object is placed, between the two flat Braſs Plates; obſerving always to put that Side of the Slider where the Braſs Rings are fartheſt from the Eye. Then ſcrew in 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 C C, till your Object is brought to the true focal Diſtance, which you will know by its then appearing perfectly clear and diſtinct. The Way of examining any Object accurately, is to look at it firſt thro' a Magnifier, that will 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 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 C C 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 C C, will eaſily prevent this Miſchief, by giving it Room enough.

How to change the Objects in the Ivory Sliders, has been ſhewn in the firſt Chapter.

The Circulation of the Blood may be eaſieſt ſeen in the Tails or Fins of Fiſhes, in the thin Membrane between the Toes of a Frog's hind Foot, or beſt of all in the Tail of a Water-Newt. 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 its hind Foot, as wide as you are able. When your Object is ſo adjuſted, ed, that no Part thereof can intercept the Light from the Place you intend to view, unſcrew the long Screw C C, 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.

Make Uſe of the third and fourth Magnifiers for Frogs, or Fiſhes; but for the Tails of Water-Newts, the fifth or ſixth will do; the firſt or ſecond Magnifier cannot well be employed to this Purpoſe, for the Thickneſs of the Tube, wherein the Object is placed, will ſcarce admit its being brought ſo near to the focal Diſtance of the Magnifier.

This Single Microſcope of Mr. *Wilſon*'s, has ſometimes been 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 Addition of the following Contrivance.

The beſt Light for viewing Objects, is a clear Sky-Light, the Sun ſhining on any white Thing, or the Reflection of its Rays from a Looking-Glaſs; which laſt is found to be full as ſtrong as any, and much more convenient for Uſe, particularly in examining Liquids; for if you hold this Microſcope up to to receive the Light from the Sky, your Liquid ſubſides, and is ſoon loſt; but when placed in a perpendicular Poſition, ſo as the Rays of Light may be thrown from a Glaſs, fixed beneath it, you view it with more Eaſe, and leſs Inconvenience. For the Application of which obſerve,

CHAP. V.

A Contrivance for fixing Mr. WILSON'*s Pocket Microſcope, and reflecting Light to it by a Mirrour.*

A B C, Fig. 7. is a Braſs Scrole, which, for the better Conveniency of Carriage, is ſo order'd, as to take into three Parts, and put into the Draw upon which it ſtands, with its reflecting Mirrour, and *Wilſon*'s Pocket Microſcope.

The Top-Part of the Scrole is taken off at B, by unſcrewing half a Turn of the Screw; then lift it up, and it comes out of the Socket. The lower Part unſcrews at C, and the Baſe unſcrews at E.

The Mirrour lifts out at F, which with the Scrole lie in one Partition of the Box.

To apply this Scrole to Uſe, fix the Body of the Microſcope to the Top thereof, by the Screw A, as in Fig. 7. by ſcrewing it in the ſame Hole as the Ivory Handle.

The Braſs or Ivory Slider being fixed as before deſcribed, and the Microſcope placed in a perpendicular Poſition; move the reflecting Glaſs D in ſuch a Manner, as to caſt the Light of the Sky, the Sun, or a Candle, directly upwards, through the Microſcope; by which Means it is made to anſwer moſt of the Ends of a double reflecting Microſcope, hereafter to be deſcribed.

It is alſo rendered more uſeful for viewing opake Objects, by ſcrewing the Arm Q, Fig. 6. into the Body of the Microſcope, at G, then ſcrewing into the round Hole R, that Magnifier, which you think will beſt ſuit your Object; and put the concave Speculum S, on to the Outſide of the Ring R, you will find in the Body of the Microſcope, between the Wood or Braſs F, and the End of the Male Screw C C, a ſmall Hole U, through which ſlide the long Wire T, which has a Point at one End, and Forceps at the other, that may be uſed occaſionally, as your Object requires: When you have fixed this, and your Object on it, turn the Arm R, which is performed by two Motions, till the Magnifier is brought over the Object; it may be then adjuſted to the true Focus, by turning the Male Screw C C, in the ſame Manner as before deſcribed. It muſt alſo be turned exactly over the Speculum, by twiſting the upper Part of the Scrole to one Side, till your Object, and the two Speculums, are in one Line, as will be found by Trial, and then fix it by the Screw B, at which Time the upper Surface of the Object will be ſo exceedingly enlightened by the Light reflected upward from the Mirrour, to the concave Speculum, as to be ſeen as clear and diſtinct as any tranſparent one.

CHAP. VI.

Of the Manner of applying Mr. WILSON'*s Pocket Microſcope, to the Solar Apparatus.*

THE Solar Apparatus having been already deſcribed in the 3d Chap. it remains only to ſhew how Mr. *Wilſon*'s Pocket Microſcope, is to be applied to it.

After having fixed the Apparatus to the Window-Shutter, and adjuſted it to the Altitude and Situation of the Sun, ſo as to form a round Spot of Light on the Screen.

Screw the Tube H, Fig. 5. into the Middle of the Plate and Rings, taking Care not to alter the Looking-Glaſs; then ſcrewing the Magnifier you chooſe to employ, to the End of your *Wilſon*'s Microſcope, at G, Fig. 6. In the uſual Manner, take away the Lens D, at the other End thereof,

thereof, and place a Slider, containing the Object to be examined between the thin Braſs Plates E.

Things being thus prepared, ſcrew the Body of the Microſcope A B, by the Screw D, Fig. 6. to the ſhort Braſs Tube K, Fig. 5. which ſlip over the ſmall End L of the Tube I, and pull out the ſaid Tube I, more or leſs, as the Object is capable of enduring the Sun's Heat.

The ſhort Tube K, which your Microſcope is ſcrew'd to, enables you by ſliding it backwards or forwards on the other Tube L, 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.

For the Screen, and all the other Particulars, See Chap. 3.

CHAP. VII.

Of the Microſcope for Opake Objects.

A, Fig. 8. is a fixed Arm, through which paſſes a Screw B, the other End whereof is faſtened to the moveable Arm C.

D, is a Nut fitted to the ſaid Screw, which when turned, will either ſeparate or bring together the two Arms A C.

E, is a Steel Spring, that ſeparates the two Sides when the Nut is unſcrewed.

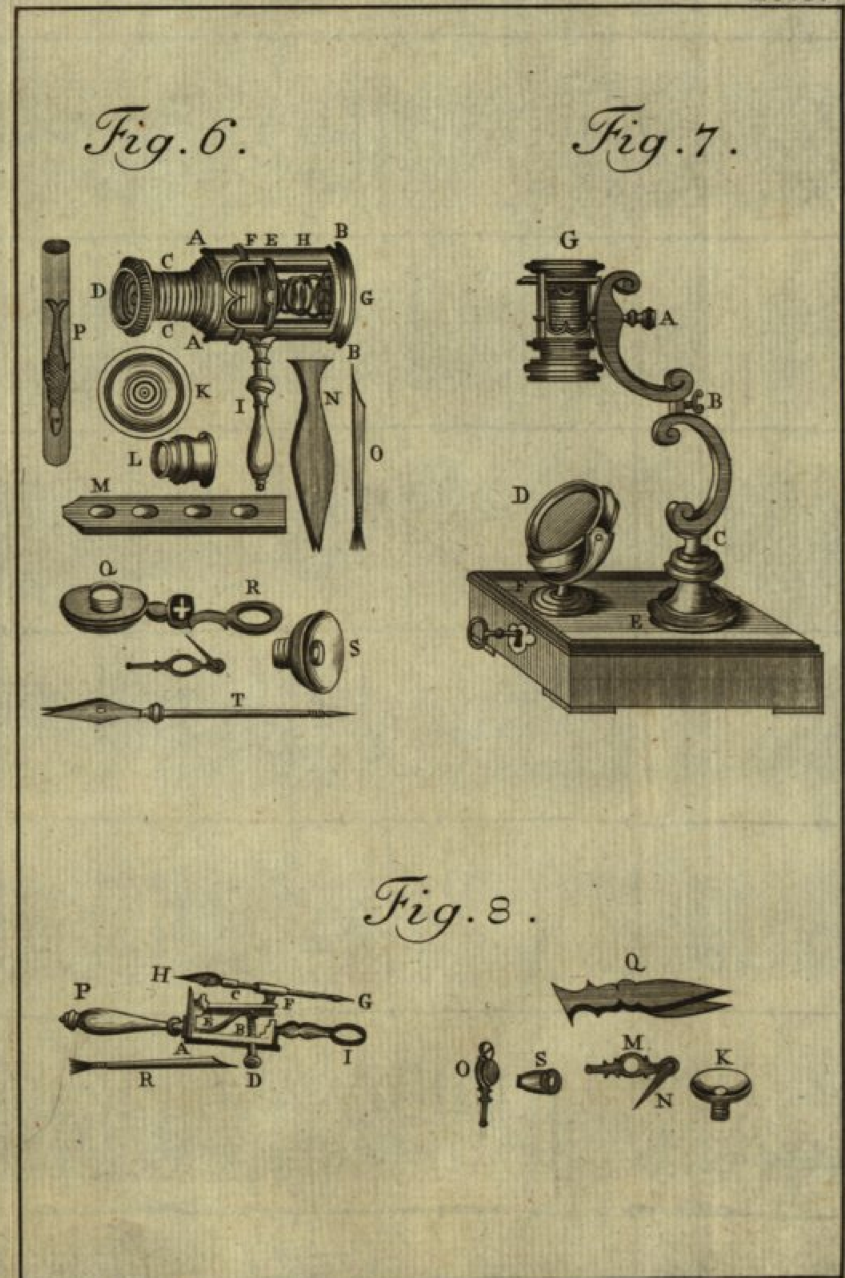
F, a Piece of Braſs turning round in a Socket, whence proceeds a ſpringing Tube, moving on a Rivet, through which runs a Steel Wire, one End of which finiſhes in a Point G, and the other End hath a Pair of Plyers R ſolder'd to it; theſe are either to thruſt into, or to take up and hold any Object; and may be turned round as required.

I, a Ring of Braſs, with a female Screw fixed on an upright Piece of the ſame Metal, which turns on a Rivet, that it may be ſet at a due Diſtance when the leaſt Magnifiers are uſed; and ſerves 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 to fit the Braſs Ring I, which may be ſcrewed into the ſaid Ring at Pleaſure.

Four of theſe concave Specula of different Depths, are fitted to four Glaſſes of different magnifying Powers; to be uſed as Objects to be examined may require. The greateſt Magnifiers have 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, upon the white, and if white, on the black Side. A Steel Spring N, turns down on



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on each Side to make any Object faſt; and iſſuing from the Object Plate is a hollow Pipe to ſcrew it on the Needles 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 at G.

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

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

R, a ſoft Hair Bruſh to clean the Glaſſes or Specula.

When you would view any Object, ſcrew the Speculum with the Magnifier you intend 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 turned 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 appear very diſtinct and clear.

CHAP. VIII.

A Deſcription of the Double Microſcope, commonly, though very improperly, called the Reflecting Microſcope.

AB C, Fig. 9, is the Body of this Microſcope, in which ſlides C D, the inner Tube, that contains all the Glaſſes. The Eye Glaſs is at E, the broad middle plano convex Glaſs at F, and the Object Glaſs being ſet in a Button at G, is ſcrew'd upon the End of the narrower Tube I, which being fixed in the Baſe of the inner Tube, paſſes freely through a Hole in the Baſe of the outer.

The Buttons that contain the ſeveral Object Glaſſes are number'd 1, 2, 3, 4, 5, and the Convexity of the inner Tube, is alſo marked with dotted Circles number'd 1, 2, 3, 4, 5, in order to bring that Circle to coincide with the Mouth of the outer Tube, whoſe Number is the ſame as that of the Object Glaſs then made uſe of: But if the Object does not then appear quite diſtinct, ſlide, or rather twiſt the inner Tube gently, higher or lower, or turn the Screw of the Magnifier gradually till the Object appears distinct. The greatest Magnifiers are known by their having the smallest Apertures.

The Base B C of the outer Tube is supported by three Brass Pillars on Scroles, fixt on a Mohogany Pedestal H K, in which is a Drawer L, to hold the Magnifiers and other Parts of the Apparatus. A little below the Object-Glass is fixed a Plate M, like a Stage between the Pillars.

N, three small brass Circles with Holes thro' the Middle of them which are to be placed over the Hole in the Middle of the Stage, and then the Ivory Slider O may be put between the two uppermost, which are pressed together by a spiral springing Wire lodged between the two undermost. The two outermost being held together by four small Pillars passing through four Holes in the Circumference of the middle Circle.

P, is a Fish-pan to fasten a small Fish on, to see the Circulation of the Blood, its Tail being spread across the oblong Hole at the smallest End; then by shoving the Button inwards through a Slit made in the Stage, a small Brass Spring under the Stage will keep it steady; for viewing it the Tail may be brought exactly under the Magnifier, by turning the Pan on the Button, or by shoving it inwards or outwards along the Slit in the Stage.

All transparent Objects are well illuminated in this Microscope, either by Candle or Sky-Light reflected upwards from a concave Looking Glass R, placed in a Frame upon the Center of the Pedestal. While you are viewing the Object through the Microscope, turn this Concave upon its horizontal Poles a b, and you will soon find out that Position of it wherein it reflects the most Light through the Hole c upon the Object.

Opake Objects when laid upon the Plate s, which is on one Side black Ebony, and on the other a Piece of white Ivory, being laid over the Hole c, in the Stage may be illuminated by the Light of the Sun-shine or a Candle transmitted through a double Convex Lens a, which by turning on two Screws, e, d, and the Foot of it put into the Hole f of the Stage. The Candle must be placed in a Line drawn from the Object through the Middle of this Lens at such a Distance to be found by Trial as will form the smallest Spot of Light upon the Object Plate. By Day-light this Glass is of no Service.

T, an Ivory Cone to screw on to a male Screw under the Center of the Stage: Its Use is to intercept some Part of the oblique Rays when the first and second Magnifiers are used.

V, a Glass Tube to put a small Frog or Newt in, to see the Circulation of the Blood. When the Object is well expanded on the Inside of the Tube, slide it over the Hole c, in the Center of the Stage; and bring that Part of the Object you would examine directly under the Magnifier.

W,

W, a Cell, containing a concave and a plain Glaſs, is to confine Fleas, Lice, Mites, or any ſmall living Objects, and being placed over the Middle of the Stage may be viewed with Eaſe.

X, a plain circular Glaſs to be placed over the Center of this Stage to lay any Objects on that may at any Time offer, and a looſe concave Glaſs being laid with its hollow Side downwards, will eaſily confine any living Inſect.

Y, a long Steel Wire with its Pliers and Point to hold or ſtick Objects on, ſlips backwards and forwards in a ſhort Braſs Tube, which by the Button fits into the Hole of the Stage, and then it may be conveniently managed under the Magnifier.

O, a flat Piece of Ivory called a Slider with four round Holes through it, and Objects placed in them between *Muſcovy* Talcs.

Z, a little round Ivory Box to hold Iſinglaſs for the Sliders.

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

J, a Pair of Nippers to take up any Object to be examined.

N. B. When the Body of this double Microſcope is made of Braſs, it is ſupported with a ſingle Pillar, to which is fixed a ſliding Bar, an adjuſting Screw, and a concave Speculum for opake Objects, *&c.* But as this Apparatus comes to double the Price of that juſt deſcribed, and being not at all better for Uſe, I have omitted a drawing thereof.

CHAP. IX.

Of a Single or Double Microſcope, what, how it magnifies, and why.

A Single Microſcope is only a very ſmall Globule of Glaſs, or a double convex Lens, whoſe focal Diſtance is very ſhort. The former being at preſent diſus'd, I ſhall confine myſelf only to a Deſcription of the Nature and magnifying Powers of the latter.

A thin Piece of Glaſs bounded on one Side by a poliſhed plane Surface, repreſented by the Line E F, Fig. 10, 11, and on the other Side by a ſmall Portion of a poliſhed ſpherical Surface, repreſented by the Arch A C B; or bounded on both Sides by ſpherical Surfaces A C B E D F, Fig. 12, 13, 14. is called a Lens, or ſimply a Glaſs; and by Mathematicians is conceived to be generated or deſcribed by turning the Figure A C B F D E round about the Line C D, drawn through the Middle of it, perpendicularly to both its Sides.

 This

This Line produced is therefore called the Axis of the Lens; and passes through G and H, the Centers of its Surfaces.

The Points C D, where it cuts the Surfaces, are called the Vertexes of the Lens, and the middle Point between them is called its Center.

The 10th Figure represents a plano Convex, the 11th a plano Concave, the 12th a double Convex, the 13th a double Concave, and the 14th a concavo Convex, or a Meniscus Lens.

As Rays of Light are thrown out and dispersed in all possible Directions from every Point of a luminous Body; so as they illuminate other Bodies upon which they fall, they are also incessantly thrown back from, or transmitted through every Point of these Bodies. For the Points of opake and transparent Bodies so enlighten'd, are visible to the Eye, at any Point of Space, and in any Point of Time, as well as the Points of the luminous Body that enlightened them. The numberless Rays which flow from all visible Bodies, called Objects, are considered as consisting of so many physical Points, and these Points are conceived to radiate all Manner of Ways.

The Point Q, Fig. 15. from which Rays diverge, or towards which they converge (being made to go back towards the same Point, though they may never meet at it) is called the Focus. And in both Cases, any Parcel of these Rays, as Q B C, or Q B A considered a-part from the rest, is called a Pencil of Rays; and these Rays are said to belong to that Focus, whether they be near at Hand, or at an immense Distance; and in the latter Case, the Rays are called, and consider'd as parallel, or equi-distant from each other; because the Difference of their Distances at any two given Places is insensible, * as those from the Sun, and other vastly distant Objects. A B, Fig. 16. represents such parallel Rays, which falling upon the Lens C D, are made to approach nearer and nearer together in their Progress; tending to one certain Point, where they all unite. Thus the Rays proceeding from the Lens C D, to the Point E, are called converging Rays; and the Point E their Focus, where they cross, and continually recede from each other as they pass along. So that those Rays flowing from the Point E, towards F G, are called diverging Rays.

Let A B, Fig. 17. be a double convex Lens, E F the Object at its Focus C; G, the Eye very near the Lens E F, the Rays coming from the Object, will, after their Refraction, fall parallel † upon the Eye, and consequently make distinct Vision. For the Fabrick of the Eye having its focal Distance just at the Bottom of it, upon the Retina, requires that the Rays from each single Point, should fall nearly parallel, in order to be there collected; that is, that the Basis of each Cone of Rays, flowing from every

* *Smith*'s Opt. *p.* 6. † *Greg.* Opt. 170.

Fig. 9.

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Point of an Object, which Baſis is the Pupil of the Eye, ſhould bear ſo ſmall a Proportion to the Length of the Cone, as that theſe Cones may be looked upon as little Cylinders. The Diſtance requiſite for diſtinct Viſion, is not limited to a Point, but is indulg'd in larger Bounds; becauſe Nature has furniſh'd us with the Power of contracting the Pupil, as the Object comes nearer; and ſo diminiſhing the Baſis of each Cone in Proportion, and conſequently of preſerving diſtinct Viſion; but this is only to a certain and that no very great Degree.

Therefore a minute Object E F, ſeen diſtinctly thro' a ſmall Glaſs Lens A B, by the Eye put cloſe to it, appears ſo much greater than it would to the naked Eye; placed at the leaſt Diſtance E D, from whence it appears ſufficiently diſtinct, as this latter Diſtance E D, is greater than the former E C; for having put your Eye cloſe to the Glaſs A B, in Order to ſee as much of the Object as poſſible at one View, remove the Object to and fro till it appears moſt diſtinctly, ſuppoſe at the Diſtance C E, then conceiving the Glaſs A B, to be removed, and a thin Plate A B, with a Pinhole in it, Fig. 18. to be put in its Place, the Object will appear diſtinct, and as large as before when ſeen thro' the Glaſs, only not ſo bright. For if the Hole be ſo ſmall as to admit but a ſingle Ray, from every diſtinct Point of the Object, theſe Rays will fall upon the Retina, in as many other diſtinct Points, * and will make a diſtinct Picture †; and when the Pencils of Rays fall upon a thin Lens, their Axis go ſtrait thro' the Middle of it, and conſequently will proceed to the ſame Points upon the Retina, as when they paſſed thro' the Hole. Now ſuppoſing the Lens to have ſuch a Figure, that the Rays of every Pencil ſhall be refracted by it, and by the Eye together, to thoſe very Points of their Axis which touch the Retina, the Picture will ſtill be diſtinct; and will be the ſame in Magnitude and Poſition as before. The only Difference in the Effects, between the Hole and Lens, will be in the Degree of Brightneſs upon the Retina. And in this latter Caſe, the Object appears ſo much greater than it does to the naked Eye, at the Diſtance E D, either with the Pin-hole, or without it; as the Angle C E F, is greater than the Angle A D E, or as the latter Diſtance is greater than the former.

Since the Interpoſition of the Glaſs has no other Effect than to render the Appearance diſtinct, by helping the Eye to increaſe the Refraction of the Rays in each Pencil, it is plain, that the greater apparent Magnitude is entirely owing to a nearer View than could be taken by the naked Eye. If the Eye be ſo perfect, as to ſee diſtinctly by Pencils of parallel Rays falling upon it, the Diſtance C E of the Object from the Glaſs, is then the focal Diſtance of the Glaſs.

* *Greg.* Opt. *p.* 171. † *Smith*, Opt. *p.* 37.

Now

Now if this *focal* Diſtance of the *Lens*, be $\frac{1}{5}$ of an Inch, and if the Diſtance E D be 8 Inches from the Object, the uſual Diſtance at which we view minute Objects, the apparent Image, or Diameter of the Object, may be ſaid to be ſo much magnified, as thoſe 8 Inches exceed the little Space C E, or the *focal* Diſtance of the *Lens* A B, which is at the Rate of 40 to 1. Therefore the leſs the *focal* Diſtance of the little *Lens* is, the greater will its Effects be in dilating the Image of a ſmall Object; (for if its *focal* Diſtance be yet ſmaller, ſuppoſe $\frac{1}{20}$ of an Inch; the Diameter or Length of an Object will appear 160 Times longer thro' ſuch a *Lens*, than to the naked Eye, at 8 Inches; its Surface 15600 Times greater, and the Solidity or Bulk would be magnified to 2,496,000 Times) inſomuch that its *focal* Diſtance may be ſhortened, till it is reduced to an infinitely ſmall *Spherule*. Tho' there are ſome Inconveniencies which here offer themſelves, and forbid our going beyond certain Limits; for theſe ſmall *Spheres* are inferior to little Lens's, on this Account, that for the ſame Degree of magnifying, the *Lens's* are three Times more diſtant from the Object than the *Spheres*, the Effects of which are thus demonſtrated. Let there be a Glaſs *Sphere*, Fig. 19. whoſe Center is A, and Axis B D, in which, produced on both Sides, the Eye is placed at H, and the Object at C, each of the Diſtances B H, D C, being taken equal to half the Radius A B, and conſequently the Point C is the *Focus*, where Rays falling parallel to the Axis B D, upon the Sphere at B G, are after Emmerſion collected. Wherefore an Object placed at C, will ſend Rays upon the Sphere, which will, after Refraction, be received parallel by the Eye, and conſequently make diſtinct Viſion. But if we take the Point L, ſuch that L B may be equal to the Radius A B, the Point L is the *Focus*, towards which parallel Rays, after Refraction, at the firſt Surface D E tend in their Paſſage through the Sphere, and from which they are diverted after Refraction at their Emmerſion, and collected at H. Make E F parallel to the Axis, and comprehending the Portion of the Object C F, and draw the right Line F H. The Ray F E being refracted at E, proceeds according to E L, and being again refracted at G, goes on to meet the Eye at H, wherefore the Line C F is ſeen under the Angle B H G, and would appear to the naked Eye under the Angle C H F, which is but half the former Angle.

Becauſe B L is double to B H, the Angle B H G is double to B L G, but H L is parallel to F E, and to be looked upon as equal to it, or to the right Line D C; becauſe C F is to be a Line very ſmall, with Reſpect to the Diameter of the Sphere. Therefore the Angle B H G is alſo double of the Angle C H F, and conſequently equal to the Angle C A F. From whence it is plain, that to the Eye placed at H, the Line C F will appear under the ſame Angle, in which it would appear to the naked Eye, ſeeing from the Point A. Whence if the Diameter of the little Sphere B D, were $\frac{1}{12}$ of an Inch, we ſhould have A C equal to $\frac{1}{16}$ of an Inch; which is to the Diſtance of 8 Inches in the Proportion of 1 to 128, ſo that the Magnitude of the Object will be increaſed 128 Times.

But if K E, the *focal* Diſtance of the *Lens* M N, Fig. 20. be equal to the right Line A C of the laſt Figure; we have ſhewn, that by this Means the Object L P would be ſeen in the ſame Magnitude, as if the Eye were placed at K, without the *Lens*; nor in uſing this *Lens* will the apparent Magnitude be any Ways changed, in whatſoever Part of the Axis K E, produced, the Eye be placed. Therefore, 'tis plain the ſame Degree of magnifying, and the ſame Effect every Way is performed equally by the *Lens* M N, Fig. 20. and the little *Sphere* B D, Fig. 19. and it is alſo manifeſt, that the Diſtance K L, is equal to thrice D C, Q E D.

If an Object A B be placed in one *Focus* of a *Lens* M N, Fig. 21. and the Eye in the other *Focus* D; ſo much of the Object as is equal to the Diameter of the *Lens*, will be ſeen by the Eye, for the Rays A M and B N, which flow from the Object to the Extremities of the *Lens*, proceed from thence converging, till they meet at D the *Focus*; muſt neceſſarily paſs from the Object to the *Lens*, parallel to the Axis, and therefore parallel to each other. Conſequently that Part only of the Object A B, ſeen by the Rays M D, and N D, will be equal to the Diameter of the *Lens* M N.

If the *Lens* be covered with a thin Plate, and only the Part m n, Fig. 21. be left open, then only ſo much of the Object a b, as is equal thereto, will be perceived by the Eye. For as A B is equal to M N, or a b to m n; the Angle M D N, or m D n, is the Meaſure under which Part of the Object A B, or m n appears to the Eye at D.

In order to ſee a larger Portion of an Object than the *Lens*, or its *Aperture*; the Eye muſt be placed nearer the *Lens*, than its *Focus*; for, let the two *Foci* of the *Lens* M N, Fig. 22. be H and G. Let an Object A B be placed in the laſt *Focus*, larger than the *Lens*. The Rays proceeding from the Extremities A B of the Object, towards the *Lens*, will, after Refraction, unite in the Point C, between the Lens M N, and its Focus H. Therefore if the Eye be placed at C, its Field of View or Portion of an Object, will be greater than the *Lens* M N.

If E F be a Portion of an Object leſs than the *Lens*, the Rays E M, E N, produced to the Extremities of the *Lens*, will after Refraction unite in a Point D, farther diſtant from the *Lens*, than the *Focus*. From whence it appears, that if the Eye be placed farther from the *Lens* than its *Focus*, it cannot ſee any Part of an Object ſo large as the *Lens*, but always ſmaller.

Therefore, in the *Univerſal Single Microſcope*, I have contrived the Manner of fixing the Magnifiers, which are *Double Convex Lens's*, ſo as to admit the Eye to be placed almoſt cloſe to them, by which Means we always ſee a Portion of an Object larger than the Aperture of the Lens. And in this Way of uſing ſingle Lens's, microſcopick Objects appear exceedingly diſtinct and clear, and are in all Reſpects far preferable to the Double Microſcopes, which are compos'd of three convex Glaſſes.

Upon the *Apertures* of *Microſcopes*, all their Effects and Virtue entirely depend. It is therefore to be obſerved, that in ſingle *Lens's*, if their *focal* Diſtance be about ¼ an Inch, or greater, there will be no Occaſion for limiting the *Aperture*, in order to make diſtinct Viſion; becauſe the very Narrowneſs of the Pupil of the Eye excludes as many of thoſe Rays which diſturb Viſion, as is neceſſary, and as much as they would be excluded, if the *Lens* were made to have a leſs *Aperture*. But in ſmaller *Lens's*, where this Limitation of the *Aperture* is neceſſary, the Rule is, that the Diameters of thoſe Apertures ſhould be in the ſame Proportion with the *focal* Diſtances of their reſpective *Lens's*, in order to have the Object ſeen by both equally diſtinct. But the *Light* or *Brightneſs* will be in a duplicate Proportion of thoſe *focal* Diſtances *; ſo that the more convex the *Lens* is, the greater indeed, but then the more obſcurely will the Object be ſeen.

In my *Univerſal Microſcope*, I have contrived the black Eye-Piece N, in ſuch a Manner, as to receive any *Lens*, whoſe *Aperture* wants no Limitation, and have taken Care to limit all the Apertures of the ſix Magnifiers, ſo as to admit as much Light as poſſible, without deſtroying diſtinct Viſion, an Advantage which few of the modern Microſcopes have.

In order to find the magnifying Power of any *Lens*, we need only find its exact *focal* Diſtance in 100th Parts of an Inch (which is eaſily done by ſetting a minute Object in the Microſcope, ſo as to appear perfectly clear and diſtinct; this Diſtance meaſured on a Scale of an Inch, divided into 100 Parts, will give its true focal Length;) and by computing how many Times thoſe Parts are contained in 8 Inches, we ſhall have the Number of Times the Diameter of an Object is magnify'd to, and that Number multiplied into itſelf, will produce the Magnitude of the Superficies, which Product, multiplied by the Diameter, will ſhew the Solidity or magnified Bulk.

It was with theſe Sorts of ſingle Microſcopes, that the famous Mr. *Leeuwenhoeck* made ſuch wonderful Diſcoveries; and it was this Conſideration which induced me to contrive an Apparatus that ſhould make theſe ſingle Microſcropes eaſy in Uſe, to thoſe Gentlemen whoſe Curioſity leads them to ſearch into the *minute Receſſes* of *Nature*, and thereby be taught to contemplate and adore the wonderful and ſurprizing Contrivance of *Nature's* ALMIGHTY *Architect*.

* *Gregory*'s Opt. *p.* 184.

Of

Of Double Microscopes.

A double Microſcope is compoſed of two convex Glaſſes, placed at E and L, Fig. 23. the Glaſs L next the Object P Q is very ſmall, and very much convex, and conſequently its focal Diſtance L F is very ſhort; the Diſtance L Q of the ſmall Object P Q, is but a little greater than L F; ſo that the Image p q may be formed at a great Diſtance from the Glaſs, and conſequently may be much greater than the Object itſelf. This Picture p q being viewed through a convex Eye-Glaſs A E, whoſe focal Diſtance is q E, appears perfectly diſtinct. Now the Object appears magnified upon two Accounts, firſt, becauſe if we view its Picture p q with the naked Eye, it would appear as much greater than the Object at the ſame Diſtance, as it really is greater than the Object, or as much as L q is greater than L Q; and ſecondly, becauſe this Picture appears magnified through the Eye-Glaſs, as much as the leaſt Diſtance, at which it can be ſeen diſtinctly with the naked Eye, is greater than q E, the focal Diſtance of the Eye-Glaſs. For Example, if this latter Proportion be 5 to 1, and the former of L q to L Q, be 20 to 1, then upon both Accounts the Object will appear 5 times 20, or 100 times greater than to the naked Eye.

To fit theſe Microſcopes to ſhort-ſighted Eyes, the Glaſſes E and L muſt be placed a little nearer together; ſo that the Rays of each Pencil may not emerge parallel, but may fall diverging upon the Eye; and then the apparent Magnitude will be alter'd a little, but ſcarce ſenſibly.

In the laſt Example, let us ſuppoſe the Eye-Glaſs E A to be 1 Inch $\frac{6}{10}$ Focus, which will be found exactly 5 times in 8 Inches, the Diſtance at which the ſame Object would be ſeen diſtinct by the naked Eye. Therefore this Eye-Glaſs magnifies 5 times; and if the Object Lens L, has for its Focus L Q $\frac{1}{4}$ of an Inch, and the Picture be formed at P q, whoſe Diſtance L q is 5 Inches, the Picture will be magnified 20 times; becauſe the Diſtance L Q $\frac{1}{4}$ of an Inch is contained 20 times in L q, 5 Inches; and this Picture magnified 5 times greater (as appears above) by the Eye-Glaſs E A, and therefore 5 times 20, that is 100 times.

The Length being magnified 100 times, the Surface of Objects will be magnified 10000 Times, and their Solidity or Bulk 1000000 times.

Altho' we can readily, by this Method, find out the magnifying Powers of the ſeveral Sorts of Microſcopes, yet our Notions of the comparative Smallneſs of any minute Object, muſt be aſſiſted by a larger one, whoſe Dimenſions we know, and by finding how many Times the leſſer is contain'd in the greater; which ſhall be the Subject of the remaining Part of this Chapter.

* *Smith*'s Opt. *p.* 41.

Mr. *Hook*'s Method of computing the Magnitude of Objects, ſeen in the *Microſcope*, was, after he had adjuſted the *Microſcope*, to ſee the Object very diſtinctly: At the ſame Time that he look'd upon the Object thro' the Glaſs with one Eye, he looked upon other Objects at the ſame Diſtance with his other bare Eye, by which Means he was able, by the Help of a *Rule* divided into Inches and ſmall Parts, * and laid on the Pedeſtal of the *Microſcope*, to caſt up, as it were, the magnified Appearance of the Object upon the Rule, and thereby exactly to meaſure 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 magnifying. This Method is very eaſy to thoſe Perſons who can accuſtom themſelves to ſuch a Practice, I mean of obſerving two Objects at the ſame Time, one of them with one Eye by direct Viſion, and the other by refracted Viſion, through the Glaſs. It is indeed a Method I have practiſed with Succeſs to eſtimate the magnifying Power of Teleſcopes for many Years.

The Method Mr. *Leuwenhoek* made uſe of to compute the Size of Animalcules in Water, in *Semine Maſculino*, the *Salts* in Fluids, *&c.* was by comparing them with a Grain of Sand, one hundred of which laid in a Row, will but juſt equal an Inch in Length. Then conceiving one ſingle Grain of Sand, magnified to the Bigneſs of Fig. 24. A B C; and ſeeing an Animalcule ſwimming, or running by, or acroſs it, the Magnitude of Figure D. The Axis of which he eſtimates by his Eye, and concludes it to be a twelfth Part of the Axis D C of the Grain of Sand. From whence it follows by the common Rules, that the Figure of the Body or Sphere A B C, is 1728 times larger than the Sphere D.

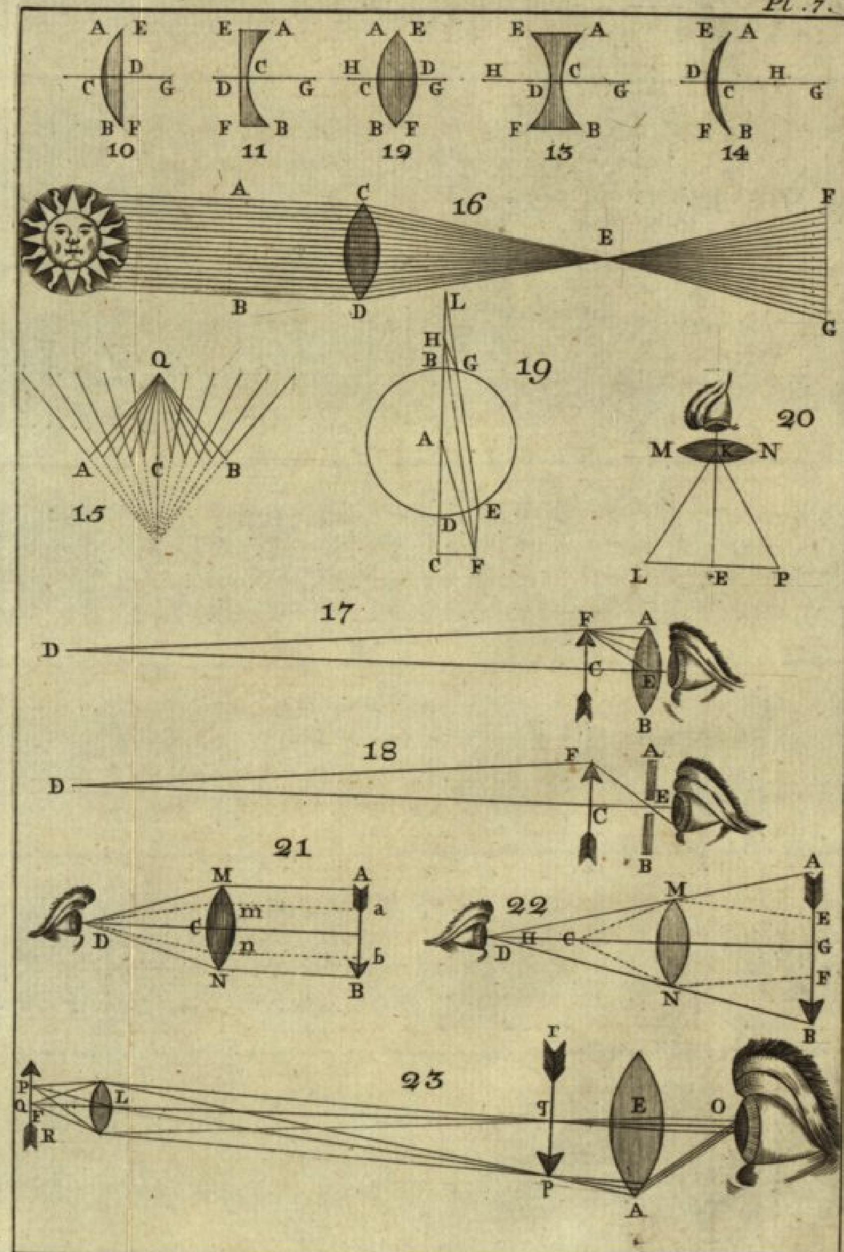
Alſo amongſt the reſt, he ſees a ſecond Species of Animalcules E, the Diameter of which, by the Help of a very good *Microſcope*, he alſo meaſures, and eſtimates it to be a Fifth; but leſt he ſhould exceed, ſets it down to be only four times leſs than the firſt Animalcule D; therefore according to the former Rules, the Animalcule D is 64 times larger than that of E. Likewiſe upon a cloſer View, he ſees a third Species of Animalcules F, ſtill leſs than the ſecond, whoſe Diameter he meaſures by Eſtimation as before, and judges it to be 10 times leſs than the Diameter of the Animalcule E. Therefore the Animalcule, Fig. E, is 1000 times bigger than that of F.

In multiplying the firſt Sort by the ſecond, and that again by the third, will plainly ſhew how many of theſe laſt are required to fill a Sphere no bigger than a Grain of Sand, *viz.*

* Preface to *Hook*'s *Mycographia*, printed *Anno* 1675.

Diame-

Pl. 7.



Front. Page. 26.

Diameter of D 12 times less than a
12 Grain of Sand.
—
144
12
—
1728 in a Grain of Sand.

The third Sort F, whose Diameter
is less than that of E,
10 times
10
—
100
10
—
1000 in one of the 2d Sort.

Diameter of E 4 times less than
4 that of D.
—
16
4
—
64 in one of the first Sort D.

1728 of the first Sort D in a Grain of Sand.
64 of the second Sort E in one of the first Sort D.
—
6912
10368
—
110,592 of the 2d Sort E in a Grain of Sand.
1000 of the 3d Sort F in one of the 2d.
—
110,592,000 of the 3d Sort F, contained in a Sphere no bigger than a Grain of Sand *.

The ingenious Dr. *James Jurin*, in his excellent Dissertation on *Physico Mathematical Subjects*, *Pag*. 45. has taught us a more accurate and ready Way of measuring microscopick Objects; as follows,

He first twists a very fine silver Wire a great many times upon a slender Pin, so closely as to leave no Interval between the Wreaths, which he carefully examines by a magnifying Glass; then he takes the Interval of the outermost Wreaths, between the Points of a Pair of fine Compasses, and applies this Extent to a diagonal Scale of Inches, and by dividing this Measure of that Extent by the Number of Wreaths therein contained, he obtains the Thickness of the Wire itself. Then cutting it into very small Bits, and scattering them upon the Object-Plate, he places the Object upon them, if transparent; or the Wires upon the Object, if it be opake; and by the Eye he compares the Parts of the Object, with the Thickness of those Wires that happen to lie contiguous to them.

Thus he observed, that 4 Globules of human *Blood* would generally cover the Breadth of a Wire, which he had found to be $\frac{1}{485}$ Part of an Inch, and by Consequence, that the Diameter of a single Globule was $\frac{1}{1940}$ Part of an Inch, which was also confirm'd by Mr. *Leeuwenhoek*'s Observations upon human Blood, made with a Piece of the same Wire transmitted to him from Dr. *Jurin*. *Philos. Trans.* N° 377.

This Method of Dr. *Jurin*'s gave Rise to another which I have contrived, that is, a Method of straining a few of these small Silver Wires, in

* *Vide Leeuw. Exp. & Contemp. Tom.* IV. *Pag.* 23.

form

form of a Lattice; in ſuch a Manner, that the Diſtances between the Wires are exactly equal to the Diameter of the Wire itſelf. By which Means having a Wire, whoſe Diameter is a certain known Part of an Inch, we may be able to meaſure a very ſmall Animalcule, *&c.* and be more exact in our Calculations, than by either of the former Methods. For by placing this Lattice of Wires, cloſe under a *Muſcovy* Talc, upon which the Object may be placed, if it be tranſparent, or placing the Lattice over the Object, if it be an opake one. And when the Object is adjuſted to the Magnifier, the Parts thereof may be eaſily compar'd with the Number of Wires and Intervals, and their true Magnitude, or Dimenſions very nearly known, or if I obſerve the Diameter of an Object to be juſt the ſame with one Wire, or an Interval, I know it is the 560th Part of an Inch, ſuppoſing the Wire of that Size. If half that Width, the 1120th Part of an Inch; if one Quarter of the Width, the 2240th Part of an Inch, and ſo on *ad infinitum.*

Or thus, if an Object cover but the 6th Part of the Diameter of a Wire or Interval, it will be but 3360th Part of an Inch in Diameter, which multiplied into itſelf, will ſhew the Superficies to be the 11,289,600th Part of an Inch, and that Product multiplied by the firſt Number will ſhew the Solidity to be the 37933,056,000th Part of an Inch, and thus may the Minuteneſs of any Object be exactly determined.

However, this laſt Method, tho' infinitely better than any other in Practice amongſt us, is ſtill deficient on this Account; if the Object be conſiſiderably leſs than the Diameter of one ſingle Wire or Interval between the Wires, we are obliged to eſtimate, or gueſs its Proportion to that Diameter or Interval; but if the Object be no ſmaller than one fourth Part of ſuch Interval, the Eye is able to determine that to the utmoſt Exactneſs poſſible.

I have, therefore, to remove this Deficiency, invented a particular and curious Micrometer, applicable both to ſingle and double Microſcopes, but particularly adapted to my *Univerſal Microſcope*, deſcribed Fig. 1, and 3.

The magnifying Power of the ſolar Microſcope, is found by reckoning how many Times the focal Diſtance of the Magnifier is contain'd between it and the Diſtance of the Screen, or Sheet, upon which the Image of an Object is caſt. For Inſtance, let us ſuppoſe the *Focus* of the *Lens* in Uſe, to be $\frac{1}{4}$ of an Inch, and the Screen ſet at the Diſtance of ſix Feet, and as the focal Length of the Lens will be contained 288 times in the Screen's Diſtance, the Diameter of an Object is magnified in the Proportion of 288 to 1. The Superficies 82,944 times, and its Solidity, or Bulk 23,887,872 times, and by removing the Screen farther off, the Object may be magnified to almoſt what Size you pleaſe.

CHAP.

CHAP. X.

Of chusing, preparing, preserving, and applying Objects to the Microscope.

WE must be very curious in chusing such *Objects* as are proper for the MICROSCOPE, which are either small Parts of larger Bodies, or exceeding small Insects, *Salts*, *Sands*, *Seeds*, *Farina* of *Flowers*, &c. or the Interstices between the solid Parts of *Bodies*, as *Minerals*, *Shells*, the *Air Vessels* in *Vegetables*, *Pores* in the *Bones*, *Skin*, &c. of *Animals*, or the Motion of the several Parts of minute Animals, or of the *Fluids* in *Animal* or *Vegetable Bodies*.

The greatest Care imaginable should be taken in preparing *Objects* for an Examination; otherwise the best skill'd in magnifying Glasses may be misled, if they give too sudden a Judgment on what they see, without assuring themselves of the Truth by repeated Experiments.

If *Objects* are flat and transparent, the best Method is to inclose them between two *Muscovy* Talcs, in an Ivory Slider, as the *Farina* of *Flowers*, *Scales* of *Fishes*, *Wings* of *Butter* and other *Flies*, &c. the Bodies of *minute Insects*, &c. By this Method, every Virtuoso may always have ready two or three Dozen of these *Ivory Sliders*, furnished with the most curious *Objects*; which will be a most delightful natural History of the surprizing Beauty, Perfection, and Contrivance, we find in the Works of Nature.

In collecting *Objects* for the Ivory Sliders, Care should be taken to put those into the same Slider, which are of the same Degree of Transparency and Size; that they may all be viewed with the same Magnifier. There is a convex Glass of about an Inch Focus to hold in the Hand, in the Case with my *New Universal Microscope*, by the Help of which you may adjust the *Objects* properly between the Talcs, before you fix them down with the Brass Rings; the Number of the Magnifier may be also marked on each Slider its *Objects* are fittest for. Many small living Objects may be placed in this Manner between the Talcs, such as *Mites*, *small Spiders*, *Lice*, *Fleas*, &c. without being killed or hurt, and will remain alive several Days in this Manner. But for present Examination, these as well as larger *Objects*, may be put into the *Glass Slider* V, Fig. 2. described Page 4, and designed for that Use, or in the jointed Cell X, Fig. 2. Page 4, or else stick them upon the Pin l, or pinch them between the Nippers m of the Apparatus V. Fig. 2.

The *Animalcula* in *Fluids*, may be examined in a small Drop, taken up with a Pen or Hair Pencil, and placed in the Glass Slider before described, Page 3, or on the single Glass Slider R, Fig. 2. if in viewing them you find them (as is often the Case) so exceedingly numerous, that by by their continual running over one another, their Shape cannot be diftinguifhed: Some Part of the Drop muft be taken off the Glafs, and a little fair Water put to the reft, which will feparate, and make them appear diftinct. It is neceffary thus to dilute, with fair Water, the *Semine Mafculinum* of all Animals; otherwife their Shape cannot be difcovered, they are fo crowded together in fuch infinite Numbers.

If *Salts* in *Fluids* are to be view'd, you muft let the Fluid evaporate, that the Salts may be left behind upon the Glafs, and be more eafily examined.

For viewing the *Circulation* of the *Blood* in the Tails of *Fifhes*, in *Frogs*, *Newts*, &c. they are fometimes put into Glafs Tubes, but my *Univerfal Microfcope* hath a particular Contrivance a b f, of Fig. 2. defcribed Page 3, proper to hold down the Tails of Newts and Fifhes, and the filmy Membrane between the Toes of a Frog's hind Foot; the Circulation is beft feen in the *Mefentery*, or thin tranfparent Membrane, that joins the Guts together, and this Part, by pulling out the Gut a little, may be eafily adjufted to the Magnifier, by Help of an Apparatus hereafter to be defcribed, which is another Method quite new, and never before applied in fo eafy a Manner.

Patience and Dexterity are required to diffect Infects, and view their internal Structure, fuch as *Gnats*, *Mites*, *Lice*, *Fleas*, &c. which will be eafily done with a fine Needle and a Lancet; if they are placed in a Drop of Water, their Parts will then be feparated with Eafe; and the Stomach and Bowels lie plainly (before the Microfcope) to be viewed and examined.

Bits of different colour'd Glafs are neceffary for this Purpofe, to place *Objects* on, becaufe many *Objects* are much more diftinguifhable, when placed on one Colour, than on another. Glafs Tubes of all Sizes, are likewife of Ufe, from $\frac{1}{2}$ an Inch Bore to a fine Capillary.

It is alfo neceffary to have a few *Glafs Tubes*, ready prepared, with Cork Stoppers, one at each End, each Cork having a Bit of a fmall capillary Tube, run thro' its Center, as at Fig. 25. in this Manner *pregnant Infects* may be kept alive till they lay their Eggs; and their *Worms* or *Maggots* after they are hatched, till they pafs thro' their feveral Changes; and in fuch *Glafs Tubes* it is, that Mr. *Leeuwenhoek* made his greateft Difcoveries: They are more particularly defcribed in the 2d Section of the 19th Chapter, and are to be applied to the *Univerfal Microfcope*, between the Object-carrying Plate I, and Springs b.

Fig. 27. is a very fhort cylindrical Glafs, which may be filled with Water, or any other Liquid, in order to examine Aquaticks, which are too large for the Slider S.

Fig. 26. A rectangular Box having its two broadeft Sides of Glafs, is defign'd on Purpofe to be filled with Water, in order to apply Aquaticks to the folar Microfcope.

These

These two last are also to be placed between the Springs b, and Object-Plate I.

Fig. 28. Is another Contrivance to place transparent *Objects* between two circular Plates of Ising-Glass, one of them being divided into Partitions, by pasting a cut Paper to it, whereon the Partitions are number'd, having different Objects placed between them, and covered with another Talc, which is held down by a Brass Ring, as in the Ivory Sliders. This is a concise Way of keeping a great Number of *Objects*, ready to shew a Friend at all Opportunities; so that any Person who is desirous to preserve a large Collection of *Objects*, may have as many of these, or of the Ivory Sliders, as he thinks proper. They are to be applied to the *Universal Microscope*, between the Object-Plate I, and Springs b; the two Brass Ribs to which the Springs are fixed, being filed into concave circular Arches for their Reception, they may be turn'd round at Pleasure, and by pushing the Object-Plate either nearer to, or farther from the Pillar E, any *Object* contain'd between them will be easily brought under the Magnifier.

There is no better Way to preserve transparent *Objects*, than placing them between two *Muscovy* Talcs in Sliders, or in the circular Talc-Plates, Fig. 28.

And the very best Way of preserving opake *Objects* for those Gentlemen who are desirous to keep a Collection of them, is to prepare small thin Slips of Ivory, or rather Holly, about an Inch long, and $\frac{1}{10}$ of an Inch wide, and some a little broader, according to the Size of the *Objects* to be put thereon. Which Slips being stain'd of several Colours, we shall obtain a Contrast to almost any Colour, and by fixing Objects upon Colours the most contrary to themselves, they will be seen to the best Advantage.

I have contrived these chiefly for my new *Universal Microscope*, to be applied between the Nippers, under the reflecting Speculum O, Fig. 1.

Wet the Slips about half their Length with strong, but very transparent Gum-Water, and upon that stick on your Objects.

I have also contrived a little Ivory Box, in Form of a Parallelopipid, to keep these Slips in. In the Sides of which there is cut small Curfs, to receive the Ends of these small Ivory Slips, that they may be placed three or four of them in a Row, and also so high above each other, as that the upper Row shall not touch the Objects in that next under it.

I have prepar'd some of these little *Cabinets* for *opake Objects*, which contain some 30, some 60, *&c.* of those Slips, which when stored with *Objects*, will be always ready for Examination, and may be carried from Place to Place, without doing the least Injury to the Objects therein contain'd.

The Reader may be supplied with these *Ivory* and *Holly Slips*, *Cabinets*, *Ivory Sliders*, *Talc Rings*, short cylindrical *Glasses*, *rectangular Boxes*, with *Glass Sides*, circular *Ising-Glass Plates*, and *Glass Tubes*, all together in one Box,

Box, or ſeparate if he pleaſes, at my Shop, the Sign of *Tycho Brahe*'s Head, the Corner of *Racquet-Court*, in *Fleet-Street*, LONDON.

Having deſcribed the new invented *Univerſal Portable Microſcope*, together with its Application to the ſolar Apparatus; and the other Sorts which are moſt in Uſe amongſt us: By which the Reader will be able to determine how much eaſier it is in all its Applications than any, nay all of them taken together are, and have alſo ſhewn how to calculate their magnifying Powers, and how to prepare and preſerve Objects: I ſhall next proceed to ſhew what wonderful and ſurprizing Diſcoveries have been made by the Microſcope. In the Proceſs of which, I ſhall not only preſent the Reader with a Variety of Copper-Cuts, of moſt of the minute Inſects and Animalcules that have been obſerved by Mr. *Hook*, Mr. *Leeuwenhoek*, Mr. *Joblott*, myſelf, and others, but alſo ſhew how to apply either the whole, or the ſeveral Parts thereof to the Microſcope. In doing of which I have ſpared neither Coſt nor Pains to make the Work compleat.

CHAP. XI.

Of the Circulation of the Blood, and how to examine it by the Microſcope.

SECT. I.

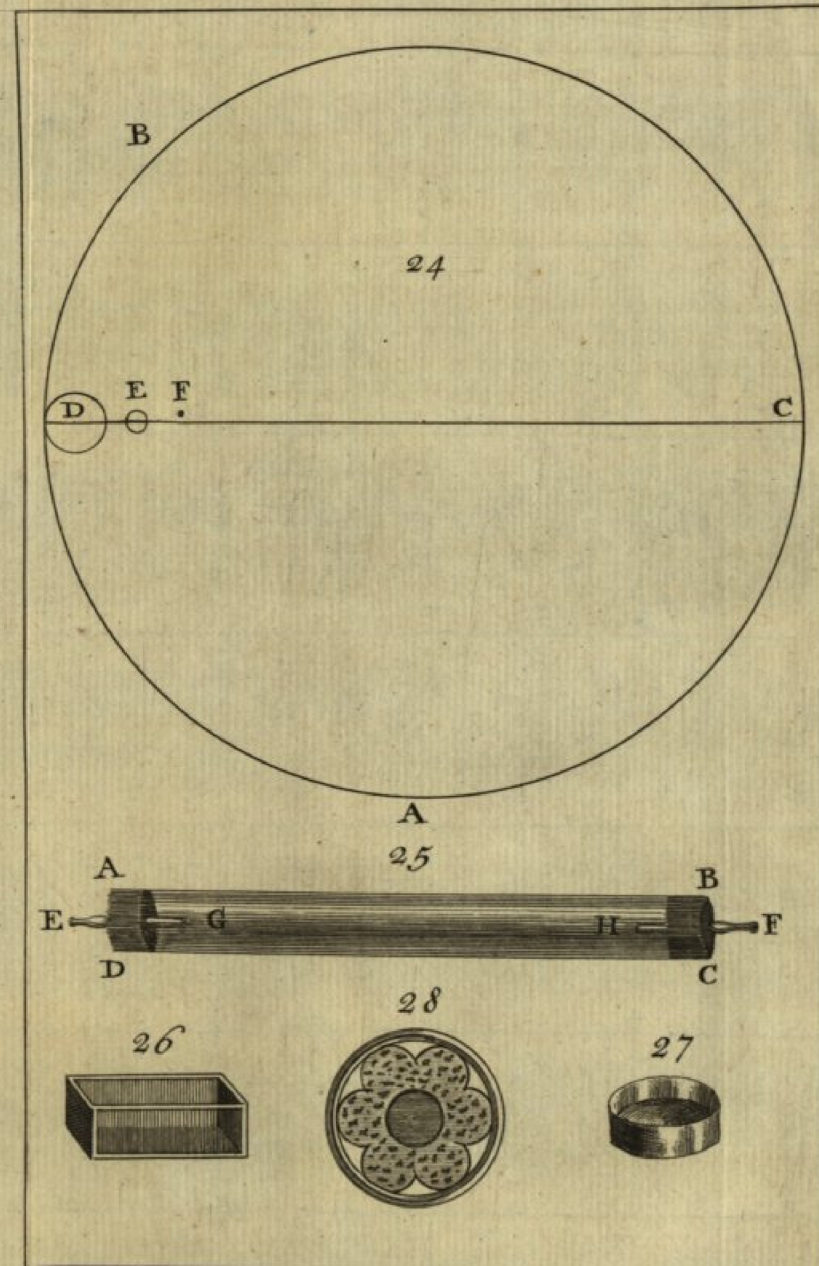
THIS noble Fluid, the *Blood*, yields us the moſt ſublime Speculations imaginable, by the Aſſiſtance of the *Microſcope*. For by the Help of it, *human Blood*, and that of *Land Animals* is found to conſiſt of round red Globules, which float in a tranſparent Fluid, each of which is compos'd of ſix ſmaller, and more tranſparent ones, and each of theſe (as Mr. *Leeuwenhoek* has ſhewn in his 128th *Epiſtle to the Royal Society)* into ſix more minute and without Colour. He hath alſo ſhewn us how eaſily ſix ſoft flexible Globules, which are compreſſible into any Shape, and in continual Motion, may, by ſtriking againſt each other, compoſe one large Globule of a perfectly ſpherical Figure, one of which, and five of the ſmaller Sort, as they appear in Contact, the ſixth lying behind, is repreſented Fig. 29. which, by their mutual Attraction to, and Preſſure againſt each other, readily unite to form a perfectly round Body, as at Fig. 30. Their Attraction towards each other is ſo conſiderable, as to form a Kind of fleſhy Subſtance, when brought into Contact; and their ſpecifick * Gravity more than the Serum in which they float.

How theſe Globules, and alſo the more minute ones of which they are compoſed, are occaſionally ſeparated, in order to paſs through extremely

* *Phil. Tranſ.* No. 361.

minute

Pl. 8.



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minute Veſſels, which without ſuch a Separation, they cannot poſſibly enter, and how they re-unite again in Veſſels where they have more Room, is eaſily comprehended by a due Conſideration of the two foregoing Figures.

The Diameter of a common round Globule of *human Blood*, is equal to the $\frac{1}{1940}$th Part of an Inch, as by the Method deſcribed, Page 27. appears.

In order to view the *Blood* with the *Microſcope*, upon the Tip of an Hair Pencil, take a ſmall Drop of *warm Blood*, immediately as it comes from the *Vein*, and ſpread it as thin as poſſible upon the Object carrying Glaſs R, Fig. 2. of the *Univerſal Microſcope*, and apply it between the Object-Plate I, and Springs, to the firſt and ſecond Magnifiers. It may alſo be extreamly well examined, if a little of it be taken up into a ſmall, but very thin capillary Tube, which being held in the Nippers m of the Apparatus V, Fig. 2. may be readily applied to the Magnifier. If you dilute a Drop of *Blood* with warm Water, and apply it either of theſe Ways to the Magnifier, ſome of the larger Globules will be ſeparated from each other, and ſeveral of them will be divided into the ſmaller ones of which they are compos'd.

By either of theſe Methods, the Globules of the *Blood* may be diſtinctly ſeen, and a little Practice will diſcover any Alteration that may happen in the Colour, Shape, or Size of them; in its ſeveral Changes between Sickneſs and Health. Mixtures of medicinal, or poiſonous Liquors, may be blended with it immediately as it comes from the Vein, and a Drop of this Mixture, if applied as before directed to the *Microſcope*, will diſcover what Alterations can be produced on the Contexture of the *Blood*. The Veſſel in which the *Blood* is received, ſhould be put into a Baſon of Water, ſomewhat hotter than the *Blood* †, to prevent its coagulating before the Mixture.

The *Circulation* of the *Blood* thro' its Veſſels, is to be ſeen in ſuch ſmall Creatures, whoſe Tranſparency permits us to look within them, or in the thinneſt Parts of larger ones; by which we are very well informed, the whole animal Syſtem being eſtabliſhed on the ſame Plan, the Circulations carried on in Veſſels of a like Form, both in the meaneſt and nobleſt living Creature, and accelerated or retarded by the ſame Cauſes.

In theſe ſmall Creatures we are not only able to ſee the general Courſe of the *Blood*, but can perfectly diſtinguiſh each Globule, and the Alteration they ſuffer in paſſing out of the larger into the more minute Veſſels, many of them being ſo ſmall, that ſingle Globules can ſcarce enter, till they are

† The exact *Blood-heat* of the Water, may be obtain'd by a Pocket *Thermometer*, made with *Quickſilver*, with which the Reader may be ſupplied at my Shop, at *Tycho Brahe's Head* in *Fleet-Street*.

compressed into an oval Form; and yet these very Vessels are large, when compar'd with the finest of all, in which the Globules must be divided and subdivided into their smallest component Parts, before they can find a Passage.

Providence has been surprizingly careful in the Disposition of the Veins and Arteries, for these last, which convey the *Blood* to the Extremities of the Animal, continually lessen their Diameters in their Progression, and divide into smaller Branches. At which Division, the Globules rush against an Angle, which as it were causes them to recoil upon those immediately behind, before they can readily separate into the two smaller Branches C D, of the Artery A B, Fig. 31. in which the Blood flows upwards from B to A, towards the Extremity; and on the contrary in its Return back from the Extremities to the Heart, their Diameters increase, and those smaller Vessels are continually uniting into larger, as in the foregoing, Fig. 31. the Branches C and D join their Currents in the Vein E F, till at last all their Streams fall into one, at every such Conjunction of two Branches, as at E, and their Streams violently rush against each other, by which means unnatural Cohesions are prevented.

The MICROSCOPE affords us an ample View of the Veins and Arteries, the latter of which is very distinguishable by a Protrusion of the Blood, at each Contraction of the Heart, then a Stop, and then a new Protrusion, continually succeeding each other, whilst in the Veins it rolls on with inexpressible Rapidity.

The ingenious Mr. *Leeuwenhoek* hath told us, that with great Admiration he saw in the utmost Extremities of a very small *Fish's Tail*, how the larger Arteries were divided into the finest Vessels, * and many of the small Veins, which returned from the said Extremities, met together in a larger Vein; that there was such an Agitation of that *Blood*, which flowed from the larger Arteries, towards the evanescent ones, at the Extremity of the *Tail*, and returned afterwards through many minute Veins into a larger one, as can hardly be conceived: In the larger Arteries he saw a continual new Protrusion of the *Blood*'s Course, received from the Heart; but in the smaller, the Motion seem'd equable without any such repeated Propulsion; and tho' no Colour appear'd in the minute Vessels, yet in the larger Arteries and Veins, that were near the Extremity of the Tail, the Blood was plainly red.

The exact Magnitude this *Fish* appear'd of to the naked Eye, as delineated by him, is represented in Fig. 32. Its Tail magnified, as it appear'd in the Microscope, at Fig. 33. In which were 17 little *Bones* or *Gristles*, that give a Stiffness to the *Tail*, three of them are shewn by the Letters A B C, on each Side of which he saw a very open Communication

* *Arc. Nat. Tom.* IV. *p.* 167.

of

of the Veins and Arteries, the Blood running thro' Arteries, and returning back thro' Veins, which were of the ſame Size, and evidently a Continuation of the ſame Veſſel, this was diſtinctly ſeen in 34 different Places, ſo that in the Tail of this *ſmall Fiſh* could plainly be ſeen 64 *Blood Veſſels*, 34 of them Arteries, and as many Veins, beſides the little Spaces about D and E, which were not obſerved.

This will be better underſtood by a microſcopical Repreſentation of Part of one of theſe little *Griſtles* F H G, Fig. 34. on each Side of which runs an Artery I K and M N. The Blood flowing rapidly from I and M, to K and N, their open Communication with the Veins K L, and N O, from whence it return'd to L and O, ſo that both theſe were but one continued *Blood Veſſel*; for no Veſſel can be properly called an Artery beyond the Pulſation; farther than which, and returning towards the Heart, it may be called a Vein; for Veins, as by the preſent Figure appears, are only Arteries elongated; and as they generally divide into Branches that eſcape the Sight, it is very difficult to determine where the Arteries end, or where the Veins begin. If in the Tail of this ſmall Fiſh, the whole Bulk of which was no bigger than that of Fig. 32. and conſequently under half an Inch in Length, 34 diſtinct Circulations of the Blood could be ſeen, how incredibly numerous muſt that of the Circulation be in an human Body? Nor is it to be wonder'd at, when we ſee it iſſue forth at every Prick of a Pin or Needle. In this Conſideration he alſo adds, that he is fully convinced in a Space no bigger than his fore Finger Nail, a thouſand diſtinct Circulations of the Blood are performed.

Mr. *Leeuwenhoek* obſerved the Motion of the *Blood* in a ſmall Veſſel, in the Tail of a *Tadpole*, ſomewhat wider than to admit a red Globule thereof, as A and B, Fig. 35. which Veſſel is called an Artery, through which the *Blood* coming from the Heart, in the Direction A, B, is impelled with great Swiftneſs, and divided at B into two Branches, B C and B E, which are again united at D, and continue ſo to F, where they are again divided into two other Branches F G and F I running crooked till they are again united at H, where they formed a ſomewhat larger Veſſel as H K, and became bigger at K, for which Reaſon we muſt call the *Blood Veſſels* A B C, D F G, and A B E F I, Arteries, * becauſe they convey the Blood to their greateſt Diſtance from the Heart at G and I, and the *Blood Veſſels* G H K, and I H K, Veins, becauſe they return the *Blood* to the Heart again.

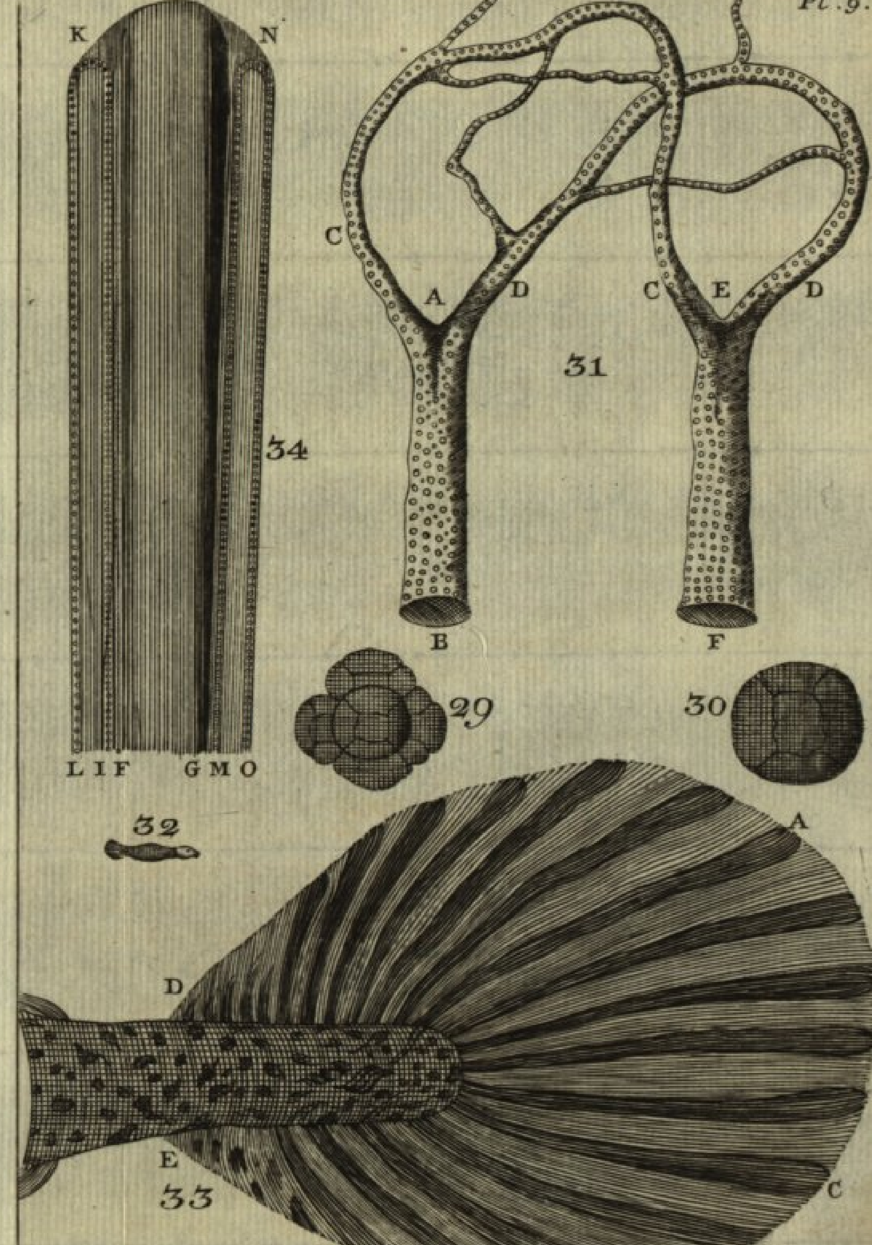
In another Place he ſaw the *Blood* running in an Artery, large enough to admit about 20 red Globules † at once; this was a great Artery in Proportion to that before-mentioned, a ſmall Part of which is delineated at L M, Fig. 36. out of which proceeded a leſſer, as M O. The *Blood* in the Veſſel from L to M, had not ſo quick a Motion as it had in others,

* *Arc. Nat. Ep.* 119. † *Phil. Tranſ.* No. 260.

becauſe the *Blood* in the Veſſel at R, did in a Manner ſtagnate, inſomuch, that no ſeparated Parts could be diſtinctly ſeen, it appearing there of one uniform red Colour; yet in the Veſſel M O, the *Circulation* was as ſwift as in any other Veſſel. That the blue Spots, occaſioned by a Fall or Bruiſe, is not ſtagnated *Blood*, which perſpires before it begins to corrupt through the Skin with the Sweat, Mr. *Leeuwenhoek* was convinced of by the following Obſervation. The *Blood* at R being thus without the leaſt Motion, it was by every Pulſation of the Heart impelled upward, from N to P, and the next Moment recoiled back again, and this alternately with an undulatory Motion; as is known if never ſo much Violence be uſed in preſſing Water, yet it cannot be preſſed cloſer than it was before; ſo the *Blood* being now impelled forwards through the Heart, cannot be compreſſed into a leſs Space; this being ſo, we muſt conclude, that the Tunick of the *Blood Veſſels* between N and P, and alſo ſomewhat below N, is diſtended at every Pulſation of the Heart; and as ſoon as this uncommon Diſtention is performed, ſo ſoon alſo does the Tunick of the Veſſel contract itſelf again; whereby the *Blood* that was thus puſhed forwards is forced to run back again. After a ſhort Space of Time he ſaw the *Blood* begin to move from P to R, in ſuch a Manner as to be puſhed back again, and that during his Obſervation, the *Blood Veſſel* M O, was a little more extended; conſequently more *Blood* ran through it than when he firſt began to look upon it; the *Blood* in the Veſſel N S, wherein was little or no Motion before, now ran as ſwift as in any other Veſſel, the Veſſel P Q was ſo ſmall, that only one ſingle Globule could paſs through it at once, wherein not the leaſt Motion, at his firſt obſerving it, could be diſcovered, now began to flow; yet the Particles of *Blood*, which at firſt paſſed through it, were but few in Number, and conſequently far aſunder; henceforward all the *Blood* from P to R was put into Motion, as well by being puſhed forward, as by recoiling back again, and that at every Pulſation of the Heart; Mr. *Leeuwenhoek* ſpent about two Minutes in theſe Obſervations. From whence it plainly appears, that the ſtagnant *Blood* can not only be made to move again by the Motion of the Heart, which we call the beating of the Pulſe, but alſo that the coagulated red Globules are again diſſolved, and aſſume their firſt Figure; from which we may reaſonably conclude, that the coagulated *Blood* in any Animal occaſioned by a Blow or Bruiſe, can in a few Days be made to move again; it being taken for granted, that the Heart of a Man puſhes out the Blood 75 times in one Minute, which is 4500 in one Hour, and 108000 times in the Space of a Day and Night; and finding that in 10 Days Time the coagulated *Blood* ſeem'd to vaniſh, and alſo conſidering that in this Time the Heart performs 1080000 Pulſations, and that in each Motion, into ſeveral Veſſels together, there has been looſen'd and ſet a-going the Quantity of a Grain of Sand, how much more will be puſhed forward in the ſame Time.

Mr.

Pl. 9.



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Mr. *Leeuwenhoek* could see the *Blood* received from the Heart at each Impulse, in the Vessel above-mention'd. If we suppose that the Quantity of a cubick Inch of coagulated *Blood*, occasioned by a Blow, is too much, and that seldom so much is coagulated at once, we may easily conceive, that such coagulated *Blood*, by Means of so many Protrusions as above-mention'd, may be loosen'd, and its Motion again restor'd, if not in all, yet in most of the Vessels.

At another Time Mr. *Leeuwenhoek* laid one of these *Tadpoles* upon a Piece of white Paper, a little while before he came to look upon it. A small Part of the Tail was wounded by the Skin sticking to the Paper; so that out of an Artery in the excoriated Part, so large that about four red Globules of the *Blood* might pass through it at once, there flowed some *Blood* that remain'd without Motion about the wounded Part, yet that whereon his Eye was fixed, not being half an Hair's Breadth from the excoriated Artery, there proceeded a Branch of a Vein, wherein the Circulation of the *Blood* did still remain, as if the Artery had not been broken, Fig. 37. T V, exhibits the Artery wounded a little above V. V X shews the *extravasated Blood*. V W, the small Artery wherein the *Blood* retain'd its full Course, altho' it was so near the Artery T V, out of which the *Blood* flowed; which at first seemed very strange, but observing that the *Blood-Vessel* V W was united at W to a large *Blood Vessel*, that conveyed the *Blood* to the Heart, the *Blood* out of V W was continued as swift as if it had been impelled from T to V, in such a Manner that Mr. *Leeuwenhoek* imagined, the Vein at V had not been united with T, but had lain with its Aperture at V, in the *extravasated Blood*; so that the *extravasated Blood* was only for a little sucked up and convey'd thro' it. He then saw a Vein wherein the Motion of the *Blood* seemed very uncommon, as at Fig. 38. whereof a b represents an Artery, whereby the *Blood* is impelled with great Velocity from a to b, then b c, whereby the *Blood* is conveyed towards the Heart, must be called a Vein, close by which lies another Artery d c e, wherein the *Blood* is conveyed from the Heart from d to c; now if the Vein b c be united with the Artery d e, as is seen at c, and the *Blood* be thus conveyed from c to e, b c should be called a Vein, and the *Blood* coming to c, being there transfused into c e, is the arterial *Blood*, because it is conveyed thither from the Heart, it being certain, that d c e is an Artery.

Amongst others, Mr. *Leeuwenhoek* had a *Tadpole*, wherein he could perceive no Motion at all of the *Blood*, how attentively soever he view'd it; at first there appear'd no Reason for it, till upon examining this Animal with his naked Eye, he observed the fore Part of his Body was contracted, by which he imagin'd the Heart was so oppressed, that it could not force out the *Blood*, and receive it back again. Whilst he was thus contemplating, the Animal made a very strong Motion; beating its Tail about, and bending its Body, by which it got clear of the Oppression it was under;

der; and on viewing it again, perceived the *Blood* to have a slow Motion, and Impulse in several Vessels, which increased till it at length came to its proper Motion, yet not with such Velocity as it would have had, if the Heart or Body had not been oppressed. Mr. *Leeuwenhoek* says, that the Motion of the *Blood* in these *Tadpoles*, exceeds what he ever saw in any other Animal. Fig. 39. exhibits a *Tadpole* arrived to such a Bigness, as to use its hinder Legs, and the fore Legs were also discernable, but yet covered with the Skin.

Mr. *Leeuwenboek* observed the Circulation of the *Blood* in several *Butts*, one of which, bating the Tail, was but an Inch in Length, the greatest Motion of the *Blood* observable through the Fins, was on each Side the various little single Bones placed therein, where the *Blood-Vessels* were so large, that 25 of those Particles which constitute the *Blood* of a red Colour, could pass in Breadth, but disappear'd as they drew nigh the Extremity of the Fins, small Vessels being all along dispers'd from the Arteries; on one Side of a little Bone, runs an Artery, and on the other a Vein, corresponding thereto; and finding it easy to extend the Tail, he accordingly stretched it in Breadth, equal to what the Fish gives in swimming, that he might the better observe the Motion of the *Blood* in these extended Vessels, and found when the Fish did not move, some of those small Vessels, which before received three Particles in Breast, being now stretched out with the Tail-fin, which they run a-cross, did not only admit no more than one Particle, but likewise these Particles did not move so fast, as when the Vessels were not extended; and in some Places were at such a Distance, that one or two more might lie in the Intervals, but could not from all this determine, that the Particles were perfectly oval *.

But to trace the Matter further, he took the *Blood* running from a live *Salmon*, † when cut into Pieces, and put it into a Glass Tube, no larger than a small Quill, which in a short Time congealed; but when it became partly fluid again, he put it into a smaller Glass Tube, and having placed it before his Eye in the *Microscope*, the Particles being in Motion, some of them appear'd of a flat oval Figure, and others, which shewed themselves sideways to the Eye, seem'd a little thick, and those whose Sides did not directly face the Eye, seem'd a little broader, without the least Appearance of any globular Form. Mr. *Leeuwenboek* also put some of the same *Blood* upon a very clean Glass, and where the Particles lay thin, he perceived them oval; nay in several Ovals he discovered Globules, and in some few six Globules.

Fig. 40. A B C D represent the oval Particles of the *Blood* of a *Salmon*, that weighed 30 Pounds; A B, the Particles that appear'd flat and broad, but did not directly face the Eye; those about c were streight be-

* *Arca Nat. Epist.* 128. † *Philos. Trans.* 263.

fore

fore the Eye, and for the moſt Part a little clear Sort of Light in the Middle, larger in ſome than others.

Mr. *Leeuwenhoeck*, likewiſe, placed ſome of the *Blood* of a very ſmall *Butt* before the Microſcope, which was not mixed with any Liquor, only the Particles lay in their Serum, and are repreſented by Fig. 41.

Thoſe Particles of the *Blood*, which are diſtinguiſhed by ſhining Spots in the Middle, are delineated Fig. 42. Mr. *Leeuwenhoek* proſecuted this Enquiry yet farther, with a greater Magnifier than he had hitherto uſed, and ſo he plainly made out the oval Particles; now the greater the magnifying Power of the Glaſs, the ſwifter does the Circulation of the *Blood* appear; and having retarded this Motion, he employed two or three Seconds of Time, in obſerving the little Veins, and found, that in ſeveral ſmall Veſſels, the oval Particles were ſo broke, that he could neither ſee them, nor thoſe, of which ſix conſtituted a Particle of *Blood*, but only a ſimple Fluid of a faint Colour, running along the Veſſels; but in a great Artery at the Tail, the *Blood* mov'd ſo ſlowly, that he could eaſily diſcern the Particles were oval; and not only ſo, but he likewiſe perceived more clearly than before, the Globules that conſtituted the oval Parts, if not always, yet at leaſt for the moſt Part, as repreſented in Fig. 43.

How venous *Blood* may become arterious without being firſt in the Heart, appears by the following Experiment. Suppoſe A B, in Fig. 44. to be a Vein, in which the *Blood* view'd thro' the *Microſcope*, paſſes with great Celerity from B to A, from this Vein proceeds two ſmall Branches, C and D, which unite between E and F. Again ſuppoſe H I to be an Artery, in which the *Blood* moves upwards with equal Swiftneſs from H to I, out of H I ariſes a venous Spring, delineated in K F L; the *Blood* moving from K to F, joins the other at F; and by this Means, Part of the *Blood* coming from the Artery, is thrown into the Vein, as paſſing from F to G, and to the beſt of Mr. *Leeuwenhoeck*'s Obſervation, a Quantity of Blood, juſt equal to that carried from K F to G, moves from C E to F, and directs its Courſe upwards from F to L, ſo that whatever Quantity of arterious *Blood* paſſes thro' K F and F G, an equal Quantity of venous *Blood* returns thro' C E and F L. Though the agreeable Motion of the *Blood* was formerly apparent, yet this Experiment afforded him a very clear Perception of the above-mention'd Variety; and beſides, this Union of the *Blood-Veſſels* was not formerly diſcover'd.

Mr. *Leeuwenhoeck*, in his 112th *Epiſt.* has given us an accurate Delineation of the *Blood-Veſſels* in Part of the *Tail* of an *Eel*, whoſe whole Length did not exceed that of the Length of his little Finger. The Figure, as by him delineated, is repreſented in Fig. 45. whereof A, C, E, repreſents the Veins, and B, D, F Arteries.

The Letter D repreſents an Artery, from which a Branch G proceeds, that is divided about H, into two leſſer Branches, one of them repreſented ed by the Letters H I K, ſo much of this ſmall Veſſel as reaches to I, is called an Artery, becauſe the *Blood* may to that Place be propelled in its Progreſſion from the Heart. The other Part I K of the ſame Branch may be called a Vein, becauſe by it the *Blood* is conveyed back again to the Heart. In the other Part of the ſame Branch H L M, the *Blood* is drove forwards till it arrives at M, where it is diſcharged into the Vein E, which in this Figure is the firſt Place that can take the Name of a Vein.

Here alſo it may be obſerved, that as the Arteries are extended in Length, they gradually leſſen. And on the contrary, the Veins increaſe in their Diameters as they approach the Heart.

Furthermore, from this ſame Artery D, another Veſſel may be ſeen branching out from N, from whence the Blood flows to O, and there diſcharges itſelf into the Vein E.

Raiſe your Eye a little higher to P, where another ſmall Artery advances from the great one D, towards Q, where it cloſes again with the Vein E.

Alſo obſerve that about the Letter R, another ſmall Veſſel leads from the ſame Artery towards S, at which Place the *Blood* that flows both from the Artery D and B, is joined, and from thence pour'd into the Vein C.

Somewhat higher, about T, advances a little *Blood-Veſſel*, which is divided into two Branches at V, ſo that from thence two diſtinct Veſſels may be ſeen to diſcharge themſelves into the Vein E, at X and h.

About the Letter Y proceeds from the ſame Artery D, another ſmall Veſſel, which at Z branches out into two more minute Veſſels; the *Blood* flowing through them toward a and b, where it is diſcharged into the Vein C.

Not far from Y, about c, proceeds a ſmall Branch from the Artery D, through which the *Blood* alſo returns into the Vein C, with which it joins at d.

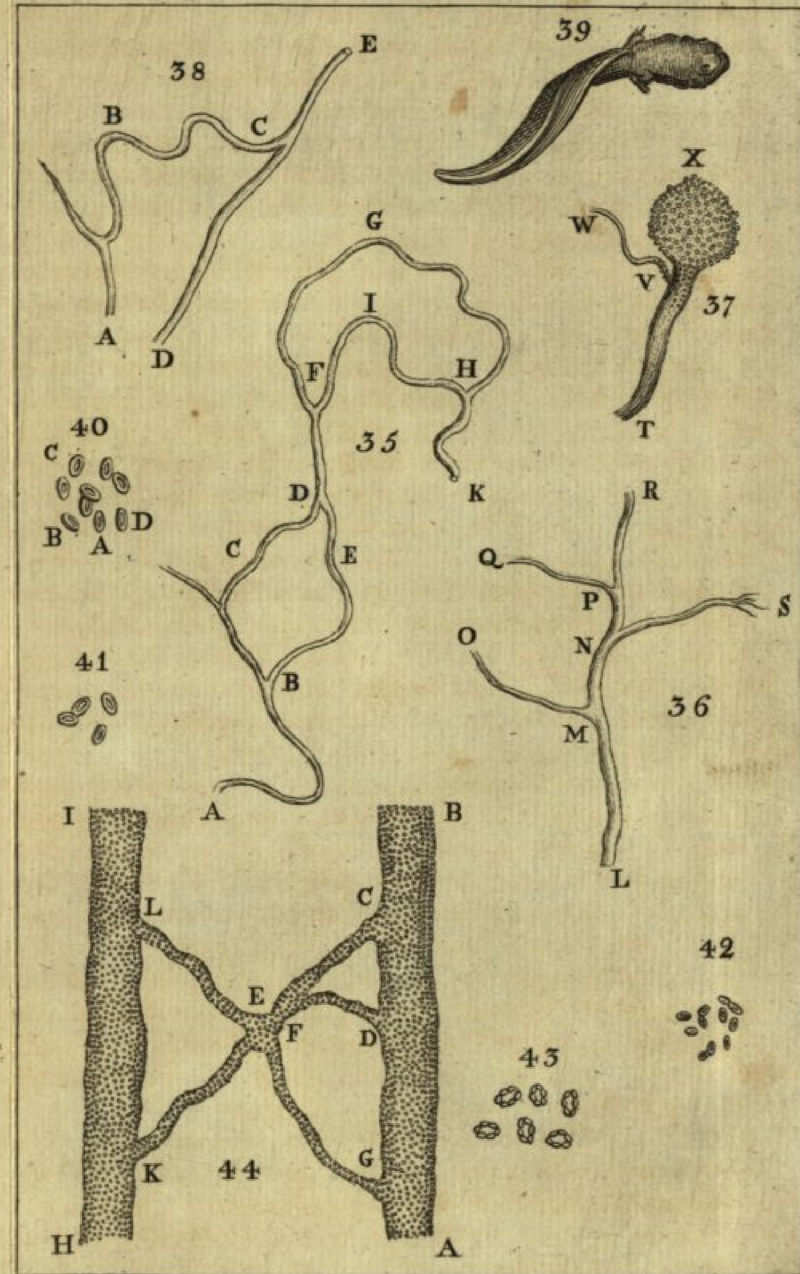
From the ſame Artery D riſes a minute Branch e, f, which is ſeparated into two leſſer Branches at f, ſending back the *Blood* to the Vein E, at g and h.

If the ſame Artery be examined a little higher, another Branch I k l, will be ſeen iſſuing from I, which is alſo divided at l into two others, that likewiſe diſcharge themſelves into the Vein E, at m and n, near I; at o, are alſo two other Branches, which vent their Streams at p and q, into the Vein C.

Moreover from the ſame Artery D, about r, proceeds forward a ſmall one r ſ, which is divided into finer Branches, one of which r ſ t, joins the Vein C, the other ſ, u, w, x, joins the Vein E at x.

The moſt evaneſcent Artery, flowing from the large one D, which is repreſented by the Letters r y z, unites with the Vein E at A; the ſame minute

Pl. 10.



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Front.^s Page. 40.

minute Artery, near the Letter u, is again divided into two Branches, the Part u b is diſcharged into the Vein C, at t.

An Eel of this Size may be conveniently placed before the Magnifiers in the *Univerſal Microſcope*, either in the Fiſh Pan, or in a ſmall Glaſs Tube filled with Water, and put between the Object Plate and Springs, after wiping off its Slime, which would obſcure the Glaſs, ſtop both its Ends to prevent the Water from running out; the Tail may then be viewed, and the Circulation will appear in an agreeable and pleaſant Manner, as in the foregoing Figure is deſcribed.

The Tails of any Sort of ſmall Fiſh, may be alſo readily applied to the Magnifiers in the ſame Manner. Under the Spring of the Fiſh-Pan a b f, as is before directed in Fig. 2. of Chap. 1. *Flounders*, *Eels*, and *Gudgeons* live a long Time out of Water, and are to be had at almoſt any Time in *London* alive.

Alſo the Tail * of a *Water Newt*, or a *Lizard*, if applied to the *Microſcope* in a Glaſs Tube, repreſents an agreeable Proſpect of the Circulation, through Variety of ſmall Veſſels, particularly in an exceeding ſmall one of the Water-Kind, which may ſometimes be procured ſhorter than an Inch, and ſo tranſparent, that the *Blood* may be ſeen running in all Directions, not only through the Tail, but particularly in every ſingle Toe, and thro' its Fins or pointed Branches. The *Blood* may be ſeen running through an Artery towards the Extremity, and returning through a Vein, with which its Communication is very apparent, and ſurprizingly delightful.

Mr. *Leeuwenhoek* informs us, that he has obſerved the Circulation of the *Blood*, in the fartheſt Joints of little *Crabs* † hinder Legs, with greater Rapidity than in any other Creature, and that their red Globules were twenty-five times fewer than in any other Land or Water Animal he had before examined.

Exceeding ſmall *Crabs* may be found under Brickbats and Stones, on the Shores of the River *Thames*, when the Tide is out.

The Circulation of the *Blood* may be ſeen in the Legs and Tails of *Shrimps*, if view'd in Water, wherein you have mixed a little Salt, but in theſe the *Blood* is not red.

I have frequently ſeen a Fluid flowing through the filmy Wings of *Graſshoppers*, of a greeniſh Colour.

The Motion of the *Blood* is alſo to be ſeen in the tranſparent Legs and Feet of ſmall *Spiders*, and in the Legs of very ſmall *Buggs*, and an extraordinary Vibration of the Veſſels not diſcernable in other Creatures.

You may often obſerve in viewing ſeveral of thoſe Objects, the Globules cannot paſs through the ſmaller Veſſels, otherwiſe than ſingle, and then ſqueezed into an oval Form.

* *Philoſ. Tranſ.* No. 288. † *Arc. Nat. Tom.* IV. *Ep.* 84, and 86.

If a little *Frog's Spawn*, in the Spring Time, be kept a few Days in ſome of the Ditch-Water, in which it is found, you'll have a great Number of exceeding ſmall *Tadpoles*, which at their firſt beginning to ſwim, are nearly tranſparent, place them before the Microſcope in a ſmall Tube, with a little Water, or in a cylindrical Glaſs, and you may behold the Circulation of the *Blood* in every Part of the Subject, and in a more particular Manner in the Tail, near * fifty Veſſels preſenting themſelves at once to View; and alſo the Pulſation of the Heart; but they grow ſo opake in a Day or two, that the Circulation can then be only ſeen in the Fins, and at the joining on of the Head, and in the Tail.

The Circulation of the *Blood* affords an entertaining Sight in the thin Membrane between the Toes of the hind Foot of *Frogs*, if well expanded; in the Machine a b f, of Fig. 2. Chap. 1. of the *Univerſal Microſcope*, and being ſo placed before the Magnifiers as there directed, the Arteries and Veins will be diſtinctly ſeen.

The *Blood* may be retain'd in the Lungs of *Frogs* and *Lizards*, as follows; on making an Inciſion into the Bodies of theſe Animals, their Lungs will ſtart out, and be diſtended with inſpired Air; on theſe as quick as you can, paſs a waxed Thread, and tie it firmly towards the upper Part of the Lobe, as near the Heart as poſſible; when the Lungs are dried, after being thus diſtended, they may be placed in Parts, between the Talcs of the Ivory Slider T, Fig. 2. and by this Means you may always keep by you, Objects of the Lungs of thoſe Animals, only remember to place their external ſmooth Surface towards the Magnifier. Theſe ſeveral Parts of the Lungs, are very entertaining Objects in the *Microſcope*.

But the Circulation of the *Blood* is no where ſeen with ſo much Satisfaction as in the Meſentery of a *Frog*. For which I have contrived an eaſy Method to hold the Animal during the Operation, as will be ſeen in the following

SECT. II.

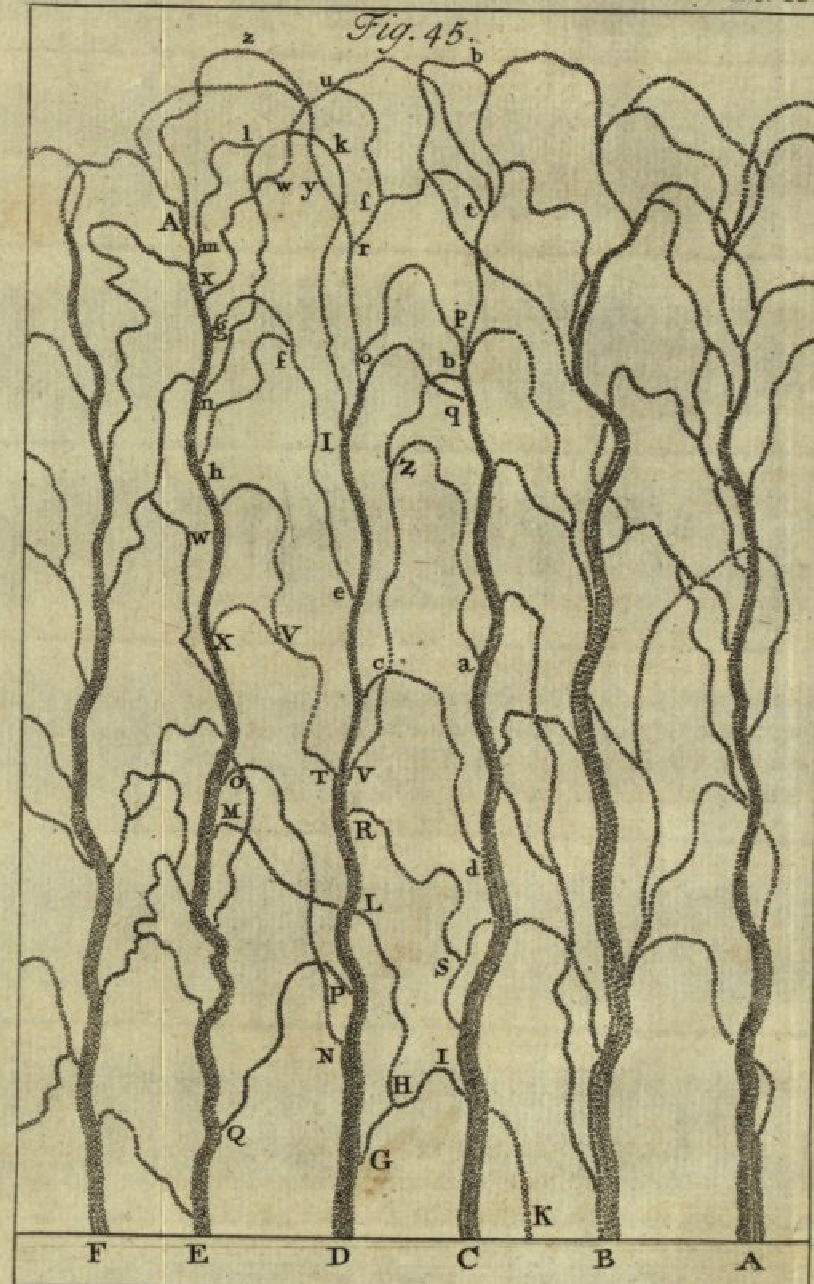
The Deſcription of a New Apparatus for confining Frogs, Mice, Bats, *or any other Creatures of the like Size, particularly adapted to the* Univerſal Microſcope, Fig. 1.

THIS Apparatus conſiſts of a ſquare Frame of Braſs A, B, C, D, Fig. 46. which may be taken to Pieces at Pleaſure. It is held together at the Corners, by the four Pillars F, F, F, F, which alſo ſupport the Frame. At the lower End of the two Pillars which ſupport the Corners C and D of the Frame, is fixed a Steel Bar G H, having one of its

* *Arcan. Nat. Epiſt.* 112.

Ends

Pl. 11.



Front. Pag. 42.

Bowles sc.

Ends made faſt to one of the Pillars at G, and the other End ſcrewed to the oppoſite Pillar by the Nut H: On this ſquare Bar is fitted a ſliding Socket I K, with its Stem T V.

When a *Frog* is to be diſſected, tie a String to each of its four Legs; firſt having ſtrain'd Strings thro' ſome of the principal Holes of the Frame, croſſing each other, as in the Figure is repreſented by the ſmall Letters a b, c d, e f, g h, i k, l m, which form a kind of Lattice, or Couch, whereon to extend the *Frog*. Then firſt put the two Strings which are tied about his Arms, thro' two Holes, the neareſt to the Corners A, C, and there fix them with two Pegs made of Fur, as at n and o, in the Figure. The Reaſon why I direct his two fore Legs or Arms to be faſtened firſt is, becauſe you may with Eaſe hold his hind Legs in your Hand, till the fore Legs are pegg'd down faſt; whereas if you attempt to fix the hind Legs firſt, the Creature will give ſuch Springs and Starts, as will not only tire himſelf, and thereby prevent him from being able to go thro' the Operation, but even make it almoſt impoſſible for you to fix him to your Mind. Then fix his hind Legs as before directed by the Pegs p, q. If now you find him not quite faſt, you may make him ſo, by pulling out one of the Pegs at a Time, and ſtraining the String a little tighter, after which replace the Peg. The Ends of the Strings which confine his Arms and Legs, are repreſented in the Figure by the Letters r, ſ, t, v, and the *Frog* lying upon his Back.

The Object being thus extended, and faſtened on the Frame, as above directed, open the Skin of the Belly, from near the Anus to the Throat in the Direction of the dotted Line I K, by firſt juſt entering the Point of a very ſharp Penknife at I, thro' the firſt Skin only, taking Care not to touch the ſecond Skin, and let the Inciſion be no longer than the little ſtreight Stroke I w, in which thruſt the Probe or Director, Fig. 47. almoſt up to his Throat, with the Curf x y upwards, in which Curf you may run the Point of a Pair of Sciſſars, without being in any Danger of cutting any other Part of the Subject, and thereby open the upper Skin from I to K, then turn the Director ſideways from K to L, and from I to M, and give it a little Snip in that Direction, both at the Top and Bottom. Stick a Fiſh-Hook, with the Barbs filed off, into each Corner of the Skin, firſt having put the Strings N O, to which the Hooks are tied, through any two of the Holes in the Frame, as at P and Q. Then by gently pulling the Strings N O, the Skin will readily ſtretch out into the Direction of a ſquare Flap, as repreſented in the Figure by the Letters L M R S, and the three dotted Lines which ſurround them.

If now you put the Stem T V into the Hole of the Pillar E of the *Univerſal Microſcope*, you may place any Part of this Flap before the Magnifiers, either by ſlipping the ſquare Steel Bar G H backwards and forwards in its ſliding Socket I K, or elſe by pulling the ſaid Socket farther from, or pushing it nearer to the upright Pillar E of the *Microscope*, Fig. 1. by which Means, you may with the greatest Ease imaginable, examine all the *Blood Vessels* in this transparent Flap or Piece of Skin, by sitting at a Table before a Window, and directing the illuminating Glass, so as to fling the Rays of Light immediately under this Part of the Skin.

If the Sun shines, and you have the solar Apparatus, describ'd Page 9. screw'd ready in the Window Shutter, take out the illuminating Glass F, and in its Stead, screw the Socket K, of the solar Apparatus, and apply the *Microscope* and *Frog* to the solar Part as before shewn, and after having directed the Sun's Rays thro' the Tube, upon any Part of the skinny Flap L R S M, and placed the Screen at about four or five Foot from the Machine, so as to receive the Sun's Rays, and adjusted the Object to the Focus of the Magnifier, and Distance of the Screen, by Help of the Screw P, as in Fig. 1.

You will have represented on the Screen, a most beautiful Picture of the Veins and Arteries in the Skin, with the *Blood* circulating thro' them; in the Arteries you may 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 rolls on in a continual Current, with inexpressible Rapidity; and when the Arteries are very much magnified, if you remove the Screen to a considerable Distance, the alternate Expansion and Contraction of their Sides are very visible.

When you have consider'd this as long as you think needful, open the Abdomen, and extend the Muscles before the *Microscope*, by Means of the two Fish-Hooks, as before in the Extension of the Skin, and you will with Pleasure view their Structure, which consists of Numbers of transparent Strings or Fibres, lying parallel to one another, and joined together by a common Membrane.

These Strings or Fibres appear thro' their whole Length, to be made up of minute roundish Vesicles; and the *Blood Vessels* which intermix with them, afford an agreeable Prospect.

The next Experiment is gently to draw out a Part of the Frog's Gut, in order to apply the Mesentery to the *Microscope*, which is a most beautiful and surprizing Phenomena, when view'd through the *Universal Microscope*, as standing upon a Table: But when applied to the solar Apparatus before described, you may view it in so distinct and fine a Manner, that no Words can describe the wonderful Scene which will then be presented to your Sight. The *Blood* flowing through numberless Vessels at one and the same Instant, in some one Way, in others the quite contrary; several of the Vessels may be magnified to an Inch in Diameter, and the *Blood* Globules rolling thro' them, will appear near as large as Pepper-Corns, and at the same Time in the minutest Vessels, only single Globules can find a Passage, and that not without putting on the Form of oblong

Sphe-

Spheriods; here alſo in the moſt inexpreſſible Manner, will be ſeen the Pulſation and Acceleration of the *Blood* in the Arteries, as before deſcribed.

As the *Animal* grows languid, and near expiring, the *Blood* in the Arteries will be ſeen to ſtop ſuddenly, and as it were ſeem to coagulate, and then run backwards for ſome Time; after which it will again recover its natural Courſe, with a great deal of Rapidity.

A due Conſideration of theſe Appearances, may poſſibly account for the Intermiſſions, Starts, and Irregularities in the Pulſe of Perſons near the Point of Death.

Fig. 48. M, L, R, S, repreſents a microſcopick Picture of a Part of the *Frog's Gut*, and *Meſentery* extended, by Means of the Fiſh Hooks R, S, M, the Ends of their Strings being pegg'd to the ſquare Frame, one of which is ſeen at p. B, I, K, C, is a Part of the Body of the Frog. And I, K, that Part where the Belly was opened. D, E, Part of the ſquare Braſs Frame. The ſhaded Part within the Gut, marked M, L, R, S, is called the Meſentery, in which is plainly ſeen the *Blood-Veſſels*. Thoſe Veſſels, which are a little darker than the reſt, are called Arteries. In every one of which I plainly ſaw a Pulſe, and the *Blood* flowing from A to R. The others are Veins, thro' which the *Blood* flowed in a conſtant Stream, in the Direction V, N.

As there are many ſmall *Fiſh*, whoſe Fins are more tranſparent than their Tails; I thought it might be acceptable in this Place, to give a Cut of the Manner how they may be faſtened upon the ſame Frame the *Frog* was, which take as follows,

Firſt cut a Piece of Leather in the Shape of Fig. 49. and tie a String to each Corner of it, as at A, B, C, D, and obſerve, that the Part G H of the Leather be no longer than from the *Fiſh's Neck* to the Part where the Tail begins to grow ſmall, and cut a Slit from A to I, and from B to K, then put the String C E through the Slit A I, and the String D F thro' the Slit B K, and put the *Fiſh* in Head foremoſt; after which draw the Strings cloſe, and apply it to the Frame, Fig. 50. fixing down the String D F to the Frame by the Peg N, and the String B M by the Peg O. The String C E may be made faſt with the Peg P, and the String A L with the Peg Q, in which Poſition the *Fiſh* cannot poſſibly get away, but on the contrary will lie exceeding quiet: Then may you ſtick a Fiſh-Hook to the thick Part of its Fin at R, and ſtretch it out by drawing the String R S gently, and then making it faſt by the Peg T.

After which place the Frame to the *Microſcope*, as above directed; and you will have a beautiful Proſpect of the Circulation, if viewed thro' the Eye-Piece N upon a Table; but much more ſo if you apply it to the ſolar Apparatus.

I hope by this Time the Reader will be enabled to fix any other Subject of the like Size to this Apparatus, in order for Diſſection, and alſo be ready

at

at applying them to the Microſcope, either to be look'd at by the Eye through the Magnifiers, or caſt upon a Screen when applied to the ſolar Apparatus. The Reader will alſo perceive that none of the modern Microſcopes, is ſo capable of having all Sorts of Subjects applied to them, as this is, and that in one Apparatus; and ſo eaſy in its Uſe, as to give Gentlemen as little Trouble as poſſible in the Application of all Sorts of Objects.

CHAP. XII.

Of Bones.

THEIR ſuperficial Part is found to conſiſt of a vaſt many ſmall Veſſels, and ſome few of a larger Size; which laſt, when they came to the Surface of the Bone, appeared to Mr. *Leeuwenhoeck* either with a Membrane, or *bony* Subſtance, perfectly tranſparent: He once diſcovered four or five Veſſels in a ſmall Piece of a Shin *Bone* of a ſufficient Size for a ſingle Filament of Silk to paſs through them, and one of them ſeemed to him to have a Valve * ſo diſpoſed as to admit nothing into it, but only to let out what was therein contained.

The ſpongy or cellular Subſtance on the Inſide of the *Bone*, conſiſts of long Particles cloſely united, that are made up of a vaſt many ſmall Veſſels, ſome running lengthways, others tending towards the Sides of the *Bony* Particles, ſome lying parallel, and others perpendicular to the Length of the *Bone*, theſe laſt have Veſſels proceeding from their Extremities; and others that compoſe the Cortex or ſuperficial Part of the *Bone*, proceed from their Sides, thoſe long Particles, which lie parallel to the Length of the *Bone*, emit Veſſels from their Sides, that iſſue out through the Side of the *Bone*. It is impoſſible to conceive what a prodigious Number of ſmall Veſſels compoſe the cortical Part of the *Bone*, which on the ſpongy Part in ſome Places is no thicker than a human Hair; tho', in others, three or four times that Thickneſs.

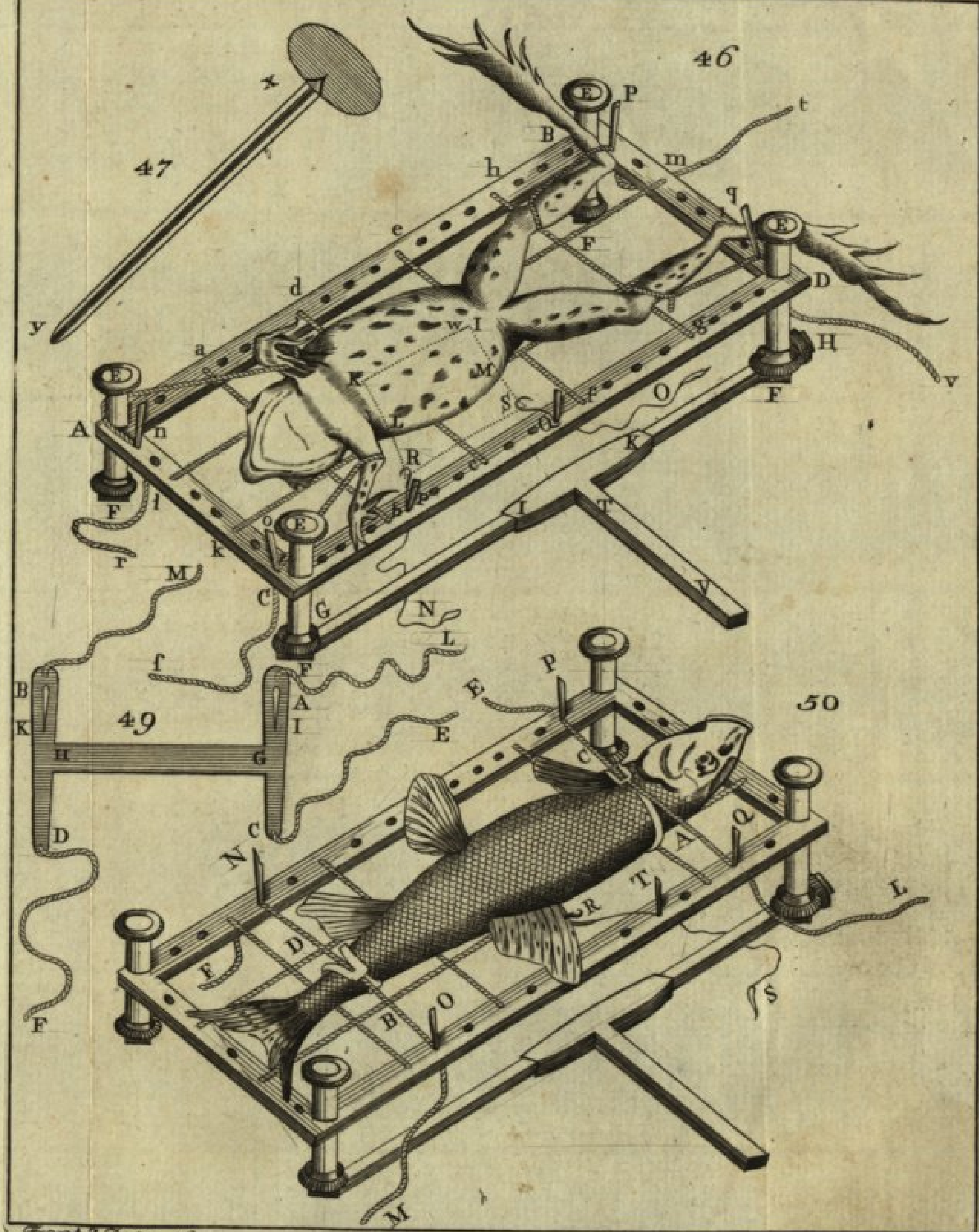
The *Perioſteum* is united to the Cortex of the *Bone*, not only to the Outſide of the Cortex, but even by entering into its very Subſtance in ſeveral Places, and is joined thereto by the Veſſels which proceed from the *Bone*.

Fig. 51. repreſents a ſmall part of the *Bone* with the Perioſteum adhering to it; ABCDEF ſhews the Bony Part, BGHIE the Perioſteum, in which all the ſmall Veſſels are repreſented by Dots. In other Places where the Thickneſs was twice as much, not only thoſe Veſſels that had been tranſverſly cut, and conſequently repreſented by ſo many Points;

* *Phil. Tranſact.* No. 366.

but

Pl. 12.



Front. Page 46.

but alſo many other Veſſels running lengthways, as in Fig. 52. L O P Q N M, and that Part repreſented by B G H I E, Fig. 51. are not entirely membraneous, but really *bony*. K L M N A repreſent the *bony* Part, in which tho' no Pores or Veſſels are here repreſented, yet it is full of Openings. Fig. 53. R S W X T V repreſents a Part of another *Bone*, S W X T the *Perioſteum*, which in this Place was no thicker than a large Hair of a Man's Beard; but in another Part of the ſame, and at a ſmall Diſtance, it was four times that Thickneſs. In another Piece of *Bone* ſo placed before the *Microſcope* as to ſhew only the *Perioſteum* and *muſcular Fibres*, which were cut tranſverſly, and appeared to be ſurrounded by Fibrils of the *Perioſteum*, as in Fig. 54. where Y Z A B is the *Perioſteum*, and Z C D A are the fleſhy *Fibres* cut tranſverſly, this was part of a Rib taken from a fat Ox.

It appears therefore from Mr. *Leeuwenhoeck*'s Obſervation on *Bones* of all Kinds, that they do conſiſt of exceeding ſmall Veſſels, ariſing from the inner hollow or ſpongy Part of the *Bone*, and paſſing thro' the ſuperficial or cortical Subſtance, enter the *Perioſteum*; and from thence are continued farther into the Body, even to the remote Parts thereof. Hence it is, that in a healthful Body there is a conſtant Supply of an oily Subſtance conveyed into the *Bones*; which again is conſtantly carried out from the *Bones* by Means of theſe Veſſels into all Parts of the Body, even to the Extremity of the Fingers. He examined a very ſmall Piece of the ſolid Part of the *Shin Bone* of an *Ox*, and found it to conſiſt of four Sorts of Tubes, perforated lengthways. The firſt Sort ſo ſmall and ſo cloſely united, as ſcarce to be diſcernable in a tranſverſe Section of it. The ſecond Sort of Tubes (ſome of which are four, ſome ſix times larger than the firſt) are alſo difficult to be diſcover'd; becauſe in cutting or ſhaving the *Bone*, although the Knife was ſharp, it deſtroyed and broke many of the tubular Parts, which ſhut up their Apertures. The third Sort greatly exceed thoſe of the ſecond, but were alſo difficult to be diſcerned, becauſe the Knife tore ſome of them in cutting; yet notwithſtanding he was perſwaded, that *Bones* are compoſed out of ſucceſſive Additions of Rings of Tubes, in the ſame Manner as Wood is. The fourth Sort are much larger than theſe, and fewer, as will appear in Fig. 62. whereof M repreſents a very ſmall Piece of a Shin *Bone*, which when viewed by the naked Eye, appeared no bigger than the Spot, Fig. M.

A B C D is the ſame Piece of *Bone* magnified, E F G is the Point of a very ſmall Needle, upon which this little Piece of *Bone* * was ſtuck for Examination before the *Microſcope*, he was not able to repreſent the firſt Sort of theſe little Tubes in the Picture, becauſe their Surface was ſo mangled in cutting, but the ſecond Sort is repreſented by the Letters H H H, the

* *Arc. Nat. Tom.* I. *p.* 200.

third Sort by the Letters I I I, which are ſeldom circular, but of different Shapes, like the great Veſſels in Wood. The fourth Sort are a great deal larger, as ſhewn by the Letters K K. The curved Lines L and M are little Clefts or Cracks made by the Knife in Cutting.

To examine the *Bones*, ſhave off with a very ſharp Razor thin Pieces of them croſſways, lengthways, and obliquely, and that from the Inſide, Outſide, and Middle of the Bone: Then apply to the Microſcope ſome of theſe Shavings dry, and others moiſtened with warm Water, by which Means you may view the Veſicles in all Directions. Or put the Bones in a clear Fire till they are red hot; then carefully taking them out, you will find the bony Cells perfect and entire, and being quite empty, may be view'd with great Eaſe and Pleaſure.

They may be applied to the *Univerſal Microſcope*, Fig. 1. either upon the Glaſs R, Fig. 2. or ſtuck upon the Point of a very ſmall Needle, which Needle may be held between the Nippers m of the Apparatus V, Fig. 2. and thereby examined with Eaſe, and little Bits thereof may be preſerved between the Talcs in an Ivory Slider, or in one of the circular Talc Rings.

CHAP. XIII.

Of the Muſcular or Fleſhy Fibres of Animals.

MR. *Leeuwenhoeck* hath diſcovered each muſcular Fibre to be made up of ſmaller *Fibrils*, which, notwithſtanding their Smallneſs, he plainly diſcern'd to be vaſcular, for on cutting a-croſs their Length, the Light might be ſeen thro' their Apertures; but if he cut them ever ſo little obliquely, could ſee no Light. He alſo obſerved the Structure of the *Fibres* in the Fleſh of an *Ox*, and of a *Whale*, but plainer in that of a *Whale*; the Fibres of the other being more compact and cloſe, and found alſo that the Fibres of a *Mouſe* were of the ſame Size as * thoſe of an *Ox*, from whence he concludes, the different Size of *Animals* is entirely owing to the Number and Length of their Fibres. Theſe fleſhy Fibres appear throughout their whole Length, to be encompaſſed as it were with ſpiral Circumvolution, as is exactly repreſented in Fig. 69.

Which Diſpoſition ſeems to be wonderfully contrived for Readineſs in the Diſtenſion and Contraction of the Fibres. Two of thoſe *fleſhy Fibres* are repreſented by G H, and I K, Fig. 68.

To view the muſcular *Fibres* with the Microſcope, cut off a Piece of dried Fleſh or Fiſh, as thin as poſſible, and lay it upon the Glaſs R, of

* *Arc. Nat. Tom.* III. *p.* 108.

Fig.

J. Wigley. Sc.

Front.^s Page. 48.

Fig. 2. and moisten it with warm Water, which drying soon away, will leave the Vessels open and distinguishable. As the Learned differ in their Opinions with Respect to the Figure and Structure of these little Vesicles, I shall leave it to the Curious for farther Examination.

Mr. *Leeuwenhoek* informs us, that the fleshy Fibres in Insects are no less visible than those of larger Creatures, which he found by cutting off the Legs of *Flies*, *Gnats*, *Ants*, &c. in all which he could plainly distinguish the circular Wrinkles or Circumvolutions encompassing the Fibres, as in Fig. 69.

Upon cutting the fleshy *Fibres* of a *Whale*, length-wise, and a-cross, † he plainly discovered each Particle, or fleshy *Fibre*, to be enveloped in a fine thin Membrane. It appear'd in the Microscope, as represented Fig. 55. in which the Parts lay so close together, that their encompassing Membranes, represented by the black Lines, were but just discernable; some however appear'd larger than others, and these, † if attentively view'd, seem'd to be divided into a great many others, some also cut transversly, and crowded so close together, that their Figure, as well as Size, was very different. Fig. 56, represents a thin Slice of the Flesh of a *Whale*, which after having been made throughly wet, and applied to the Microscope, appear'd as in the Figure. Upon letting the Moisture evaporate from these Slices, the Particles became much smaller, and the Membranes, with which each was encompassed, were very visible. Fig. 57. represents a Piece of the same Flesh, wherein the Particles seem'd to touch, but on their being dried, shrunk up, from the surrounding Membranes, whereas the Membranes themselves could not shrink, because they were all join'd together. All along these fleshy *Fibres* § run Membranes about the Thickness of an Hair, and Distance of a Grain of Sand; from these larger Membranes, other Parts were spread, dividing each *Fibre* into a great many *Fibrils*; from whence we may say, that each fleshy *Fibre*, no bigger than an Hair, is a small Muscle encompassed with its peculiar Coat or Membrane. Fig. 58. represents a small Piece of these *Fibres* greatly magnified; on moistening again the *Fibres* represented by the two last Figures (that were dried and shrivell'd up) they became so distended, as to fill up the Spaces between the Membranes, and re-assume the Shape they had before they were dried. Among several little Pieces of Flesh, moisten'd as above, and placed before the Microscope, there was one, whose Particles were not separated upon drying; suppos'd to be owing to the splitting and tearing ‡ asunder of a large Membrane, which run thro' its Middle, as represented in Fig. 59. by Q R S T V W, where between S T and V, the dried Particles remain unseparated, S W shews the thick Membrane that divided this Piece about

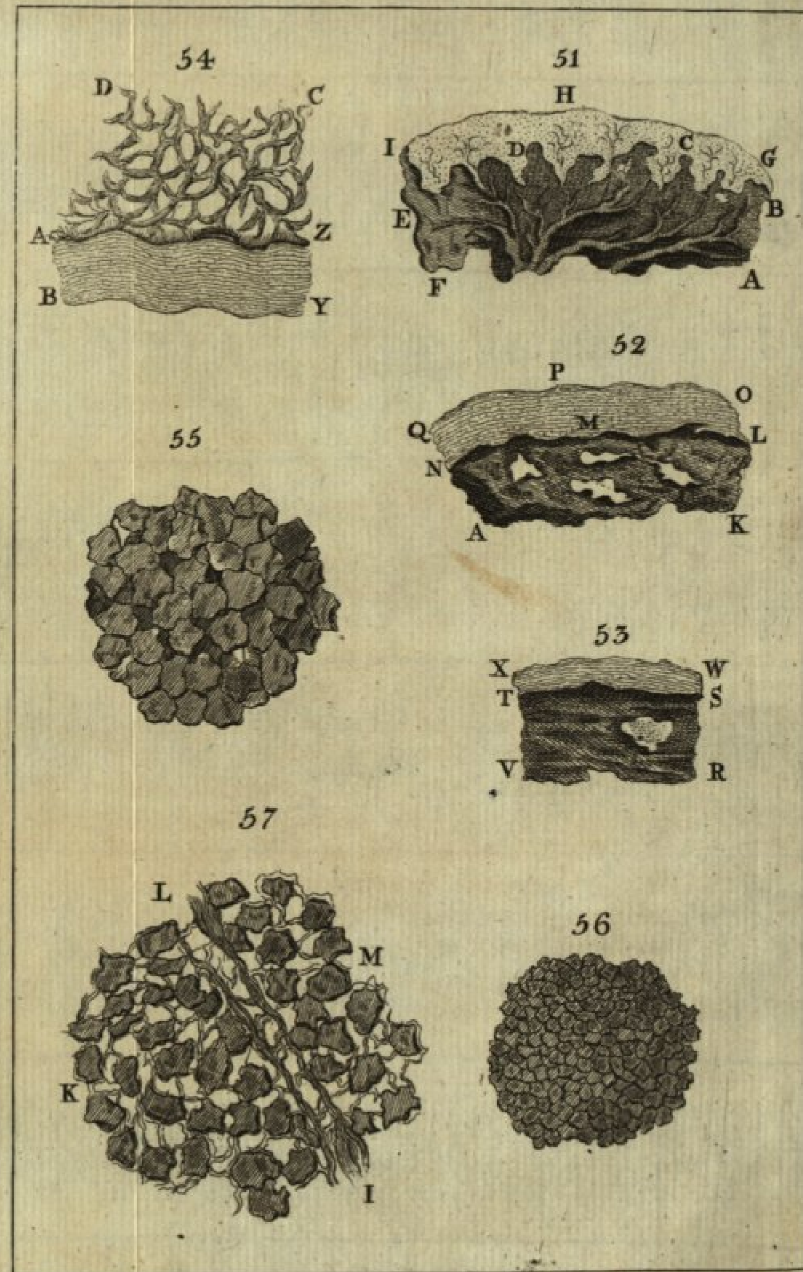
† *Epist. Phys.* *p.* 3. § *Ibid.* *p.* 4. ‡ *Phil. Trans.* No. 39.

the Thickneſs of an Hair, that ſent out a Branch at T, and at W was ſplit into two. Fig. 60. repreſents a very ſmall Piece, conſiſting only of five *Fibres* cut lengthwiſe, as they appear'd thro' the Microſcope; between C and F may be ſeen the little Membranes which encompaſs the *Fibrils*, but are here torn aſunder. Fig. 61. exhibits four ſmall *Fibrils* of a Piece of Fleſh of another Whale, by which it plainly appears, that the Diameters of theſe *Fibres* are as ſmall again as thoſe in the foregoing Figure, therefore they muſt be four Times as big as theſe; as each fleſhy *Fibre* is compoſed of a great many ſmaller *Fibrils*, we may imagine each of theſe incloſed ones, to conſiſt alſo of others of the like Nature.

Mr. *Leeuwenhoek*, on viewing ſeveral ſmall *Fibres* of *Ox* Fleſh, obſerved each of its contained *Fibrils* to be encompaſſed with a thin Membrane; but could not ſhew theſe Membranes ſo diſtinctly to others in this Fleſh, as in that of a Whale; becauſe the Parts of the firſt are of a Texture much more compact and cloſe, than thoſe of the latter; for which Reaſon they do not ſhrink ſo much in drying. And is alſo of Opinion, that what he has ſaid of the Membranes encompaſſing the *Fibres* and *Fibrils* of Whale-Fleſh, will alſo hold true in other Kinds of Fleſh, even down to that of a *Rat* or *Mouſe*.

Mr. *Muys* confirms the foregoing Obſervations on the fleſhy *Fibres* of the Muſcles, being compoſed of ſmaller *Fibrils*, and computes that 500 or 600 of them may be reckoned into one fleſhy *Fibre*, whoſe Diameter is the 24th Part of an Inch, * and that each of theſe *Fibrils* are alſo made up of more than 300 tranſparent Tubuli, but ſo ſlender as not to admit a 24th Part of a ſingle Globule of *Blood*. He has ſhewn, that tho' the fleſhy *Fibres* of the Muſcles are joined to the Tendons, and tendinous Membrane of a Muſcle; yet thoſe tendinous *Fibres* are not a Continuation of the fleſhy ones, as is generally ſuppoſed. He found that upon injecting warm Water into the crural Artery of a *Lamb* of a Year old, all the fleſhy *Fibres* loſt their Redneſs and became White. He then injected a colour'd Liquor into the ſame Artery, upon which not only the ſmall Arteries appear'd replete with the tingid Liquor, but that it had alſo paſſed thro' each *Fibre*. He alſo obſerved, that ſeveral Branches of the Arteries now became viſibly ſpread round the ſmall *Fibrils*, and tingid with the ſame Liquor; and upon examining the Parts of the fleſhy *Fibres*, near the Extremity of the Arteries with a Microſcope, found the ſmall *Fibrils* filled and tingid with the ſame Liquor; and not the leaſt Appearance of the Liquor in the Interſtices between the *Fibrils*. And upon injecting another colour'd Liquor by the crural Artery, he ſaw not only the *Fibres* in ſome of the Muſcles, and moſt Part of them in others, filled with this Matter, but upon examining them in a good Microſcope, found the Fibrils, and even the leaſt

* *Phil. Tranſ.* No. 339.



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Tubuli that compos'd them, filled and tingid with the same, yet the small Ramifications of the Nerves appear'd perfectly white. Whence it appears, that the small Tubes which form a *Fibril*, are really hollow; and that the Extremities of the capillary Arteries open into them, and empty therein a Part of their Liquor, which is re-conveyed by the Veins into the Heart.

In the spinal Marrow of an *Ox*, Mr. *Leeuwenhoek* tells us, he saw with great Delight minute hollow Vessels of an inconconceivable Finess, invested with their Membranes, and extending length-wise parallel to each other, make up their Composition. He did not only discern their Cavities, which he computed to be 3 times less than their Diameters, but in some perceived the Orifices, as the Holes in a prick'd Paper are seen, when held against the Sun. This Examination requires the utmost Dexterity. For after a thin Slice of the spinal Marrrow is placed before the Microscope, in less than a Minute's Time it becomes dry, and the whole Appearance lost *.

He also examined the Brain of an *Indian Hen*, a *Sheep*, an *Ox*, a *Sparrow*, &c. and did in them distinguish Multitudes of Vessels extreamly small; and farther † observ'd, that the Vessels in the Brain of a *Sparrow* are no smaller than in an *Ox*, and from thence he argues, that there is no other real Difference between the Brain of a larger and a smaller Animal, but only a greater or a smaller Number of Vessels; and that the Globules of the Fluid passing thro' them, are in both of the same Size.

CHAP. XIV.
Of Hairs.

FROM *Malphigi*'s curious Observations of the *Hair*, we are informed, that they are compos'd of a Number of extreamly minute Tubes, which are mostly distinguishable near the End of the *Hairs*, in a Horse's Main and Tail, and in the Bristles of a Boar, wherein those Tubes so manifestly appear, that he could sometimes reckon above 20 of them; and in the Hedge-Hog's Prickles, he plainly saw those Tubes, together with medullary Valves and Cells.

That which this sagacious and not enough to be commended Observer, took Notice of in the Structure of *Hair*, and its Parity to the *Spines*, § is observably true in some Measure in the *Hairs* of *Cats*, *Rats*, *Mice*, and in divers other Animals, which look very prettily when viewed with a good Microscope.

Fig. 63. A, B, C, represents three cylindrical Pieces of human *Hairs*, they are transparent throughout their whole ‖ Length; and are composed of small

* *Arc. Nat. Tom.* III. *p.* 310, 355, 440. † *Ibid. Tom.* I. *Part* I. *p.* 38. § *Derham*'s *Phis. Thes. p.* 220. ‖ *Hook*'s *Micrographia.* 1 *Ed. p.* 158.

long tubular Fibres, encompaſſed with a Kind of Bark; from which Structure, the Ends of long Hairs when ſplit, appear like a Stick ſhrivelled with Beating, ſome of them in *Men*, *Horſes*, *Sheep*, *Hogs*, &c. having ſix or more Splinters.

Fig. 64. repreſents a cylindrical Piece of the *Hair*, or *Briſtle* of an *Hog*, which is neither perfectly round nor ſharp edged, but priſmatical, with divers Sides and roundiſh Angles.

Part of a Whiſker of a *Cat* cut tranſverſly, is repreſented by the ſhort Cylinder, Fig. 65. which ſeem'd to have a large Pith in the Middle, like that of Elder.

The *Hairs* of *Indian-Deer* appear perforated from Side to Side. The long *Hairs* of *Horſes*, as at D E F, Fig. 66. ſeem cylindrical, and ſomewhat pithy.

The *Hair* of a *Mouſe* ſeems to be one ſingle tranſparent *Tube*, with a *Pith*, made up of a fibrous Subſtance, running in dark Lines, in ſome *Hairs* tranſverſly, in others ſpirally, theſe darker medullary * Parts are no other than ſmall Fibres convolved round; and lying cloſer together than other Parts of the *Hair*; they run from the Bottom to the Top of the *Hair*, and it is apprehended that they run round in a Screw-like Faſhion. A B, Fig. 67. repreſents that Part of the *Hair* which grew near the Skin, the middle Part of the ſame *Hair* is ſhewn at C D, and the Point of it at E F.

Hairs taken from the Head, the Eye-brows, 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 Genius, but of different Species.

Hairs have each a round bulbous Root, which lies pretty deep in the Skin, being planted in the pyramidal Papillæ, and, by this imbibe their proper Food from the adjacent Humours, and as hinted above, their Extremities ſplit or divide in two or three Branches, eſpecially when kept dry, and left to grow too long; ſo that what to the naked Eye appears only a ſingle *Hair*, to the Microſcope ſeems a Bruſh.

CHAP. XV.

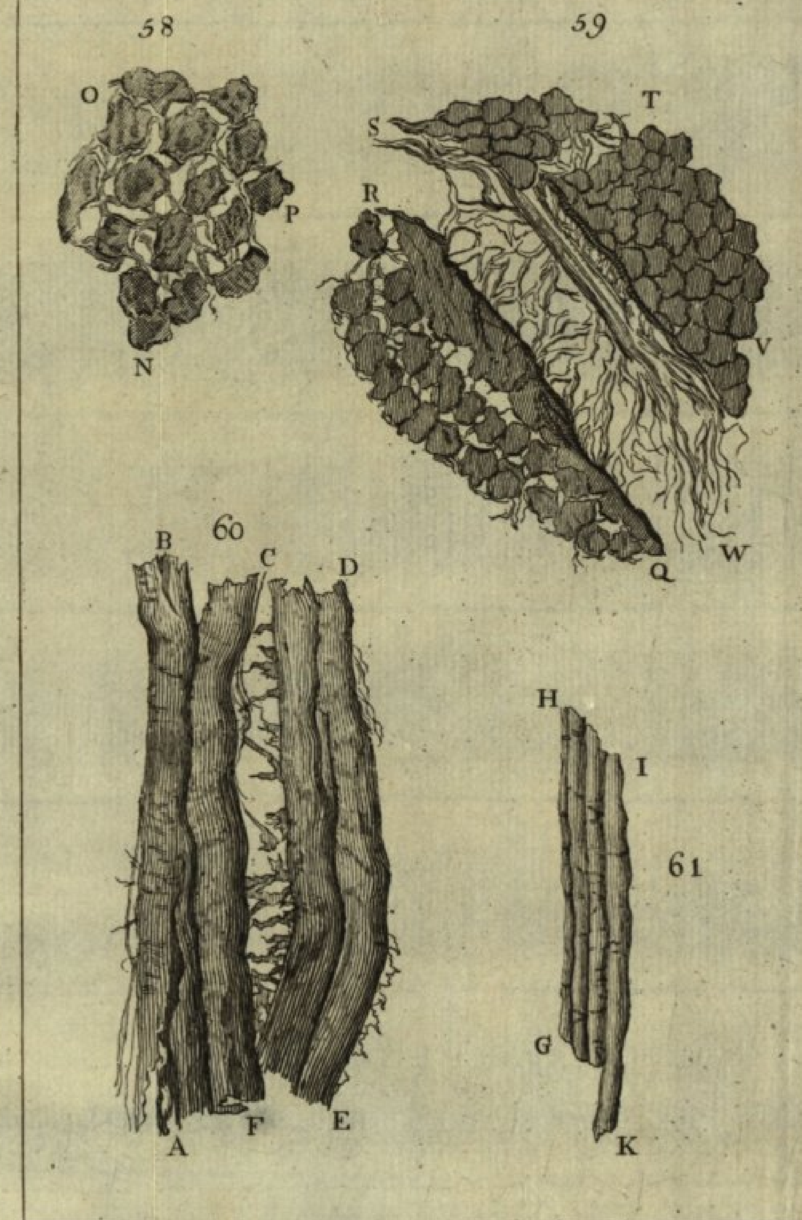
Of the Scales in Human Skin.

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

The *Scales* grow upon our Bodies, juſt as the *Scales* grow upon the ex-

* *Arc. Nat. Tom.* III, *p.* 47.

ternal



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ternal Skin of a Fiſh, * and are placed as in Fiſhes three deep, *i. e.* each Scale is ſo far cover'd by two others, that only a third Part thereof appears, as at M, Fig. 70. their 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-Veſſels are ſeen thro', and the Parts look red.

The perſpirable Matter is ſuppoſed to iſſue between thoſe *Scales*, (which lie over the Pores or excretory Veſſels, through which the watery and oily Humours perſpire) and may find Vent in an hundred Places round the Edges of the Skin.

A Piece of *Skin* taken from between the *Fingers*, *Neck*, *Arms*, *Forehead*, or any other Part of the Body which is not hairy, ſerves beſt to ſhew the *Scales:* Or if they be ſcraped off with a Penknife, and put into a Drop of Water, and ſo applied to the Microſcope, they will be ſeen to good Advantage, as at L, Fig. 70. and generally conſiſt of five Sides.

Mr. *Leeuwenhoek* tells us 200 of them may be covered with a Grain of Sand †, ſo that if a Grain of Sand can cover 200 of thoſe Scales, it will alſo cover ‖ 20,000 Places through which Perſpiration may iſſue.

To view the Pores of the Skin.

Cut a Slice of the upper Skin with a ſharp Razor, as thin as poſſible; and then immediately cut a ſecond Slice from the ſame Place, which apply to the Microſcope, in a Piece about the Bigneſs of a Grain of Sand, innumerable Pores will be perceived. If a Piece of the Skin between the Fingers, or in the Palm of the Hands, be thus prepared, and then examined, the Light may very pleaſantly be ſeen thro' the Pores.

The Pores thro' which we perſpire, are moſt remarkable in the Hands and Feet §; for if the Hand be well waſhed with Soap, and examined but with 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 Diſtance and Bigneſs, will appear; upon which the Pores may be perceived by a very good Eye, but when view'd thro' a very good Glaſs, every Pore ſeems like a little Fountain, with Sweat ſtanding therein, as clear as Rock Water, and if wiped away, it will be found immediately to ſpring up again.

* *Philoſ. Tranſ.* No. 159. † *Arc. Nat. Tom.* I. *Par.* II. *p.* 208. ‖ *Arc. Nat. Tom.* IV. *p.* 48. § *Philoſ. Tranſ.* No. 159.

CHAP.

CHAP. XVI.

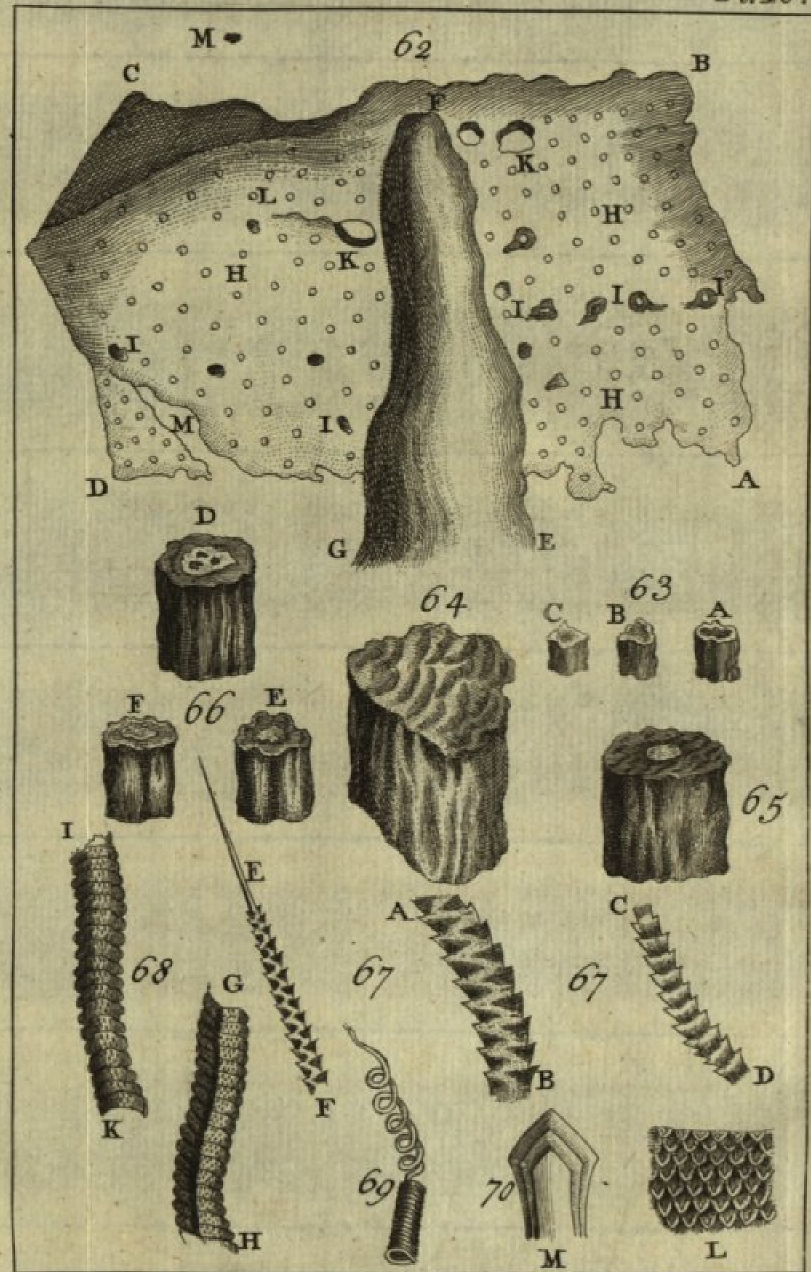
Of Feathers.

THE *Feathers* of moſt Sorts of Birds afford a beautiful Variety, obſervable in that incomparable Curioſity with which every *Feather* is made; the Vanes thereof are curiouſly gaged, broad on one Side, and narrow on the other; both which adminiſter to the progreſſive Motion of the Bird, as well as to the Union and Cloſeneſs of the Wing; and no leſs exquiſite is the textrine Art of the Plumage alſo, which is ſo curiouſly wrought, and ſo artificially interwoven, that it cannot be viewed without Admiration, eſpecially if the Eye be armed with a Microſcope.

Mr. *Hook* obſerves, that the Make and Texture of their downy Parts are moſt admirable; for, ſays he, there is ſcarce a large *Feather*, but contains near a Million of diſtinct Parts, and every one of them regularly ſhaped; with his naked Eye he counted 300 of the long downy Branches on one Side, and an equal Number on the other Side of more ſtiff and ſhorter Branches, in a middle ſized Gooſe Quill, and examining many of thoſe long downy Branches with his Microſcope, found ſeveral of them to contain near 1200 ſmall Leaves, ſuch as A B of Fig. 71. and as many Stalks on the other Side, ſuch as A C, of the ſame Figure, each of theſe Branchings A B, ſeemed divided into 16 or 18 ſmall Joints, out of moſt of which grew long ſlender Fibres, as are expreſſed in the Figure by a b c d, ſeveral of which terminated in a Hook; thoſe on the other Side were much ſhorter, the Stalks A C were divided into as many knotted Joints, but without Strings or Hooks, being divided at D into two Parts, one Side extended from D towards C, in Length equal to A C, the other Side at D was very ſhort. The tranſverſe Section of theſe Stems or Branches, were ſhaped like E F G H, whoſe Covering appear'd like Horn, and the Pith like that of the main Stem of the Feather; theſe Stems or downy Branches are ſo ranged, that the Leaves or hairy Stalks of the one, lie at Top, or are incumbent on the Stalks of the other, and croſs each other, much after the Manner of Fig. 72. by which Means, each of thoſe little hooked Fibres get between the naked Stalks, which being full of Knots, and a pretty Way disjoined, the two Parts are ſo cloſely and admirably wove together, as to reſiſt the Air; and are ſo extreamly ſmall, that the 500th Part of an Inch exceeds them in Thickneſs.

The Parts of the *Feathers* of a *Peacock*, appear through the Microſcope no leſs beautiful than the whole *Feather* does to the naked Eye; the Stem of each *Feather* in the Tail, ſends out Multitudes of lateral Branches; ſuch as A B, of Fig. 73. which repreſents $\frac{1}{32}$ Part of an Inch, each of

theſe



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theſe lateral Branches emits Numbers of little Sprigs or Hairs, on each Side as C D, C D, C D, each of which in the Microſcope appear to conſiſt of a Multitude of bright ſhining Parts, which are a Congeries of ſmall Plates, as e, e, e, e, e, *&c.* each ſhaped like a, b, c, d, of Fig. 74. a c being a Prominency or Stem; and d and b the Corners of two ſmall thin Plates, that grow into the ſmall Stalk in the Middle, making a Kind of little Feather, and lie cloſe to, or rather upon each other in the Manner of Tiling; they grow on each Side of the Stalk, oppoſite to each other, by two and two in the Manner expreſſed by Fig. 75. the Tops of the lower ones covering the Roots of thoſe next above them; the under Sides of each of theſe Plates are very dark and opake, reflecting all the Rays caſt upon them; much like the Foil of a Looking-Glaſs; but their upper Sides ſeem to conſiſt of a Multitude of exceedingly thin plated Bodies, lying cloſe together, and thereby like Mother of Pearl Shells do not only reflect a very briſk Light, but even tinge that Light ſo reflected in a moſt curious Manner, which by various Poſitions of the Light, reflect firſt one Colour and then another, in a moſt vivid and ſurprizing Manner. And that theſe Colours ariſe only from the Refraction of Light: He found that wetting the colour'd Parts with Water, deſtroyed their Colours, and though he was not able to ſee thoſe Hairs at all tranſparent in common Light, yet by looking at them againſt the Sun, found them to be tinged with a darkiſh Red, not at all reſembling the curious Greens and Blues they exhibit.

The changeable colour'd *Feathers* of *Ducks*, and ſeveral other Birds, he found upon Examination with the Microſcope to proceed from the ſame Cauſes and Textures.

The beſt Way to apply one of theſe ſmall downy Fibres to the Microſcope, is to pinch them between the Nippers.

Mr. *Derham*, in his Deſcription of the Vanes of a Flag *Feather* of a *Gooſe's Wing*, obſerves theſe two Particulars, 1. That the exterior or narrow Vanes bend downwards; the interior, wider Vanes upwards; by which Means they catch hold, and lie cloſe to one another, when the Wing is ſpread, ſo that not one *Feather* may miſs its full Force and Impulſe. 2. That the very Tips of theſe *Feathers* are alſo neatly ſloped to a Point, towards the outward Part of the Wing. The exterior Vanes towards the Body.

The Vane or Web of a *Feather*, conſiſts of ſeveral Laminæ, which are thin, ſtiff, and ſomewhat of the Nature of a thin Quill, towards the Shaft of the Feathers (eſpecially in Flag *Feathers* of the Wing) thoſe Laminæ are broad, and of a ſemicircular Form, which ſerves for Strength, and alſo for ſhutting theſe Plates cloſe to one another, when Impulſes are made upon the Air. Towards the outer Part of the Vane, theſe Laminæ grow ſlender and taper, on their under Side they are thin and ſmooth, but are parted

parted into two hairy Edges on the Upper: Each Side having a different Sort of Hairs laminated, or broad at Bottom, and ſlender and bearded above the other half.

The uppermoſt Edge of one of the Laminæ, with ſome of the Hairs on each Side, is repreſented in Fig. 76. as it appears a little magnified in the Microſcope. Theſe bearded Briſtles, or Hairs, are ſtreight on one Side thereof, as Fig. 77. thoſe on the other Side have hooked Beards on one Side of the Briſtle, and ſtreight ones on the other, as Fig. 78. both theſe Briſtles magnified (only ſcattering, and not cloſe) are repreſented, as they grow upon the upper Edge of the Laminæ ſ t, in Fig. 76. and in the Vane, the hooked Beards of one Laminæ, always lie next the ſtreight Beards of the next Laminæ, and by that Means lock and hold each other, and by a pretty Mechaniſm, brace the Laminæ cloſe to one another. And if at any Time the Vane happens to be ruffled and diſcompoſed, it can by this eaſy Mechaniſm, be reduced and repaired.

CHAP. XVII.

Of Flies.

SECT. I.

THE common *Fly* is an Object beautifully ornamented with a Mixture of Silver and Black, and thick ſet with Briſtles, pointing from its Head towards the Tail; in its Head are two large hemiſpherical Eyes, embroider'd with Silver Hairs, a wide Mouth, an hairy Trunk, and a Pair of ſhort Horns. Its Trunk has two Parts folded over each other, and ſheathed in the Mouth, whoſe Extremity is ſharp. In thoſe *Flies* which are of a light Colour and more tranſparent than others, the Motion of the Inteſtines may be plainly ſeen, and alſo the Motion of the Lungs, as they alternately dilate and contract themſelves.

In general, the Female *Fly* is ſupplied with a moveable Tube at the End of her Tail, by the Extenſion of which ſhe can convey her Eggs into convenient Receptacles, ſuch as may afford a proper Nouriſhment to the Young. From theſe Eggs proceed minute Maggots or Worms, repreſented in Fig. 79. which after feeding voraciouſly for ſome Time, arrive to their full Growth, and are transform'd into little Aurelias as in Fig. 80. whence after a longer Space of Time, they iſſue forth perfect Flies, as Fig. 81.

SECT.

Sect. II.

Of the Feet of Flies, &c.

FIG. 82. A, is a microſcopick Repreſentation of the *Foot* of a *Fly*, in which is ſeen three of its *Joints*, the two *Talons*, and the two ſkinny *Palms* or *Soles* in a flat Poſture. Fig. 82. B, ſhews only one *Joint*, the *Talons*, &c. in another Poſture, which is ſo admirably and curiouſly contrived, as to enable the *Flies* to walk againſt the Sides of Glaſs, and to ſuſpend themſelves under the Surface of a Ceiling, with the greateſt ſeeming Facility and Firmneſs. The two *Talons* A B, A C, are very large in Proportion to the *Foot*, the biggeſt Part of them from A to I I, is all hairy, their Points C and B ſmooth, and bending inwards. Each of theſe *Talons* are jointed at A, ſo that the *Fly* is able to open and ſhut them at Pleaſure: The Claws readily enter the Pores of moſt Subſtances, at which Time, as the *Fly* endeavours to ſhut them, the Claws C B, do not only draw towards, but fix each other; and alſo draw the whole Foot G G A D D forward; ſo that on a ſoft Body, the Points G G G G (of which the *Fly* has about ten to each Foot) enter. This is ſenſible to the naked Eye, in the Feet of a Chaffer, and if you ſuffer him to creep over the Hand, he makes his Step as ſenſible to the Touch alſo.

But as this Contrivance often fails the Chaffer, ſo would it the *Fly*, had not Nature furniſhed his Feet with another curious Contrivance, which is the *Palms* or *Soles* D D. They are two ſmall, thin, flat, and horny Subſtances, that ariſe from the under Part of the laſt Joint of the Foot, and are ſeemingly flexible; ſo that their two Sides do not always lie in the ſame Plain, but may be ſhut cloſer, and as it were graſp a Body of themſelves: Beſides, the under Sides of theſe Soles are all beſet with ſmall *Briſtles*, like the Wire Teeth of a Card, whoſe Points tend forward. Hence the *Talons* drawing the Feet forward as before, and theſe *Soles* being applied to the Surface of the Body, with all its Points looking the contrary Way, if there be any Irregularity, or yielding therein; the *Fly* ſuſpends itſelf very firmly and eaſily. That the *Fly* is enabled to walk on Glaſs, proceeds partly from a Ruggedneſs of the Surface, or a Kind of Tarniſh or dirty ſmoaky Subſtance, adhering to the Surface of that very hard Body; and tho' the pointed Parts cannot penetrate, yet they may find Pores enough in the Tarniſh, or at leaſt make them. This Structure Mr. *Hook* ſurveyed with great Diligence, becauſe he could not comprehend, that if there was any ſuch glutinous Matter in thoſe ſuppoſed Sponges (as moſt that have obſerved that Object in a Microſcope, have believed) how the *Fly* could ſo readily unglew and looſen its Feet; and alſo becauſe he had found no other Creature any Ways like it.

A Contrivance nearly alike to this is to be found in all Kind of Flies, and Case winged Insects, and in the Flea, in Mites, *&c.* some of which have only one sharp *Talon* at the End of each Leg. Which drawing towards the Center or Middle of their Bodies, enable these exceeding light Bodies to suspend and fasten themselves to almost any Surface. This will not seem strange; if we consider first how small their Bulk is when compared to their Superficies, their Thickness frequently not amounting to the 100th Part of an Inch. Secondly their Strength and Agility compared to their Bulk, which in that Proportion perhaps may be an 100 times stronger than an Horse: Thirdly, if we consider that Nature always appropriates the Instruments in the most fit, easy, and simple Manner possible to perform their Office; which is also verified in the Foot of a Louse, each of his Legs being footed with two small Claws, with which it grasps, and thereby moves itself to and fro upon the Hairs of the Creature it inhabits.

The Legs of Flies are best applied to the *Universal Microscope*, by being either stuck upon the Point, or held between the Nippers. Though we frequently place them between two Talcs in an Ivory Slider.

SECT. III.

Of the Eyes and Head of a Grey Drone Fly.

THE Structure of the *Eye* in all Creatures, is an admirable Piece of Mechanism; but the beautiful Contrivance of the *Eyes* of Insects is so peculiar, that it must excite our Admiration, so fenced with its own Hardness, that its own accurate Vision is a good Guard against external Injuries; its outward Coat being all over beset with curious lenticular Inlets; enabling those Creatures to see very accurately every Way, without any Interval of Time, or Trouble to move the Eye towards Objects *.

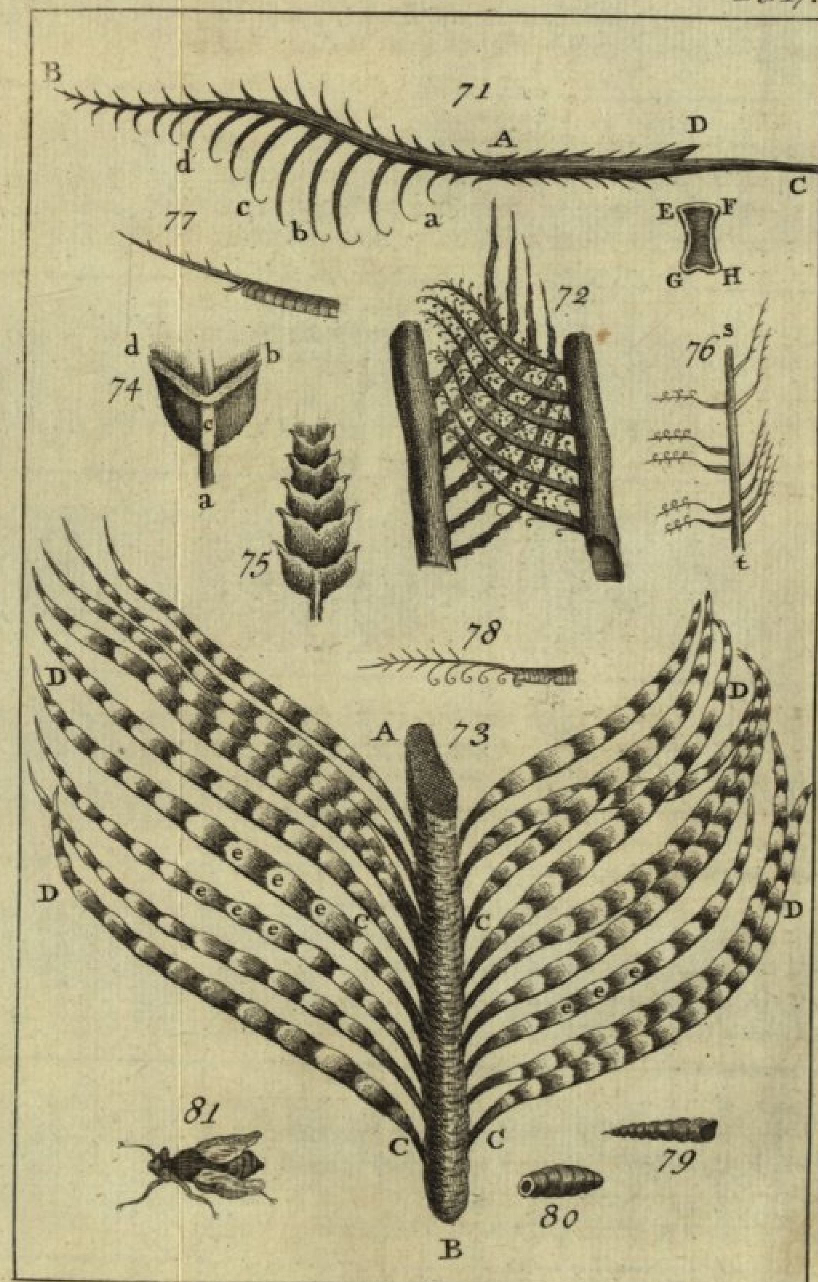
See Fig. 83. This *Fly* was made Choice of, because the Inquiry being chiefly about the *Eyes*, it was found to have the biggest Cluster of *Eyes*, in Proportion to its Head, of any other small *Fly*. It inclining something towards the Make of the large *Dragon Fly*, which is the most remarkable of all other Insects for its fine *pearled Eyes*.

The greatest Part of the Head was nothing else but two large Protuberances, A B C D E, whose Surface was cover'd over with a Multitude of small Hemispheres, placed with the utmost Regularity in Rows, crossing each other in a Kind of Lattice-Work.

That half of them C D E, C D E, which looked towards its Legs, were

* *Derham's Ph. Th. p.* 171.

observed



Front.[9] Pag. 58.

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obferved to be fmaller than the other half A B C E, A B C E, which looked upwards and fideways. The Surface of thefe Hemifpheres were fo exceeding fmooth and regular, that in each of them Mr. *Hook* was able to difcover a Landfcape of thofe Things which lay before his Window, Part of which was a large Tree, whofe Trunk and Top he plainly faw. Alfo the Motion of his Hand and Figures, if moved between the Object and the Light. Thefe Rows of *Eyes* were fo difpofed, that no Object was vifible from his Head, but fome of thefe Hemifpheres were directed againft it: And further, that where the Trunk of the Body feem'd to hinder the Profpect, thefe Protuberances were elevated, fo that a *Fly* may be truly faid to have an Eye every Way. Thefe little Hemifpheres have each of them a minute tranfparent Lens in the Middle, each of which hath a diftinct Branch of the *optick Nerve* miniftring to it, and rendering it as fo many diftinct *Eyes*; fo that as moft Animals are binocular, *Flies*, *Beetles*, &c. are multocular, having as many Eyes as there are Perforations in their *Cornea* *. By which Means as other Creatures are obliged to turn their Eyes to Objects, thefe have fome of their Eyes ready placed towards Objects nearly all round them.

Two of thefe optick Nerves are reprefented as delineated by Mr. *Leeuwenhoek*, in Fig. 84. And in Fig. 85. are exhibited † a great many of them in a Clufter, as they appeared before the Microfcope, whereof that Part of them which was fituate next the Cornea is fhewn by the Letters N O P; it is alfo obfervable, that thofe Nerves, which were neareft to the Circumference of the *Cornea*, were fhorter than thofe next within them; and fo on, till they arrive at the *central Nerve*, which is the longeft of all.

The Number of the Pearls in this *Fly*, Mr. *Hook* reckon'd to be 14000. Mr. *Leeuwenhoek* computed 6236 in a *Silk-worm*'s two Eyes, when in its *Fly* State; 3181 in each Eye of a *Beetle*; and 8000 in the two Eyes of a common *Fly*.

Cut off the Eye of any *Fly*, and with a Pencil, and fome clean Water wafh out all the Veffels; thofe Veffels may be examined by the Microfcope, and then if you carefully dry the outward Covering, fo as not to let it fhrink, it will be rightly prepared for making Experiments; and upon viewing it, we fhall diftinguifh the numerous Protuberances or Hemifpheres divided from one another with a fmall Light, iffuing between them, and fix Sides to each. Mr. *Leeuwenhoek* having prepared an Eye in this Manner, placed it a little farther from his *Microfcope* than when he would examine an Object, fo as to leave a right and exact focal Diftance between it and the Lens of his Microfcope; and then look'd thro' both, in the Manner of a Telefcope, at the Steeple of a Church, which was 299 Feet high, and 750 Feet from the Place where he ftood; and could plainly fee through

* *Derh. Phy. Theo. p.* 372. † *Arc. Nat, Ep.* 111.

every little Lens, the whole Steeple inverted, tho' not larger than the Point of a fine Needle; and then directing it to a neighbouring Houſe, ſaw thro' Abundance of the little Hemiſpheres, not only the Front of the Houſe, but alſo the Doors and Windows, and was able to diſcern diſtinctly whether the Windows were open or ſhut.

An Eye of a *Fly* thus prepared, may be held between the Nippers for Examination. But the Head of any *Fly* is beſt ſeen when ſtuck upon one of thoſe Ivory Slips, or Pieces of Card, or Holly, with ſome ſtrong Gum Water, and applied to the Microſcope under the Silver Reflecter, which Slips may be held in the Nippers.

N. B. The Horns F F, the Feelers G G, the Proboſcis H H, and the Hair and Briſtles K K, ſhall be deſcribed in Sect. V. of this Chapter.

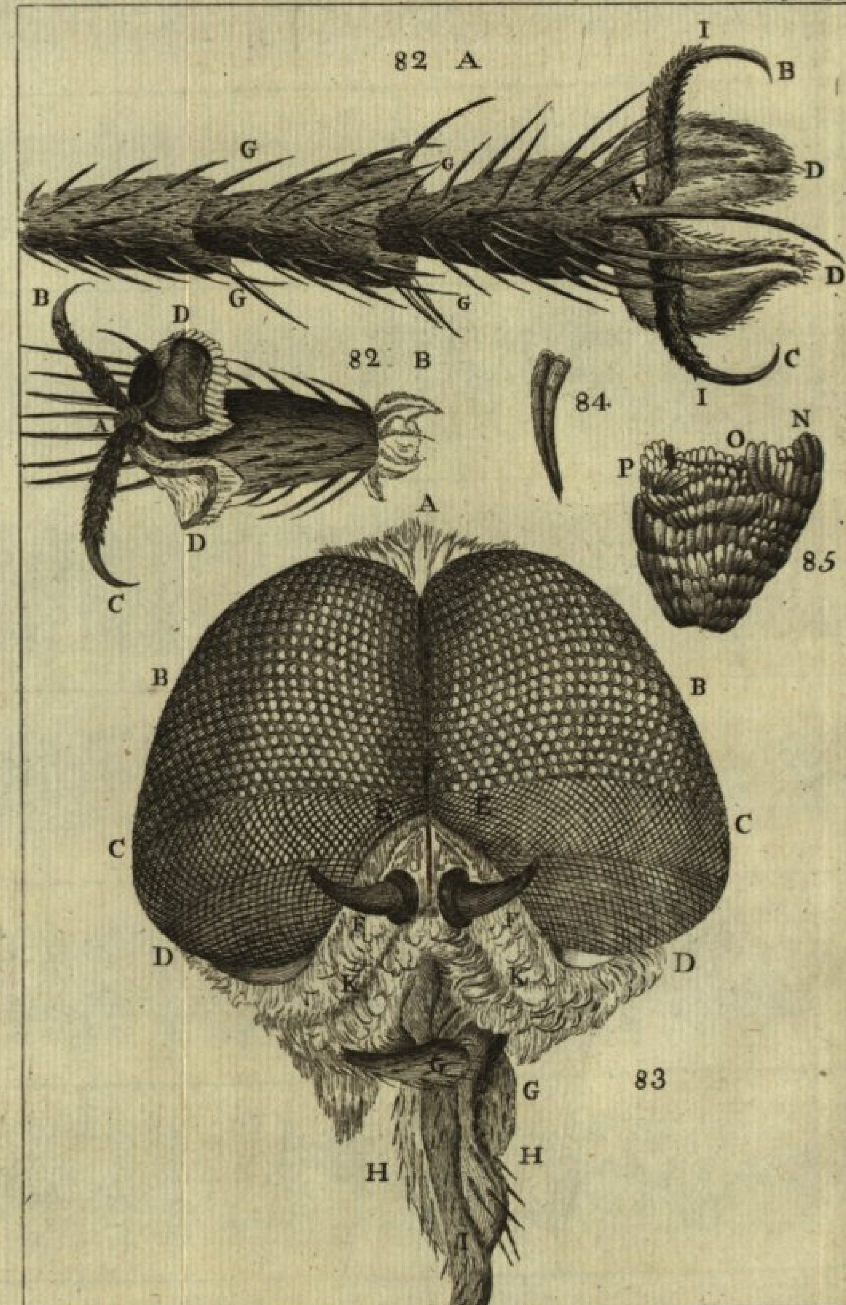
SECT. IV.

Of the Wings of Flies.

THE *Wings* of all Kinds of Inſects afford an infinite Variety, no leſs agreeable to the Mind, than pleaſing to the Eye; being diſtended and ſtrengthened by the *fineſt Bones*, and cover'd with the *lighteſt Membranes.* Some of them are adorned with neat and beautiful Feathers, and many of them provided with the fineſt Articulations and Foldings, for the Wings to be withdrawn, and neatly laid up in their *Vaginæ* and Caſes, and again readily extended for Flight.

This of the *blue Fly*, Fig. 86. here exhibited, is not without its peculiar Ornaments; it grows out of the middle Part of the Body of the *Fly*, and is ſeated a little beyond the Center of Gravity thereof, towards the Head; but that is curiouſly ballanced by the expanded Area of the Wing, which conſiſts of ſeveral *bony Ribs*, that give Strength to the filmy Parts; which are thickly beſet with innumerable ſmall Briſtles, intermixed with as many dark Spots, which ſeem to be the Roots of the Hairs that grow on the other Side.

Of other *Flies*, ſome of their *Wings* are *filmy*, as the *Dragon Flies*; others ſtuck over with ſhort *Briſtles*, as the *Fleſh Fly*; others have divided *Wings*, as the *grey* and *white feather'd Moths*; many Sorts of *Gnats Wings* are adorned with Rows of Feathers along their Ridges, and Borders of Feathers round their Edge; ſome have Hairs, and others Hooks, placed with the greateſt Regularity and Order. In the *Butterfly* and ſome *Moths*, there are an infinite Number of ſmall Feathers, which cover both the under and upper Surfaces of this thin Film, not only ſhaped much like the Feathers of Birds, but alſo variegated with the greateſt Variety of curious bright



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bright and vivid Colours; which is evident to the naked Eye, but much more entertaining when viewed thro' the Microſcope; by which we are informed, that theſe curious colour'd minute Feathers end in Quills, and are placed in orderly Rows with great Exactneſs, as the Holes they come from ſhew when they are rubb'd off.

Fig. 87. repreſents a ſmall Piece of a *Butterfly's Wing*; A B ſhews one of thoſe *bony Ribs* that gives it Strength, along whoſe Sides are ſuppoſed to branch out various *Blood-Veſſels*, conveying Nouriſhment to the intermediate Parts; although no Circulation can be diſcern'd therein, we can ſcarce doubt but that a continual Supply of Juices muſt be carried on to theſe minute Quills, Hairs, and Briſtles; C, C, C, exhibits three of theſe ſingle Plumes, with their Quills adhering to the tranſparent Membrane of the Wing, in which Membrane G, G, G, when diveſted of its Feathers, may be ſeen, the Order of Pits or Holes where the Quills are rooted, and from whence they ſhoot, D, E, F, ſhews a few of the Feathers exactly in the Form as they cover the whole Wing.

Some *Flies* have Hairs, and all the Scarab Kind have Elytra, or Caſes into which their Wings are folded and preſerved, till they want to employ them, as in Fig. 110. ſome of theſe Caſes reach almoſt to the Extremity of their Tail, as in moſt Kinds of *Beetles*; and in others are very ſhort, as in the *Earwigg*. They do by a very curious Mechaniſm extend and withdraw their membraneous Wings. It is very curious to ſee them prepare themſelves for Flight, by thruſting out, and then unfolding their Wings; and again withdraw thoſe Joints, and neatly fold in the Membranes, to be laid up ſafe in their Elytra or Caſes; for which Service the Bones are admirably placed, and the Joints miniſtring thereto are accurately contrived for the moſt compendious, and commodious folding up of the Wings.

Mr. *Hook* hath obſerved the Motion of theſe filmy Wings in ſome minute ſpinning Flies, which naturally ſuſpend themſelves as if pois'd and ſteady in one Place of the Air, in which by a faint Shadow he could perceive the utmoſt Extremes of the vibrative Motion; which Shadow, while they endeavour'd to ſuſpend themſelves, was not very long; but when they endeavour'd to fly forward, it was ſomething longer; he alſo fixed the Legs of a Fly with Glew or Wax, upon the Top of the Stalk of a Feather, and then making it endeavour to fly away, was thereby able to view it in any Poſture; and found the Motion of the extreme Limits of the Vibrations, to be about the Length of the Body diſtant from each other; and concluded by the Sound, that the Wing was moved forwards and backwards with an equal Velocity, (and comparing it with a muſical String tuned Uniſon to it) the Vibrations whereof are ſo ſwift, that it is probable there are many hundred, if not thouſand Vibrations in one Second of Time, and ſuppoſes them the ſwifteſt Vibrations in the World; whence he reflects on the Quickneſs of the animal Spirits, which ſerve to ſupply this Motion.

It

It is obſervable that moſt Inſects are provided with a little Ball, * or Bladder under each Wing, fix'd at the Top of a ſlender Stalk, moveable every Way at Pleaſure; in ſome they ſtand alone, in others (as in the whole *Fleſh Fly* Tribe) they have little Covers, under which they lie and move; with theſe Poiſes, and ſecondary leſſer Wings, they obviate all the Vacillations of their Body, and poiſe it in Flight, as a Rope-Dancer ballances himſelf by his Pole loaden at each End with Lead.

If one of theſe be cut off, the Creature flies aukwardly for a while, and at laſt falls 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; Inſects that have four Wings ballance themſelves with the two leſſer ones.

The Wings of Flies are beſt applied to the Microſcope between two *Muſcovy* Talcs, in an Ivory Slider.

If with an Hair Pencil, or Point of a Penknife, you gently bruſh or ſtroke off ſome of the minute Feathers from the Wings of *Butterflies*, and ſome Sort of Moths; then breathe upon a ſingle Talc in one of your Sliders, and apply it to the Feathers, which ſeem only like a fine Duſt, they will immediately adhere to it; if upon their Application to the Microſcope they lie not to your Mind, wipe them off, and put on others in the ſame Manner, till they lie fair for Examination, then cover them with another Talc, and faſten them down with a Ring.

SECT. V.

Of a Blue Fly.

FIG. 86. repreſents a microſcopical Picture of this *Fly*; it has many Things about it worthy of Note; ſeveral of which are already deſcribed, *viz.* the Head, Eyes, Wings, and Feet.

The Cluſters of Eyes in this *Fly* are much ſmaller than that of the *Drone Fly* in Proportion to its Head. Between theſe two Cluſters of Eyes appear'd a ſcaly Prominency B, armed and adorned with black Briſtles, ſharp, and tapering, growing in Rows on either Side, and bending towards each other, formed a Kind of briſtly Arbor, which almoſt cover'd the fore Front; at the End of this Arch, and about the middle of the Face on a riſing Part C, grew two oblong Bodies D D, which through the Microſcope looked not unlike the Pendants of Lillies, and appear'd to be jointed on two ſmall Parts at C, each of which ſeem'd again jointed into the Front: Out of the upper Part of each of theſe Horns grows a Feather, or bruſhy Briſtle E E,

* *Der. Phy. Th. p.* 377.

on

on the under Part of the Face F F, were ſeveral of the former Sort of bended Briſtles; and below all is the Mouth, out of which grew the Proboſcis G H I; which by Means of ſeveral Joints, the *Fly* was able to move to and fro, and to thruſt in and out as it pleaſed. The End of this hollow Body, which was cover'd over with ſhort Hairs, ſeem'd bent at H, and the foremoſt Side of the bended Part ſlit into two Chaps * H I, H I. Theſe he could open and ſhut very readily, and when he ſeem'd to ſuck any Thing from the Surface of a Body, he would ſpread thoſe Chaps, and apply the hollow Part of them cloſe to it.

From either Side of the Proboſcis, within the Mouth, grow two ſmall Horns K K, which were hairy and ſmall in this Figure, but of another Shape, and bigger in Proportion in Fig. 83. where they are marked G G, which two are generally called, the Antennæ or Horns of Inſects; Mr. *Derham* imagines them to be abſolutely neceſſary to the ſearching out and finding their Way, † as their Eyes are immoveable; ſo that no Time is requir'd for their turning them to Objects; there is no Neceſſity that the Retina, or optick Nerve, ſhould occaſionally be brought nearer to, or removed farther from the Cornea, as it is in other Animals; but their Cornea and optick Nerve being always at 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, as ſome have imagined, is the particular Uſe of the Feelers, and is apparent from the *Fleſh Fly*, and many other Inſects, which have their Antennæ ſo ſhort and ſtreight, as not to be capable of being bent unto, or extended over the Eyes.

The middle Part of this *Fly* was caſed with a firm Coat of Armour, the upper Part of which was thickly beſet with conical Briſtles, pointing backwards; from its under Part ſprang ſix Legs, three of which are apparent in the Figure at M, N, O; they were all of the ſame Structure, being cover'd with an hairy Shell, and compoſed of eight Joints, to the laſt of which grew the *Soles* and *Claws* before deſcribed in Page 57. From the upper Part of the Trunk grew the two Wings, which are deſcribed Page 60; the hinder Part of his Body was of a moſt curious ſhining Blue, and exactly like poliſhed Steel, brought to that Colour by Nealing.

The lamellated *Antennæ* of ſome, the cavelated of others, the neatly articulated of others, and the feather'd or tufted of others, are exceedingly 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, are *Males*; and thoſe with ſhort ſingle ſhafted *Antennæ*, are *Females*.

* *Hook's Mycro. p.* 183. † *Derham's Phy. Theo. p.* 372. ‖ *Derham's Phy. Theo. p.* 373.

Flies

Flies of any Kind may be examined in the Microſcope, by ſticking them upon the Point, or pinching any Part of them between the Nippers, and ſo applied to the Magnifier under the reflecting Concave, if it be opake. And if you are deſirous to keep its Head, or any other Part, it may be ſtuck with Gum Water upon a Piece of Card, or upon one of thoſe Ivory or Holly Slips, mentioned before in Page 31.

It is very obſervable, that *Inſects* take particular Care to depoſite their *Eggs* or *Seed* in ſuch Places, where they may have a ſufficient *Incubation*, and where the Young, when hatched, may have the Benefit of proper Food till they become able to ſhift for themſelves. Thoſe whoſe Food is in the *Water*, lay their Eggs in the Water; thoſe to whom *Fleſh* is a proper Food, in Fleſh; and thoſe to whom the *Fruits* or *Leaves* of Vegetables are Food, are accordingly repoſited, ſome in this Fruit, ſome in that Tree, and ſome in that Plant, and ſome in another, but conſtantly the ſame Kind in the ſame Tree, *&c.*

As for others that require a more conſtant and greater Degree of Warmth, they are provided by the parent Animal with ſome Place in or about the Body of other Animals; ſome in the Feathers of Birds, ſome in the Hair of Beaſts, ſome in the Scales of Fiſhes, ſome in the Noſe, ſome in the Fleſh, nay ſome in the Bowels and inmoſt Receſſes of Man, and other Creatures. And as for others, to whom none of theſe Methods are proper, they make them Neſts by Perforation in the Earth, in Wood, in Combs, and the like, carrying in, and ſealing up Proviſions that ſerve both for the Production of their Young, and for their Food when produced.

In *Flies*, *Butterflies*, &c. it is obſerved there is a kind of Gluten, by which the Female faſtens her Eggs to the bearing Buds of Trees, *&c.* ſo that the Rains cannot waſh them off, nor the ſevereſt Froſt hurt them.

Sect. VI.

Of Inſects that infeſt Fruit and other Trees.

THESE *Inſects* are of the Ichnumon Fly Tribe, that generated in the Plumb, is black, of a Middle Size, its Body near $\frac{1}{10}$ths of an Inch long, its Tail not much leſs, conſiſting of three Briſtles, wherewith it conveys its Eggs into Fruit, its Antennæ long, ſlender, recurved; its Belly longiſh, tapering, ſmall towards the Thorax, Legs reddiſh, Wings membraneous, thin and tranſparent, in Number four.

The *Bloſſoms* of *Apples* and *Quinces* are infeſted with Multitudes of ſmall Animals, ſo likewiſe are the green Leaves of *Gooſe-berry*, *Currant*, *Cherry*, *Grape*, *Plumb*, and other *Trees*, overſtock'd with infinite Numbers of theſe minute Flies. Some blackiſh, others green, ſome winged, others without

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Wings; ſeveral of which bring forth their Young alive and perfect; for if their Bodies be opened, ſeveral imperfect Embrio's may be found therein. Alſo Inſects of a greeniſh Colour of the Shape of Fig. 88. but no bigger than a Grain of Sand when firſt hatched, which at full Growth appear to the naked Eye of the Size of Fig. 89.

Theſe little Inſects *Leeuwenhoek* calls *Pediculus*, * or *Louſe*, who on plucking a Leaf from a *Plumb-tree*, and putting it into ſuch a Glaſs Tube as is deſcrib'd Page 30, which he applied to his *Microſcope*, and found thereon 36 black Flies, and ſeveral hundred of theſe *green Lice*, and among them many which were but juſt hatched. In a ſhort Time theſe green Lice died, and from their Carcaſe came forth a black Fly. Fig. 88. repreſents the Carcaſe of one of the *green Lice* as it appear'd before the *Microſcope*. The Shell or Skin of its Back had ſeveral Rows of Knobs upon it; its Eyes A B were like thoſe of other Flies; C D ſhew its two Antennæ articulated and ſet with Hairs. E F G H I K ſhew the Legs, having at their Extremity two hooked Nails, and ſhort Hairs. L M repreſents the Aperture, from whence came out the Worm, from which the Fly was produc'd, having firſt eaten up all the Inſide of the Body of the *green Louſe*.

Fig. 90. exhibits one of theſe minute *black Flies* thus produced from a Worm, which had increas'd itſelf by deſtroying its foſter Parent, and then changed into a Nymph, and at laſt from that to a Fly, furniſhed with all thoſe minute Organs as are expreſſed in the Figure; whereof A B ſhews its two Eyes, C D its Antennæ, which afford a pleaſant Sight in the *Microſcope*, its curious Joints being finely beſet with Hairs.

E F are two Organs, through which it ſucks its Nouriſhment, its long Tail G H I, K L M N, its four Wings bedeck'd with exceeding fine Hairs and a much finer Membrane, O O O O O O its ſix Feet, which were alſo furniſhed with many Joints, and thickly ſet with Hairs. The Letters P Q R expreſs the Point of the Nippers which held the Fly before the MICROSCOPE. Theſe Lice are alſo to be found upon the Leaves of *Filberd-Trees*, with this Difference, the former being *green*, and the latter *white*.

Upon the *Leaves* of *Apples* and other *Trees* are found a curious *Fly*, † the exquiſite Make and Form of its Parts are not to be diſcerned without a *Microſcope*, Fig. 91. repreſents the Size and Shape it appears of to the naked Eye. And Fig. 92. a Part of its Head, whereof A B are its two protuberant Eyes, C D E its Snout, furniſhed with various Forceps or Teeth, with which it perforates the Buds of Fruit and Flowers; this Snout is flexible and capable of bending every Way, C F and D G are the two Horns which adorn the Snout. Fig. 93. is almoſt a fourth Part of the Leg of this Fly, which conſiſts of four Joints. H I are two Nails which appear

* *Arc. Nat. Ep.* 135. † *Leeu. Ex. & Con. Epiſt.* 89.

in the Microſcope, as Horn does to the naked Eye, and K L ſhews its two ſkinny *Palms* or *Soles*.

There is another Sort of Animalcule found in the Wrinkles and wreathed Curls of *blighted Leaves* *, and in the *Extremity* of the *Sprouts* of *Leaves*, as in Garden *Currants*, *Cherries*, *Peaches*, *Nectarines*, &c. may be found great Swarms of theſe minute Inſects, no bigger than an half-grown Louſe, one of which is repreſented by Fig. 94. of its full Growth, and of the Size it appear'd of to the naked Eye. Fig. 95. ſhews the ſame magnified and near its laſt Change, the folded Wing juſt beginning to appear at A B. It had ſix ſmall jointed Feet, fenced with ſhort Hairs, and two Nails on each; C ſhews one of its Eyes, which was of a ſurprizing Make. D F repreſents the Proboſcis, with which it perforates the Leaves and Buds of Trees, and then thruſts out its Dart E and ſucks their Juice. From its Tail proceeds two upright Parts G H, out of which a tranſparent Liquor is frequently diffuſed as at H. I K L is the Needle's Point, upon which the Animal was ſtuck; and Fig. 94, as before hinted, the ſame Animal when changed into a Fly.

Mr. *Derham* could never obſerve any other kind of Fly but the leſſer *Phalenæ* † about $\frac{4}{10}$ of an Inch long to be bred in *Pears* and *Apples*; it is whitiſh underneath, greyiſh brown above, ſpotted about one Third with Waves of a Gold Colour, its Head ſmall, a Tuft of whitiſh Brown on its Forehead, and Antennæ ſmooth. The Aurelia of this Moth is ſmall, of a yellowiſh Brown.

SECT. VII.

Of Excreſcencies growing on Willow-Leaves, and a ſmall Fly bred thereon.

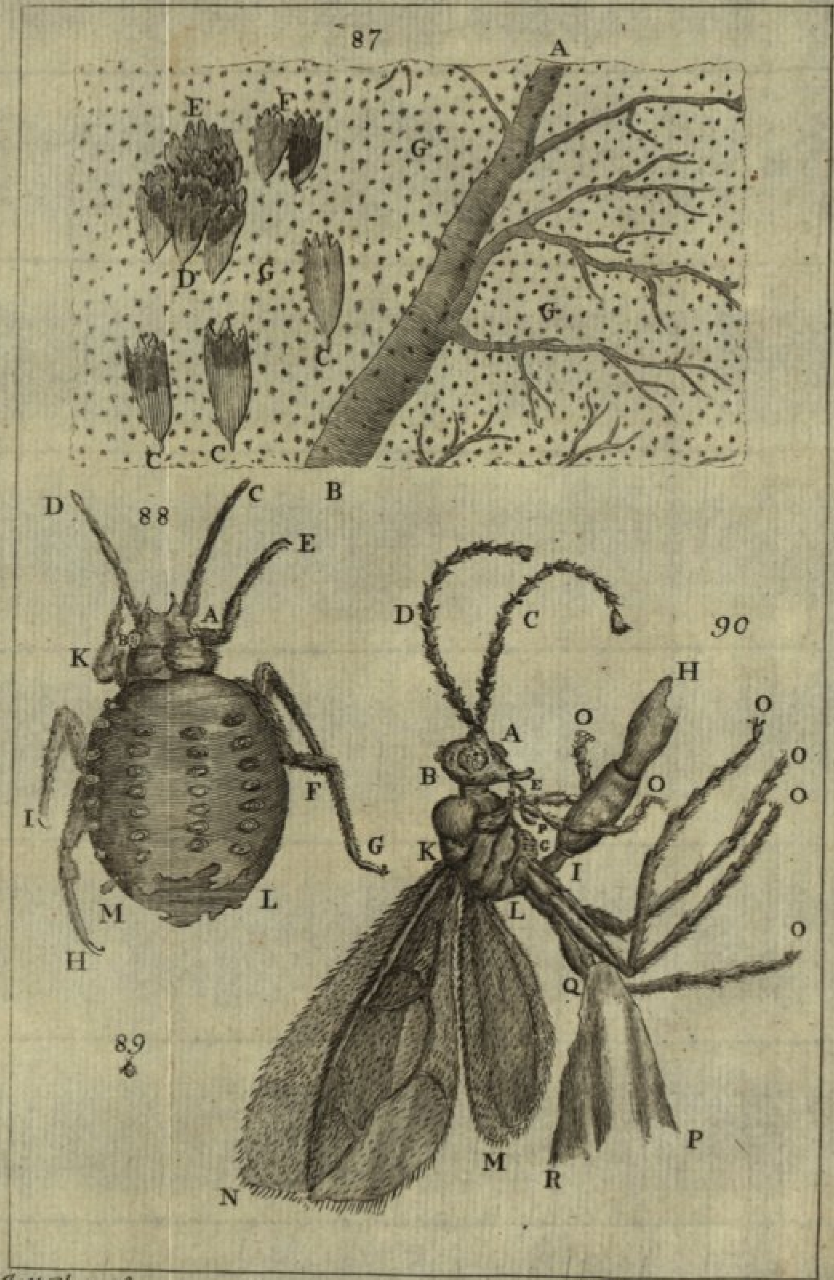
MR. *Leeuwenhoeck* frequently diſcovered more than one Sort of Worm upon opening the knotty Part of *Willow-Leaves*, and having put ſeveral of theſe Knots, whoſe contain'd Worms were not full grown, into a large Glaſs Tube, that the Worms might attain their full Growth, could not find that any of them did ſo; obſerving at the ſame Time ſeveral of theſe Knots to have none of the Worms in them, but almoſt full of the Excrements of the Worms which had been therein, and were diſlodged, through a ſmall Hole he could perceive in the Knots.

Fig. 96. A B repreſents a *Willow Leaf*, in which are ſeveral *Excreſcencies*, ſome of them with Holes as F, others as C D E; G H ſhews two of theſe Knobs cut open, and the Poſture of the Worm therein, ſeveral Worms lay dead

* *Leeu. Ex. & Con. Epiſt.* 90. † *Ph. Theo. p.* 387.

in

Pl. 20.



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in the Knobs ſuppoſed to be killed by other leſſer Worms, produced from an Egg depoſited by another Fly ſince the Production of the former, which devoured and lived upon the larger Worm.

In the Middle of *July* Mr. *Leeuwenhoeck* cropt ſeveral *Willow-Leaves*, in which were ſuch like Knobs *, and diſcovered ſeveral Worms nearly arrived to their full Growth: After theſe Knobs had been in the Glaſs Tubes about eight Days, upon opening one of them he found, that the Worm was turned into a *Tonnekin* or *Aurelia*, and in ſome others 13 or 14 more of the ſame; in ſome of the Knobs he found the ſmall *devouring Worms* above-mentioned, being ſo far advanced in Growth that they were ready to be chang'd into flying Inſects; he put theſe alſo into Glaſs Tubes. After ſome Weeks certain *black Flies* proceeded from thoſe Tonnekins, their hinder Parts of an oblong Figure, and faſhioned like a Hook. He alſo ſaw two of theſe ſmall Worms (which devoured the large ones) endeavouring to encloſe themſelves in a Web; but by reaſon of the large Space in which they lay, could not bring it quite round them, having made it only on one Side, and their Change happened in ſo ſhort a Time that he could not make his Remarks thereon.

Fig. 97. repreſents the aforeſaid Fly as it appears to the naked Eye. A B ſhews the long, ſlender and hooked Part; on examining this little Inſtrument in the *Microſcope*, it appear'd to be hollow, and was cover'd with a great Number of fine Hairs, as in Fig. 98. and on endeavouring to ſplit it, the Dart, Fig. 99. appear'd, whoſe Point is only jagged with ſaw like Teeth, which being alſo ſplit, two other diſtinct Hooks † were taken out of it both of the ſame Shape, a ſmall Part of one of them is repreſented by Fig. 100. each of them being fortified with ſaw-like Teeth, and the Dart Fig. 101, was found to be only a ſecond Caſe or Sheath for the two Hooks, wherein the Hollowneſs does plainly appear, which is filled with a corroſive Water. The Fly makes uſe of this Auger to prepare a convenient Lodgment for her Eggs (and chooſes thoſe Leaves that are moſt lacteous and juicy) under the Skin of the Leaf, from whence the Worm upon gnawing the Veſſels for its Suſtenance, occaſions the Sap to flow out of them and to coagulate into that knotty Subſtance. Mr. *Leeuwenhoek* took a ſmall devouring Worm from a larger that lay dead by it, and put it upon a living one to which it immediately faſtened, whilſt the other at the ſame Time uſed all Means, by bending, ſtretching, contracting, and winding its Body, to free itſelf from this troubleſome Gueſt, but in vain, the ſmall one ſtill keeping its Hold.

Fig. 102. exhibits a *Tonnekin*, which was a Worm but the foregoing Evening, and had caſt off a very thin Skin, this alſo conſiſted of ſeveral Rings and Circles as when in the Worm State. The Feet and Joints there-

* *Ph. Tranſ. No.* 269. † *Arc. Nat. Epiſt.* 136.

of were very viſible; A B and A C repreſents its two Antennæ; and although they were incloſed in a thin Membrane, yet all the Joints might be clearly ſeen. The Change of this Worm was ſo ſudden, that Mr. *Leeuwenhoek* was never able to ſee it.

Not only the *Willows* and other *Trees*, but Plants alſo have Caſes produced on their Leaves, as *Nettles*, *Ground Ivy*, &c. by the Injection of the Eggs of an *Ichneumon Fly*. Theſe Caſes are generally obſerved to grow near to ſome Rib of the Leaf, and their Production thus. The Parent Inſect with its ſtiff ſetaceous Tail, terebrates the Rib of the Leaf when tender, and makes way for its Egg, into the very Pith or Heart thereof, and probably lays in therewith ſome proper Juice of its own Body to pervert the regular Vegetation of it. From this Wound ariſes a ſmall Excreſcence which (when the Egg is hatched into a Maggot) grows bigger and bigger, as the Maggot increaſes, ſwelling on each Side the Leaf between the two Membranes; and extending itſelf into the parenchymous Part thereof, until it grows as big as two Grains of Wheat; in this Caſe lies a very ſmall white rough Maggot, which turns into a beautiful green ſmall Ichneumon Fly.

SECT. VIII.

Of the Crane-Fly, or Father Long-legs.

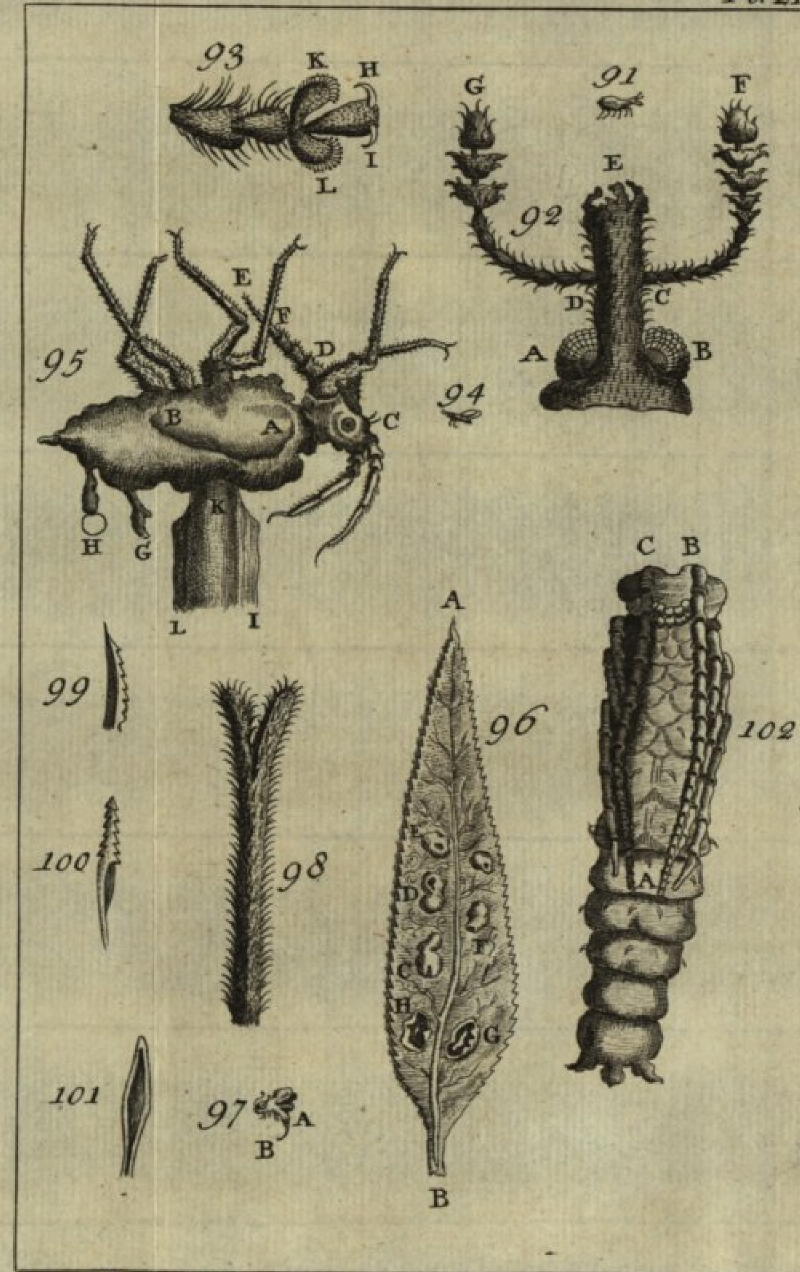
THIS little Creature, though but ſeldom taken Notice of, affords an agreeable Variety of Subjects, when examined by the *Microſcope*. It is produced from a Worm hatched in an Egg, depoſited by its Parent under the Graſs in Meadows.

Theſe Worms are to be met with but in the hot Weather upon the Ground under the Graſs in the Meadows and Fields. Fig. 103. repreſents one of them, which could not be diſcerned to change or increaſe between the Months of *May* and *Auguſt*.* Fig. 104. ſhews the Worm changed into a Nymph, and at its firſt coming forth greatly agitated. Fig. 105. ſhews the caſt-off Skin, which in its Change the Worm forſook, after which it took Wing and flew away in the Form of Fig. 106. which repreſents one of theſe male Flies, as does Fig. 107, alſo ſhew the *Female*.

The Tails both of the Male and Female are of a curious Structure, that of the Female is ſharp, and of the Conſiſtence of Bone, wherewith ſhe perforates the Ground, and depoſites her Eggs under the Graſs in a moiſt Place. This acute Tail of the Female is ſhewn at N, Fig. 107. which ſhe can open into four diſtinct Parts †. Upon opening one of theſe Females

* *Leeu. Ex. & Contemp. p.* 347. † *Leeu. Ex. & Contemp. p.* 349.

Mr.



Front.^g Pag. 68.

Bowles sc.

Mr. *Leeuwenhoek* counted upwards of 200 Eggs of a blackiſh Colour and ſmooth, like poliſhed Glaſs, and about twice as long as they were thick. The Inteſtines of this little Creature are alſo very curious, which when opened with unſpeakable Admiration he ſaw them by the Aſſiſtance of the *Microſcope*, as plainly as the Bowels in larger Animals can be ſeen by the naked Eye.

In the Feet of this Fly, if diſſected in a Drop of Water upon the Glaſs R, Fig. 2. of the *Univerſal Microſcope*, the fleſhy *Fibres* may be ſeen to diſtend and contract themſelves in a moſt ſurpriſing Manner, and to continue ſo for the Space of three or four Minutes. The Eggs alſo after Diſſection may be applied to the ſaid Glaſs, and eaſily examined by the Microſcope, or on dipping the Point of a very fine ſewing Needle (it being firſt fixed in a wooden Handle) into ſome Turpentine, and applying that to the Eggs, they will be glued thereto. The Needle itſelf muſt be held between the Nippers, and by its Handle may be turn'd round at Pleaſure.

It is very wonderful how ſo ſmall a Creature as ſome of thoſe newly hatched Maggots, that are found in the Ends of blighted Leaves, can be able to convolve the ſtubborn Leaf, and then bind it with the Thread or Web it weaves from its own Body, alſo to line the Inſide of it with the ſame, and ſtop up the two Ends thereof to prevent its own falling out.

In the Bodies of many *Caterpillars*, and other Nymphs of Inſects, are frequently found to be generated great Numbers of ſmall *Flies*, whoſe parent Animal had wounded the *Caterpillar* *, and darted its Eggs into it; and ſo made it the foſter Mother of its young.

Some Inſects lay up their Eggs in Cluſters, as in Holes of Fleſh, and ſuch Places, where it is neceſſary they ſhould be crowded together, which without doubt contributes towards the hatching †.

Other Inſects obſerve great Order in the Diſpoſition of their Eggs, which may be found upon the Poſts and Sides of Windows, very neatly laid, being round and reſembling ſmall Pearl, which Eggs produce a ſmall hairy *Caterpillar* ‖. The white *Butterfly* alſo lays its Eggs on Cabbage-Leaves, and always glues one certain End of them to the Leaf. If theſe Eggs be applied to the *Univerſal Microſcope* on the Glaſs R, Fig. 2. you will find them curiouſly furrowed and handſomely adorn'd.

The *Peaſe Ichneumon Fly* § is very ſmall, its Wings large, reaching beyond the *Podex*; Antennæ long, Alvus ſhort, ſhaped like an Heart, with the Point towards the *Anus*, it walks and flies but ſlowly. No Tail appears, but they have one concealed under the Belly.

Ichneumon properly ſignifies the *Egyptian* Rat **, which has its Name from

* *Ph. Th. p.* 390. † *Ph. Th.* 393. ‖ *Ph. Th. p.* 393. § *Ph. Th.* 387.
** *Philoſ. Tranſ.* No. 77.

its

its hunting or tracing out the Eggs of Crocodiles and Aſps: A like Obſervation made by ſome of the Ancients on certain Inſects of the Waſp-Kind, occaſioned the Application of that Name to Waſps, as well as the *Egyptian* Rat; there is but one Paſſage in all Antiquity concerning theſe Waſps, *viz.* in *Ariſtot. de Hiſt. Anim. Lib.* 5. *c.* 20. which *Pliny*, *Lib.* 11. *c.* 21. hath render'd thus, *Veſpæ Ichneumones vocantur (ſunt autem minores quam aliæ) unum genus ex aranes perimunt, phalangium appellatum, & in nidos ſuos ferunt, deinde illinunt, & ex iis, incubando, ſuum genus procreant*; that is, the Waſps, called *Ichnumons*, and which are ſmaller than other Waſps, kill a Species of Spiders, called *Phalangium*, and carry them to their Neſts, after which they beſmear them, and by Incubation produce their own Species out of them.

There is alſo a certain *black* and curious *Fly*, which proceeds from the gouty Excreſcencies of the *Briar Stalk* *, with red Legs. Black, ſmooth jointed Antennæ, large Thorax, and Belly in the Shape of an Heart. It leaps like a Flea.

The *Excreſcencies* of the Roots of *Cabbages*, *Turneps*, and divers other Plants, have always a Maggot in them, not yet ſufficiently obſerv'd.

Caterpillars, and divers others Inſects, can emit Threads or Webs for their Uſe. In this their *Nymph State*, they ſecure themſelves from falling, by letting themſelves down from the Boughs of Trees, and other high Places, with one of theſe Threads, and ſecure themſelves in their Aurelia State, in Caſes of their own Weaving.

Some of the *Fly Tribe* are alſo endowed with this textrine Art, of theſe one Sort ſpins a long milk white ſilken Web as big as the Top of one's Finger, woven round bent Stalks of *Ribwort*, &c. in Meadows. The other is a Lump of many yellow ſilken Caſes ſticking confuſedly together on Poſts, under *Coleworts*, *&c.* theſe Webs contain in them ſmall whitiſh Maggots, which turn to a ſmall *black Ichneumon Fly*, with long capillary Antennæ, tan-colour'd Legs, long Wings, reaching beyond their Body with a black Spot near the Middle, the Alvus like an Heart, and in ſome a ſmall ſetaceous Tail. Some of theſe Flies are of a beautiful ſhining green Colour. The Flies coming from theſe two Productions are nearly alike.

Many of the *Ichneumon Waſps* † are remarkable for the Nidification and Proviſion of their Young. Thoſe which commonly have golden and black Rings round their *Alvi*, line the Cells they perforate in the Earth, lay their Eggs therein, and then carry into them Maggots from the Leaves of Trees, and ſeal them up cloſe and neatly; theſe Waſps have their Jaws not only very ſtrong but nicely ſized, curved, and ſet for gnawing, and ſcraping. Thoſe little Holes they perforate in the Earth and Wood, as well as the ſe-

* *Ph. Tb. p.* 250. † *Ibid. p.* 228.

veral

veral Parts of the Waſp itſelf, are a pleaſant Object for the Microſcope.

The Bearers of Fruit-Trees are full of Aſperities, and not ſo ſmooth on their Bark as the other Parts of the Tree are. If after Harveſt, and any Time in Winter, you view theſe Bearers in the Microſcope, their Cavities will be found to be full of Eggs, of an oblong Figure, and citron Colour, eſpecially in thoſe Years wherein the *Caterpillars* * have been numerous. Out of theſe they are hatched in the Spring. The Seaſons which uſually deſtroy them, are ſuch as come in with early Heats, before the coming out of the Buds and Bloſſoms, and on which a nipping froſty Air enſues, which ſoon kills them.

SECT. IX.

Of Oak Cones.

THESE *Cones* are to Appearance, perfectly like *Gems*, only bigger, being nothing elſe than theſe increaſed in Bigneſs, inſtead of Length. The Cauſe of this Obſtruction in the Vegetation is this, into the very Heart of the young tender Gem or Bud, (which begins to be turgid in *June*, and to ſhoot forwards towards the latter End of that Month, and the Beginning of the next) into this Bud the parent Inſect thruſts one or more Eggs, and perhaps not without ſome venomous † Ichon therewith; this Egg ſoon becomes a Maggot, and eats itſelf a little Cell in the very Heart or Pith of the Gem, which is the Rudiment of the Branch together with its Leaves and Fruit. The Branch being thus deſtroyed, or at leaſt its Vegetation obſtructed, the Sap that was to nouriſh it is diverted to the remaining Parts of the Bud, which are only the ſcaly Integuments, by this Means growing large and flouriſhing, becomes a Covering to the Inſect Caſe, as before they were to the tender Branch and its Appendage.

The Caſe lying within this Cone, is at firſt but ſmall, as the Maggot included in it is, but by Degrees, as the Maggot increaſeth, it alſo grows bigger, to the Size of a ſmall Pea, long and round, in the Shape of a long Acorn.

The Inſect produced from theſe Cones, hath four membraneous Wings, reaching a little beyond the Belly, articulated Horns, large Thorax, Belly ſhort and conical, Legs partly whitiſh, partly black, of a beautiful ſhining green, in ſome tending to a dark Copper Colour.

The *Aleppo Galls*, wherewith we make Ink, are no other than Caſes in which Inſects breed, which when they come to Maturity, gnaw their Way

* *Philoſ. Tranſ.* No. 237. † *Ph. Th. p.* 397.

out

out of them, which occaſions thoſe little Holes obſervable in them; See *Philoſ. Tranſ.* No. 245.

Of this Sort alſo are the little ſmooth Caſes, about the Size of large Pepper Corns, which grow cloſe to the Ribs, under oaken Leaves, at firſt of a bluſhing red, afterwards growing brown, hollow within, but an hard thin Shell without, in which commonly lies a rough white Maggot, afterwards transformed into a black *Ichneumon Fly*, that eats a little Hole in the Side of the Gall, and ſo gets out.

Some of theſe Balls are tender, as thoſe of a yellowiſh green Colour with a reddiſh Caſt, about the Size of a ſmall Muſket Bullet, growing cloſe to the Ribs, under Oaken Leaves, their Skin ſmooth with frequent Riſings therein, inwardly they are very ſoft and ſpongy; and in the very Center is a Caſe with a white Maggot therein, which becomes an *Ichneumon Fly.** This Gall is remarkable for the *Fly* lying therein all the Winter in its infantile State, and comes not to its Maturity till the following Spring. In Autumn and Winter thoſe Balls fall down with their Leaves to the Ground, in which the incloſed Inſect is fenced againſt the Winter Froſts, partly by other Leaves falling pretty thick upon them, and eſpecially by parenchymous ſpongy Walls, afforded by the Galls themſelves.

From the large Oak Balls, called *Oak Apples*, which grow in the Place of the Buds, out of theſe Galls, come another Species of *Black Flies*.

The gouty Excreſcencies in the Body, and Branches of the Black-berry Buſh, produce a ſmall ſhining black *Ichneumon Fly*, about a Tenth of an Inch long, with red jointed Horns, four Wings, red Legs, and a ſhort Belly. They hop like Fleas.

All theſe Inſects afford an entertaining and agreeable Variety when viewed through a *Microſcope*.

SECT. X.

Of an Inſect found upon the Leaves of Spices and in Woods of ſeveral Kinds.

MR. *Leeuwenhoek* diſcover'd upon the Leaves of ſome white Nutmegs, an *Animalcule* or minute Worm, which appeared to the naked Eye of the Size of Fig. 108. but is repreſented in Fig. 109. as it appear'd when placed before the *Microſcope*. Its Body was jointed in ſeveral Places, and thickly ſet with Hairs; it had ſix ſhort Feet, which end with a ſhining Nail, toothed like a Saw, as at A, B, C, D, the hinder Part of its Body was very full of Blood Veſſels, as appears at E, F, G, H.

* *Ph. Tb. p.* 400.

At

At I K are two ſhining Horns jointed and beſet with Hairs. At L are repreſented its Forceps, with which the Worm eats its Way into Leaves or Wood, *&c.* M N ſhew the two leſſer Horns which adorn the Head of the Worm. This Worm after ſome little Time was changed into a flying Inſect, as exhibited in Fig. 110. whereof L M, B N are its two Horns, which conſiſted of divers Joints and Hairs, B L its Eyes furniſhed with a Number of little *Lenſes*, as the Eye of the Drone Fly before deſcribed. It had alſo ſix Feet armed with *Talons*, as before ſhewn: Theſe Legs had ſeveral Joints, and were cover'd with Briſtles or Thorns, two of theſe Feet and Nails are ſhewn by the Letters C O, D P. D E, and K I repreſents the two Caſes or Shields under which the Wings are folded. Theſe Caſes are moſt curiouſly adorned with ſtrait Rows of Rings throughout their whole Length. The hinder Part of its Body is jointed as it were with hollow Notches, much after the ſame Manner as the Worm from which it was produc'd. If the Wing be conſidered, it will be found to conſiſt of ſeveral ſmall Veſſels or Nerves that aſſiſt in the Expanſion thereof. The exquiſite Neatneſs with which this minute Wing was folded under the Shields, is ſurprizingly beautiful, as appears between G H, with what wonderful Nerves muſt theſe minute Wings be ſtrengthned, that can enable this Inſect ſo readily to fold up the Extremity of this filmy Membrane in ſo neat a Manner, and to expand it again, as it were inſtantaneouſly, whenever it is inclined to fly? That the curious Folding of theſe ſort of Wings might be comprehended, Mr. *Leeuwenhoek* took off one of the ſhelly Caſes and placed the Wing before the Microſcope, which appeared as in Fig. 111. Q S T V W X Y repreſent the Wing as it lay cover'd under its Shield. It was broadeſt about V; the ſecond Wing, which I ſuppoſe to be its Ballance or Poize, is ſhewn at S T. The Extremity W X Y, ſhews thoſe neat Foldings before ſpoken of, which, together with the Strength of the Nerves, diſcover the Almighty's Wiſdom in their Contrivance.

I have found of theſe Inſect Flies in Summer-time flying about my Work-ſhop, and have obſerved them to anſwer all the above Deſcription. They are ſo ſmall, that I have applied them to the Microſcope in the Ivory Sliders, but they are better ſeen when applied in the Nippers V, of Fig. 2.

There is likewiſe a ſmall *Scarab* in the very Tips of *Elm-Leaves.** In the Summer many of theſe Leaves may be obſerved to be dry and withered, and alſo turgid, in which lies a dirty, whitiſh, rough Maggot, from which proceeds a *Beetle* of the ſmalleſt Kind, of a Weeſel-Colour; it leaps like a *Graſhopper*, although its Legs are but ſhort, black Eyes, Vaginæ thin, and prettily furrow'd, with ſeveral Cavities, ſmall dubed Antennæ, and a long Proboſcis.

* *Ph. Theo. p.* 251.

The ſame, or one much like this is found on the Tips of *Oak* and *Holly Leaves*.

The *Horſe-Fly* is alſo a curious Object, its Eye is in the Form of other Flies, but is as it were indented all over with a pure emerald Green, its Body like Silver in Froſt-Work *, fringed all over with white Silk. If the Head of this Fly be cut off juſt at the ſetting on of the Neck, a pulſing Particle may be ſeen beating through the Skin for half an Hour together.

The *Trunk* or *Proboſcis* of a *Butterfly*, which lies wound up like an Helix or ſpiral Spring, gradually growing ſlender as at Fig. 113, ſupplies the Office both of Mouth and Tongue, it may with a Pin be eaſily drawn out to its full Length, if it be cut off and laid upon the Object carrying Glaſs R, of Fig. 2. and ſo applied to the Microſcope you will ſee it wind and coil † itſelf up, and then to open itſelf again for a long Time together, Nature having made it of a ſufficient Length, that when extended it may reach into the Hollows of Flowers, and from thence extract their Dews and Juices. It conſiſts of two Tubes near its Extremity, as repreſented at A C, Fig. 113. the Cavities of which unite at D, and from thence to the Throat of the *Butterfly* form but one Channel ‖. Theſe tubular Extremities are unfolded in the Manner expreſſed at B T N, Fig. 114. in order to extract the Dews, *&c.* from Flowers; after which it is immediately drawn back and coil'd up into an Helix. M M, Fig. 115. repreſents one of the extreme Parts viewed with a greater Magnifier, and delineated exactly in the Manner as it is applied to Leaves and Flowers. Whence it appears, that it is not the extreme End of the Proboſcis, which extracts the Dews and Juices; but ſeveral Nipples D E F, that are applied to the Leaf A C, at the Points i i i.

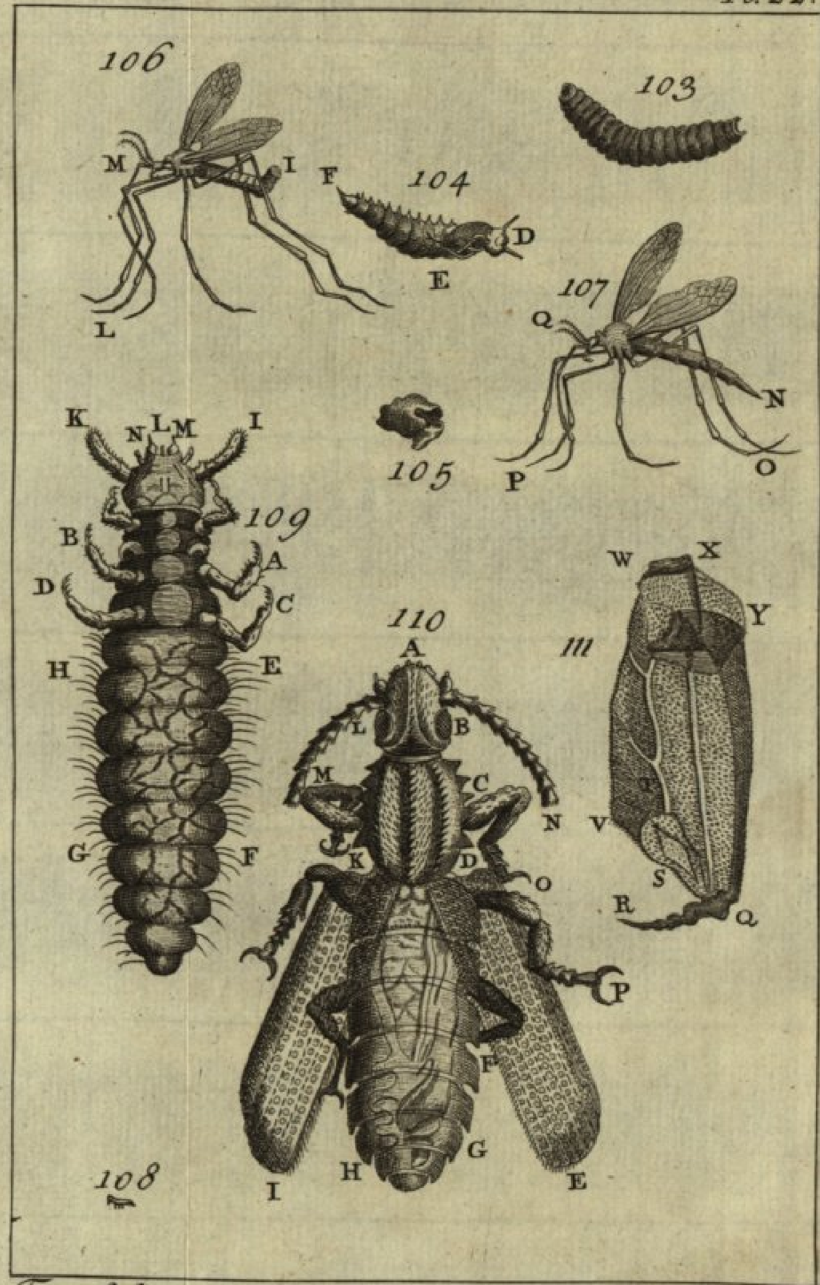
In all *Graſhoppers* there is a green Film or Plate (like a Croſlet) which covers the Neck and Shoulders; if you raiſe it up with a Pin you may ſee their *Heart beat* § for a long Time together. The *Graſhopper* is beſt held between the Nippers V, and ſo applied to the Magnifier.

There is a pretty Object, which is a white oblong Inſect that ſticks to the Back-ſide of *Roſe-tree Leaves* ** in *Auguſt*, of a perfect white, it changes into a ſmall yellow Locuſt, with two white Wings longer than its Body, and two Pointers in the Snout like a Pair of cloſed Compaſſes, and may be plainly ſeen when the Fly is laid upon its Back.

Upon the Backſide of the Leaves of *Gooſeberries*, *Sweet Briar*, and *golden Mouſe-ear* in *April* and the Beginning of *May*, is a greeniſh *Graſhopper* or *Locuſt* ††, which is a pleaſant Object; when placed before the *Microſcope* it hath two Horns and four Legs, and two curious black Eyes.

* *Power's Micro. Obſ. p.* 7. † *Ibid. p.* 8. ‖ *Microgra. de Bonan. Pars* 2. *p.* 48. § *Power's Micro. p.* 24. ** *Ibid. p.* 27. †† *Ibid. p.* 26.

On



Front.[9] Pag. 74.

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On *Sycamore Leaves* there is a yellow Inſect *, which at firſt hath no Wings, but ſix Legs and two Horns which are ſlit; it runs nimbly, the Eyes are globular and red, pearled and prominent; near the Shoulders are two Stumps, whence two long Wings come forth, when it changes into a Fly or Locuſt, it conſiſts of annulary Circles, and is hairy towards the Tail.

There is to be found a ſmall long black Inſect, creeping and leaping amongſt *Pinks*, *Gilly-Flowers*, *Roſe-leaves*, &c. with a *Waſp-like Body*, with ſix or ſeven annulary Diviſions; two curious Horns ariſing from a black knobbed Root, two fine long yellow Wings, black Eyes, and ſix black Legs, they are kill'd with the leaſt Touch imaginable; their Size is leſs than that of a Louſe: * They may be taken up with the Point of a Pin dipped in Spittle, and by that Means placed, or as it were glewed to a very ſmall Bit of Card, which may be applied to the Microſcope in the Nippers of Fig. 2. And ſtronger Inſects may be ſtuck to a larger Piece of Card with a Touch of Turpentine, and applied to the Magnifier in the Nippers as before.

On the *Froth*, which hangs on the *Leaves* of *Lavender*, *Horſe-mint*, *Roſemary*, &c. ‖ (by ſome called *Cuckow-ſpit)* is always found a little Inſect of a golden Colour; it hath ſix Legs, with two black Claws at the End of each, which it can open and ſhut at Pleaſure; its Eyes are pearled and of a duſky Red, a long reddiſh Proboſcis is ſituated between its fore Legs; its Tail had ſeveral annular Diviſions that ended in a Stump, which it could at Pleaſure thruſt out or draw back, it firſt creeps, then leaps, and at laſt flies.

The *Cow-lady*, *Lady-bird*, or *ſpotted Scarabee*, is a very nimble Animal; cut off its Head, and erect it perpendicularly upon the Neck (which may be faſtened to a Bit of ſoft Wax firſt ſtuck upon the Point, or by a Drop of Gum-Water upon a Piece of Card, which may be held in the Nippers, and ſo applied to the Microſcope) and you'll ſee two ſmall black Eyes ſet upon three white Plates like poliſhed Ivory, two ſmall ones on one Side, and a large one on the other; pull off both the cruſtaceous and filmy Wings, which are a Fence to a thin tender black Skin, under which the *Pulſation* of the *Heart* § may be ſeen to beat vigorouſly for 12 or 14 Hours, after the Head and Neck are ſeparated.

There is a *Fly* with *grey* and *black Streaks* on the *Shoulders* **, and *chequer'd* on the *Tail* with the ſame Colours; upon opening the Female of this Fly, which may be diſtinguiſhed by a Redneſs on the Extremity of the Tail, you will find two Bags of live white Worms **, long and round in Shape, with black Heads, moving both on the Hand and in the unopened Veſicles

* *Power's Mi. Ob. p.* 32. † *Ibid. p.* 31. ‖ *Ibid. p.* 28. § *Ibid. p.* 30. ** *Phi. Tranſ. No.* 72.

backwards and forwards, being diſpoſed in Cells according to the Length of the Animal's Body.

Sect. XI.

Of the Cochineal Fly.

THE *Microſcope* hath diſcovered to us that *Cochineal*, ſo valuable for its Uſe in dying *Crimſon*, *Scarlet*, and *Purple*, is an Inſect bred upon the Plant called *prickly Pear*, or *Indian Fig* †; and upon the Leaves or Twigs thereof are ſmall *Knobs* or *Protuberances*, which produce little Worms that in Time become Flies, reſembling *Cow-ladies*, or *Lady-birds*; which, when arrived at their full Growth, are taken by the Inhabitants (of the Iſlands of *Cuba*, *Hiſpaniola* and *Jamaica*, from whence it moſt commonly comes) and expoſed to the Heat of the Sun to dry, and rubbed between the Hands till their Wings, Legs, *&c.* fall off. Upon ſteeping ſome of the Grains of *Cochineal* 24 Hours in Water, a Trunk with Scales and Legs will appear; and if their Bodies be opened, many Eggs of different Sizes may be alſo found.

Fig. 116. repreſents a Grain of *Cochineal*; Fig. 117. another Grain, as it appear'd through a *Microſcope*, in which at the extreme Parts C and E F, an Orifice appears, from whence the String was broken off, whereby both Parts of the Body were joined together. The concave Arches D G, *&c.* are not natural, but adventitious to the ſame Grain, proceeding only from the drying or ſhrinking up of the great Number of Eggs that lie within the Animalculum; for if the ſame Grain was well ſoaked in Water, the concave Parts would become convex. Fig. 118. ſhews an Egg with its Membrane, as it was taken out of a Grain of Cochineal ſteeped in Rain-Water for about 24 Hours; in which might be ſeen the young one, and its Shell ſurrounding it. L M N, Fig. 119. repreſents one of theſe unborn Animalcula. Fig. 120, ſhews the Body of another *Animalcum* which was taken out of the Egg-ſhell, in which not only the Body was diſtinctly ſeen, but alſo the Parts thereof divided into ſeveral Circles, and likewiſe the two Horns with the Joints wherewith Nature hath provided all thoſe unborn *Animalcula*, were plainly viſible when placed before the Microſcope. B H, D I, and D K, ſhew its four Legs, the other two being hid from the Sight. F G repreſent the Horns, at the Extremity of each of which are three ſmall Hairs.

† *Phi. Tranſ. No.* 292.

Sect. XII.

Of the Death-watch.

THERE are two kind of Insects which make a regular clicking Noise like the Beats of a Pocket Watch; one of them called by *Swammerdam*, *Scarabeus Sonicephalus*, and the other called by Mr. *Derham*, *Pediculus Pulsatorius.*

The first of them is a small *Beetle*, about $\frac{5}{16}$ of an Inch in Length, * of a dark brown Colour, with Spots somewhat lighter irregularly placed. It is represented of its natural Size at Fig. 121. Under its Vaginæ are pellucid Wings, the Head large, by reason of a Cap or Helmet which covered it, only a little turned up at the Ears; under this appear'd its Head, which was flat and thin, the Eyes forward, the Lips hard and shining, the Bars of the Helmet greyish; two Antennæ proceeded from under the Eyes, the Head all hairy, and Face thick of curled Hair; on the Belly was a little Hair, but thinly set; its Eyes like those of a Fly. Fig. 122. is a Microscopick Picture of it; between the Eyes the Face rises in a little Ridge, which is the Nose; and just below it the Nostrils are covered with strait pendulous Hair, the Lip-shades shew the more depressed Places; under this Lip are four visible Forceps, two on each Side to lay hold on its Food. They make a Noise just like the Beats of a Pocket-Watch. Mr. *Derham* has often caused one of them to beat when he pleased by imitating its Beating, and this he kept in a little Box about three Weeks; and imagines, that these Pulsations is the Way these Insects woo each other, and invite to Copulation; and that it always draws back its Mouth, and beats with its Forehead †.

The other *Death Watch* is an Insect different from the foregoing, that beats only about seven or eight Strokes at a Time, whereas the former will beat some Hours together without Intermission, and its Strokes slower, and like the Beats of a Watch. It is a small greyish Animal, much resembling a Louse; for which Reason it is called *Pediculus Pulsatorius.* It is very nimble, but extremely shy when disturbed; it will beat freely enough before you, and also answer you when you beat, if you can view it without giving it any Disturbance, or shaking the Place whereon it lies. It is not certain whether they beat on any other Thing but Paper, their Noise being heard only in or near it.

Fig. 123. represents the second Sort of *Death Watch* ||, as it appears to the naked Eye. Fig. 124. shews it a little magnified; its Shape and Colour

* *Phil. Trans. No.* 245. † *Phil. Trans. No.* 271. || *Phil. Trans. No.* 291.

is not much unlike a Louſe; it is common in moſt Houſes in the warm Months, but in the cold Seaſon of the Year it hides itſelf in dry obſcure Places, and is ſeldom ſeen; ſome Time after Copulation, they lay their Eggs in dry duſty Places; they are much more minute than the Nits of Lice, of a whitiſh Colour, and are hatched by the Warmth of the approaching Spring, which to them is all the ſame as an Incubation: The Inſect is fully hatched, and can creep about at the Beginning of *March*, or ſooner if the Weather be warm; at their firſt quitting the Egg-Shell, they are ſo exceeding ſmall, as ſcarce to be diſcern'd, without the Aſſiſtance of a convex Glaſs: In this State Mr. *Derham* could find no other Difference between them and Mites in Cheeſe, when viewed with a Microſcope that magnified much, but only that Mites had more Briſtles about the Breech: In this Shape they continue ſix Weeks or two Months, feeding on divers Things they can meet with; after which they gradually increaſe towards their more perfect State, when they become like the old ones.

Mr. *Derham* has plainly ſhewn, that their ticking Noiſe is a wooing Act, and that it is commonly about *July*; * he never found them in *Coitu*, till about a Week or a Fortnight after their ticking; tho' it is probable they copulate at that very Time. He has ſeen the old *Death Watches* feed upon dead Inſects, as the young ones do, and alſo upon Biſkets, Tallow, *&c.* nay Duſt itſelf, and hath obſerved them thro' a Microſcope to ſelect ſome Grains thereof, and reject others.

CHAP. XVIII.

Of a Gnat.

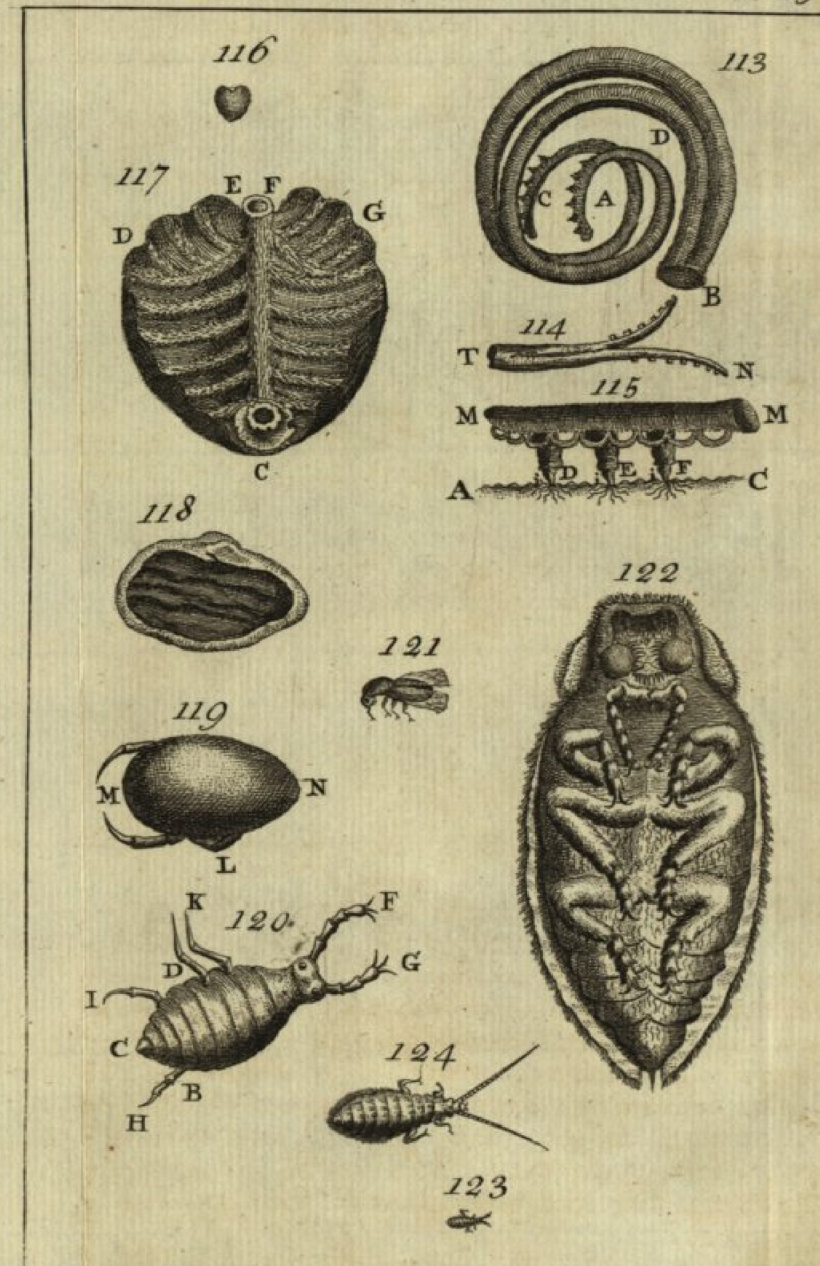
SECT. I.

THE firſt obſervable in the Generation of this Inſect, is its vaſt Spawn, ſome of them being $1\frac{1}{2}$ Inches long, and $\frac{1}{8}$ of an Inch broad, floating in the Water, but being made faſt to ſomething to prevent its being waſhed away; in this tranſparent Spawn the Eggs are neatly depoſited, in ſome a ſingle, in others a double ſpiral Line †, running from End to End, as in Fig. 125, and 126. and in ſome tranſverſly, as in Fig. 127.

When the Eggs are by the Heat of the Sun, and Warmth of the Seaſon, hatched into ſmall Maggots, theſe Maggots deſcend to the Bottom; and by Means of ſome of the gelatine Matter of the Spawn, which they take along with them, they ſtick to Stones, and other Bodies at the Bottom,

* *Phil. Tranſ.* No. 271. † *Phi. Theo. p.* 394.

and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and there make themſelves little Caſes or Cells, which they creep into, and out of at Pleaſure, till they arrive at a more mature Nymph State, and can ſwim about here and there in Queſt of Food; at which Time they are a Kind of red Worms about half an Inch long, but of the Shape of Fig. 128.

It has a very large Head, in Proportion to its Body, which is all covered with a Shell; ſeveral Tufts of Hair on ſeveral Parts, two Horns, a large Mouth, *&c.* The Form of the whole Creature will be better perceiv'd by a Deſcription of Fig. 128. the hinder Part or Belly conſiſts of eight ſeveral Joints. From the Midſt of each of which, on either Side, iſſue out three or four ſmall Briſtles. The Tail was divided into two Parts, very different in Make; one of them A, had ſeveral Tufts of Hair or Briſtles, with which it could ſteer itſelf as it pleaſed, and was enabled to ſwim about by Curvations and flapping its Body ſideways, this Way and that, and keep itſelf near the Surface of the Water: The other Part B appeared to be the ninth Diviſion of its Body, and on each Side had many ſingle Hairs. From the Part C to the Head, appeared a darkiſh colour'd Gut, through which the periſtalſtick Motion was very diſcernable. The Cheſt D E of this Creature, was thick and ſhort, and ſo tranſparent, that its white Heart could be ſeen to beat: Its Cheſt was ſtuck with ſeveral Tufts or Briſtles, and the Head was alſo adorn'd with the ſame, it had two black Eyes, and two ſmall Horns F G.

Both the Motion and Reſt of this Creature are ſurprizing and pleaſant. The Tail ſeems much lighter than the reſt of its Body; and being a little lighter than the Water in which it floats, buoys it up to the Top thereof, where it hangs ſuſpended with its Head downwards; they lift their Heads ſometimes into the Air, at other times plunge them into the Water, their Tails all the while ſliding along its Surface.

After having lived in this Manner the Time which Providence has allotted them, a ſtranger Change ſucceeds; they appear in Form of Fig. 129. and then they caſt off their whole Skin, Eyes, Horns, and Tails; and iſſue forth as Inſects of a quite different Element: The moſt beautiful and elegant Plumage adorns their Heads; their Limbs are of the fineſt Texture; their Wings are 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 drown'd if it were plung'd therein.

It is very probable, that many Sorts of the Animalcules in Fluids undergo ſome ſuch like Change.

SECT.

SECT. II.

Of the Tufted, Brush-horn'd, or Male Gnat.

ITS surprizing and particular Beauties are only to be discover'd by the MICROSCOPE; and is exactly of the Shape of one of those which Mr. *Hook* observed to be generated out of one of the little watery Insects just described.

Nature has adorned it in a most surprizing Manner: Its Head A is exceeding small in Proportion to its Body, which consists of two Clusters of pearled Eyes, Fig. 130. curiously ranged like those of other Flies; between which, upon two blackish Balls, are placed two long jointed Horns D, tapering towards the Top; from whence issued out in a circular Manner, Multitudes of small stiff Hairs from its several Joints, exactly resembling the Sproutings of the Herb *Horse-Tail*. There are also two other jointed and bristled Horns or Feelers D. And a Proboscis F, underneath which is the Sucker or Sting, which in some *Gnats* is very long. This small Head, with its Appurtenances, is joined by a short Neck to the Thorax G, which is large, and as it were cased with a black Shell; out of its under Part proceeded six long slender Legs H H, *&c.* much like those of other Flies, but longer and slenderer, which are not expressed in the Figure, because of their great Length. From the upper Part proceeds two long slender transparent Wings, shaped somewhat like those of a Fly; underneath which, as is observable in many Sorts of Flies, are placed two small Bodies, which are its Ballances or Poises. Its Belly large, and extended into nine Partitions, each being armed with Rings of Shells; six of which were so transparent, that the peristaltick Motion was plainly visible. A small clear white Part at I, seem'd to beat like the Heart of a larger Animal; the three last Divisions of the Tail were cover'd with opake Shells.

SECT. III.

Of the great belly'd or Female Gnat.

ALthough this *Gnat*, as represented in Fig. 131. differs from the former in Shape, yet this Sort also has been found to be generated out of the Water Insect before described: Its Wings were larger than those of the other; its Belly bigger and shorter; its Thorax not much unlike that of the other, having a strong rigid back Piece and Breast Plate; its Head larger and neater shaped; the Horns, that grew out of those two little Balls,

Balls which were between its Eyes, was of a different Shape from the Tufts of the other Gnat; theſe having but a few Knots or Joints and a few ſhort Briſtles; the foremoſt Horns or Feelers like thoſe of the former.

In different Species of *Gnats* their Wings are alſo different; ſome having a Border of long Feathers, others of ſhort ones, and others none at all: The Rib-work of the Wings is feathered in ſome and ſcaled in others, and in ſome beſet with Prickles.

Mr. *Hook* ſuffered one of theſe *Gnats* to pierce the Skin of his Hand, and thence to draw out its Fill of Blood, which made it appear very red and tranſparent, and this without any further Pain, than whilſt the Sting was entering; a good Argument that theſe Creatures do not wound the Skin out of Revenge, but for mere Neceſſity to ſatisfy their Hunger.

This Piercer, Sting or Sucker, as repreſented by F G H I, Fig. 132. is a Caſe cover'd with long Scales and Hairs; it lies concealed under the *Gnat's* Throat, when not made uſe of; but when it is, the Side G H opens, and four Darts are thruſt out therefrom occaſionally; one whereof H K (minute as it is) ſerves for a Caſe to the other three; the Sides of which towards the Point K are barbed or indented. F I ſhew that Part of the Sting where it was cut off from the Gnat's Throat.

Fig. 133. repreſents Part of the ſecond Sheath, whoſe Sides near the Top are barbed, but not here expreſſed. This alſo opens Side-ways for a Paſſage to the three included Stings.

Fig. 134, ſhews all the Parts of the Stings wherein two of the interior ones might be ſeen barbed and indented towards the Point; their Fineneſs is almoſt inexpreſſible, they have three Sides, as repreſented in Fig. 135, whoſe Edges ſeemed to join alternately (which when ſo united reſemble a three edged Sword, or Dagger.) Fig. 136, ſhews another Part of one of thoſe interior Stings, which is remarkably ſmall and ſomewhat curved. Its Top on the plain Side is ſhewn at Fig. 137. which Top is repreſented in another Poſition, Fig. 138. A. and in the Poſition of B its Hooks might be ſeen. 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 therein. Upon Diſſection many curious Things may be diſcovered, *viz.* numberleſs Animalcules in the Semen of the Male *, and in the Female a ſurprizing Quantity of Eggs.

* *Arc. Nat. Tom.* IV. *p.* 22.

There is a kind of *Gnat* which lays its Eggs frequently in dead Beer, *&c.* and ſome Time after this the Maggots are ſo numerous, that the whole Liquor ſeems to be alive, being full of Maggots; the larger Sort being the Offspring of this Gnat *; and the ſmaller that of a ſmall dark coloured Fly, tending to a reddiſh Colour, frequent in Cellars and ſuch obſcure Places; they turn to Aurelia, and the larger Sort from that to a Gnat of a brown Colour. The chief Difference between the Male and the Female is, that the Male is leaſt, hath a ſlenderer Belly, and its Podex not ſo ſharp as the Female's is. This Gnat hath no Spear in its Mouth.

Theſe Inſects may be applied to the *Univerſal* MICROSCOPE, by pinching them between the Nippers, or ſticking them upon the Point; their Stings when cut off may be beſt examined upon the Glaſs R of Fig. 2. when placed between the Object-Plate and Springs.

CHAP. XIX.

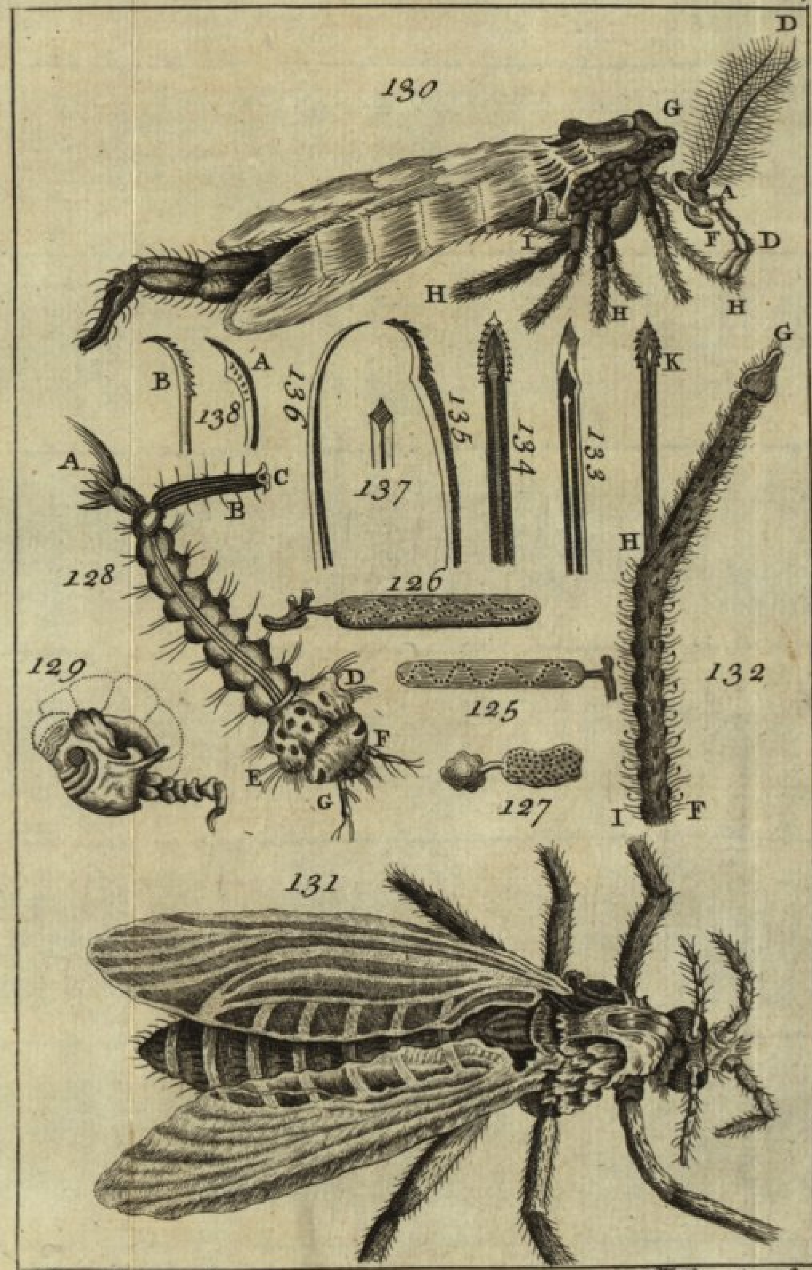
Of the white feather'd winged Moth.

SECT. I.

IT appears to the naked Eye to be a ſmall milk-white *Fly* with four Wings, the two foremoſt ſomewhat longer than the hindermoſt, and theſe about half an Inch in Length, each of theſe Wings conſiſts of two Feathers, as repreſented in Fig. 139, very curiouſly tufted or hair'd on each Side, with exceeding white but minute Hairs; its whole Body, Legs, Horns, and Stalks of the Wings were cover'd over with various Kinds of white Feathers, which rub off between the Fingers when touched. Underneath theſe Feathers this curious Inſect was covered all over with a cruſted Shell. It had alſo different Feathers, that covered ſeveral Parts of its Body; the Tufts or Hairs of its Wings, when viewed in the Microſcope, appear as repreſented in the Fig. by D. The Feathers which covered a Part of its Body, like A, conſiſting of a Stalk and a ſeeming Tuftedneſs on each Side; others which covered ſome Part of its Body, and the Stalks of its Wings much like Fig. B, thoſe which covered its Horns and the ſmaller Parts of its Legs, in the Shape of Fig. C. Mr. *Hook* obſerved, that the ſmooth winged Inſects have the ſtrongeſt Muſcles; and even this very Inſect had a very ſmall Body, if compar'd to the Length and Number of his Wings; which therefore as he moved them very ſlowly, conſequently moved them as weakly; which laſt Property is in ſome meaſure obſervable

* *Ph. Theo. p.* 386.

Pl. 24.



Front.g Pag. 82. T. Bowles sc.

in the larger Kind of flying Creatures, as Birds, *&c.* So that by the Aſſiſtance of the *Microſcope* we find, that the Wiſdom and Providence of the all-wiſe Creator, is no leſs ſhewn in thoſe deſpicable Creatures, Flies, Moths, *&c.* than he is in the larger Parts of the Creation.

Theſe little Animals may be pinched in the Nippers, or ſtuck upon the Point, and ſo applied to the Microſcope; and its Feathers may be placed between two *Muſcovy* Talcs.

SECT. II.

Of the Wolf, or ſmall Moth.

THIS *Inſect* is a little *white Worm*, which infects *Granaries* and *Corn-Chambers*. In its perfect State it is really a *Moth*, of the Size and Form repreſented at Fig. 140. it has four whitiſh Wings ſpotted with black Spots.

When in the Reptile State, it appears as repreſented under Fig. 141. a magnified Repreſentation of which is ſeen at K L, the fore Part of its Body had ſix Feet, which were not diſcernable till the Worm was turned on his Back, with its Belly upwards in this Poſition, Part of its Body is repreſented at M N, Fig. 146. wherein its ſix Feet may be ſeen. As it creeps along, an exceeding fine Thread or Web iſſues from its Mouth, by which it hangs to every Thing it touches, its Mouth is armed with a Pair of reddiſh Forceps, wherewith it gnaws its Way, not only into Wheat, and other Grain, but even perforates into Wood, and almoſt any Thing it meets with.

In theſe *Corn-Chambers* that are infeſted with this Vermin, they may be ſeen near the Decline of the Summer, crawling up the Walls in great Numbers, ſearching out for Places where they may abide in Safety, during their Aurelia State: For when the Time of undergoing a Change into that State approaches, they forſake their Food, and thoſe little Cells they had formed of hollow'd 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 envelope themſelves in a Covering of their own ſpinning; where they ſoon become metamorphoſed into dark colour'd Aurelias *, and continue ſo all the Winter unactive and harmleſs: But about *April* or *May*, as the Weather grows warm, they are transformed into *Moths* of the Kind before deſcribed. Then are they to be ſeen in great Numbers taking little Flights, or creeping

* *Leeuwen. Exp. & Contemp. Epiſt.* 71.

along the Walls; in the Fly State they eat nothing, therefore are not mischievous, but ſoon copulate and lay Eggs, not larger than a Grain of Sand, in Shape like thoſe of an Hen, each Female *ſixty* or *ſeventy*, which by Means of a Tube at the End of her Tail, repreſented by Fig. 142. as it appears in the Microſcope, 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 where they are 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***, hereafter to be deſcrib'd.

Theſe *Worms* or *Maggots* may be kept all the Winter in Glaſs Tubes, that are ſtopped at each End with a Cork and Wax, having firſt a Bit of a very ſmall Glaſs capillary Tube, put thro' the Cork to give them Air. In this Manner Mr. *Leeuwenhoek* confin'd ſome of theſe *Moths* with a few Grains of Corn, and ſaw them lay their Eggs in the Crevices of the Corn; alſo in this Manner he obſerved all the above Particulars. Therefore as theſe *Glaſs Tubes* may be readily applied to the *Univerſal* MICROSCOPE, and are alſo very commodious to confine any Kind of Inſect, in order to obſerve their Manner of Propagation, I apprehend it will not be improper to exhibit a Drawing of one of them in this Place, Fig. 25. A, B, C, D, repreſents a Glaſs Tube A D and B C, its Extremities ſtopped with Corks and Wax. E G and F H are two exceeding ſmall Glaſs Tubes, cemented in the Corks, but ſo that the Air may have a free Paſſage quite thro' them. Theſe Tubes are to be placed between the Object-Plate I, and Springs b, of the *Univerſal* MICROSCOPE, Fig. 1. ſeveral Dozens of them will be neceſſary to confine a few out of the great Variety of Inſects that one Summer Seaſon produces, therefore any Gentleman may be ſupplied with more or leſs of them as he pleaſes, at my Shop at the Sign of *Tycho Brahe*'s *Head*, in *Fleet-Street*, LONDON, where I always keep them ready prepared.

Theſe little Moths are cover'd all over with an infinite Number of little Feathers joined to their Wings, and other Parts of their Bodies by a Quill, as thoſe of Birds are, but ſo extremely different in Shape, that ſcarce two of them can be found alike. Fig. 144. ſhews three of the larger Sort, ſomewhat blackiſh towards the Top, but tranſparent near the Stalk. Fig. 143. ſhews three others perfectly tranſparent, ten of the ſmaller Sort are exhibited at Fig. 145. but all of them of a different Shape. Theſe Feathers which compoſe the Borders of the Wings, but eſpecially thoſe which grew upon that Part of the Wing which was near the Body of the Moth, were alſo of different Faſhions, and much longer than the former. Five of this Sort are ſhewn at Fig. 146.

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The Methods of deſtroying this Vermin is, when they forſake their Food, and aſcend the Walls, or when they appear in the Moth State; at both theſe Times they may be cruſhed to Death by clapping Sacks upon them: But they may ſtill be more effectually deſtroyed by cloſing up all the Doors and Windows, and filling the Corn-Chambers with the Fumes of Brimſtone *, by leaving it burning on a Pan of Charcoal, without giving it any Vent for 24 Hours: However, after that great Care muſt be taken to open them all again for ſome Hours, that the Fumes may be entirely gone before any Body enters.

N. B. The Fumes of the Sulphur are not hurtful to the Grain.

The *Nymph* of the *Cloaths Moth*, called by Mr. *Hook*, the ſilver colour'd *Book-Worm*, is a curious Object. It is a ſmall ſilver colour'd ſhining Worm, and is often found ſcudding among *Books* and *Papers*. Fig. 147. repreſents this Worm as it appears in the Microſcope, having a conical Body, divided into fourteen ſhelly Partitions, each of which are cover'd with a Multiplicity of thin tranſparent Scales, which from their ſeveral reflecting Surfaces, make the whole Animal appear of a perfect Pearl Colour: The ſmall blunt Head of this Inſect is furniſhed on either Side with a Cluſter of Eyes, (but fewer in Number than thoſe of other Inſects) each of which was beſet with a Row of ſmall Briſtles. It has two long Horns A B, ſtrait and tapering towards the Top, curiouſly ringed and briſtled, with a Girdle of ſmaller Hairs at each Ring, and ſeveral larger Briſtles here and there diſperſed among them, alſo two ſhorter Horns or Feelers C D, knotted and fringed like the former, but without Briſtles; its hinder Part terminated in three Tails, reſembling the two long Horns in every Particular. It had ſix Legs ſcaled and hair'd, which could not be repreſented in this Poſition. Theſe little nimble Animals are beſt applied to the Microſcope, upon a ſingle Piece of Talc, or a thin Slip of Glaſs, pinched in the Nippers, having firſt ſtuck them thereto with a ſlight Touch of Turpentine, or a Drop of Gum Water.

CHAP. XX.

Of the Weevil, or Corn-Beetle.

THIS little *Inſect* is ſomewhat bigger than a large Louſe of the Scarab Kind. It does much Harm to many Sorts of Grain, by eating into them, and devouring all their Subſtance: As many People are unacquainted with the *Weevil*, I have exhibited a Picture of it, in Fig. 148. of the full Size it appears of to the naked Eye. It has two jointed Horns, which are repreſented as they appear when viewed through a Microſcope, at

* *Leeuwen. Exp. & Contemp. Epiſt.* 71. *p.* 246.

E, H, G,

E, H, G, Fig. 149. Its Trunk at E D B, and its Forceps or ſharp Teeth D, with which it gnaws its Entrance into the Heart of the Grain, either for Food, or to depoſite its Eggs. Between the Forceps at D, appears a Kind of Sucker, with which it licks up the Flower or Duſt of the Grain.

If ſome of them are kept in Glaſs Tubes, prepared as before deſcribed, that the Air may have a free Paſſage into them, with a few Grains of Wheat, their Copulation may be diſcover'd, and alſo their Manner of Generation, which is thus performed. * The Female perforates a Grain of Wheat, and therein depoſites a ſingle oblong Egg or two at the moſt, and this ſhe does to five or ſix Grains every Day, for ſeveral Days together; theſe Eggs, which are not above the Size of a Grain of Sand, in about ſeven Days produce an odd Sort of white Maggot, which wriggles its Body very much, but is ſcarce able to move from Place to Place, the Maggot turns into an Aurelia, which in about fourteen Days comes out a perfect *Weevil.*

CHAP. XXI.

Of the Flea.

THESE little Creatures are a ſurprizing Object, when examined by the Microſcope; they are *Male* and *Female*, and undergo the ſame Changes as the Silk-worms do. They depoſite their Eggs at the Roots of the Hair † of *Dogs*, *Cats*, and other Animals, and by a glutinous Matter ſtick them faſt thereto; one of theſe Eggs is repreſented magnified in Fig. 150. and at 151. the ſame Egg broken by the Worm, Fig. 152. hatched therein. This Worm § contains the *Flea*, and is compoſed of ſeveral annular Diviſions, thinly ſet with long Hairs, having at its Head two extremely minute Horns at A; theſe Worms feed upon the Juices of the Body whereunto they cloſely adhere. They are very nimble, but if diſturbed, roll themſelves ſuddenly into a round Figure, and continue motionleſs for ſome Time; after which they open themſelves by Degrees, and crawl ſwiftly away. They endeavour to conceal themſelves when their Change draws nigh, eat nothing, lie quiet, and appear dying, but if placed before the *Microſcope*, will be found with the Web in their Mouths, weaving a Covering round them; the Inſide of which is perfectly white, but its Outſide as it were ſoil'd with Dirt. In this Bag they put on the *Chryſalis*, which is repreſented at Fig. 153. diveſted of its *Vermicular Skin*. About two or three Days before they break forth from this Confinement, their

* *Leeuw. Ep.* of 6 *Aug.* to the *Royal Society.* † *Phil. Tranſ.* No. 249. § *Arc. Nat. Tom.* IV. *Epiſt.* 76.

Colour

Colour darkens, and as ſoon as they iſſue from the Bag, are perfect *Fleas*, and able to leap away. A *microſcopick* Picture of a perfect *Flea* is repreſented by Fig. 158.

It is all over adorn'd with a curiouſly poliſhed Coat of Armour, or hard ſhelly Scales, neatly jointed and folded over each other, and beſet with long Spikes, almoſt like Porcupines Quills: Its Neck bears ſome Reſemblance to a Lobſter's * Tail: Its Head is adorn'd on either Side with a beautiful quick and round black Eye; behind each of which appears a ſmall Cavity, in which moves a thin Film, ſet with many ſmall tranſparent Hairs, which may probably be its Ears †. From the fore Part of its Head, proceeds a Pair of little jointed hairy Horns, or Feelers A B. Between theſe and its two fore Legs C D, is ſituated its *Piercer* or *Sucker*, that includes a Pair of Darts, which after the Piercer has made its 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 Center of it, which we commonly call a *Flea-bite*. This Piercer, its Sheath opening ſide ways, and the two Lancets within it, are very difficult to be ſeen, ‖ unleſs the two fore Legs, between which they are uſually folded in, and concealed from View, are 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; one 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*. But this requires a great deal of Patience and Dexterity. Therefore another more likely Way to ſucceed in this Experiment, is, when the *Flea* is juſt dead, to take hold of its Back with the Nippers m, of the Apparatus V, Fig. 2. and then apply it to the ſixth Magnifier; and having a ſmall ſewing Needle ready fixed in a Handle, I have been able to preſs the Horns forward with the Point of the Needle, and its two fore Legs nearer to the Body; and this whilſt I was looking thro' the *Microſcope*; by which Means I could then exactly ſee where to place the Point of the Needle, ſo as to raiſe up the Piercer in the Situation D E, as expreſſed in Fig. 154. which repreſents a Part of the *Flea*'s Head; and at the ſame Time I have open'd the Piercer, and ſeparated its two Lancets, and this without cutting off any Part of the *Flea*, Fig. 154. A B C are the two Horns, and D E are the two Sides of the Piercer, which are partly hollow, that they may the better include the Lancet, or Dart, which in this Figure appears to be but one, but if carefully ſeparated, will be found to conſiſt of two Parts, as in the next Figure 155; whereof G K and G I repreſent as before the two Parts of the Piercer be-

* *Pow. Mic. Obſ. p.* 2. † *Hook's Mic. p.* 210. ‖ *Arc. Nat. Tom.* IV. *p.* 332. *Ph. Tranſ.* No 249.

ſet

ſet with ſeveral Hairs, and G H ſhews the two Darts, but not ſeparated. At Fig. 156. they may be ſeen aſunder, whereof L O, L N, are the two hairy Parts of the Piercer before ſpoken of, and L M, O L P the Darts, in L M may be ſeen the Cavity, which includes or receives the other Dart L P, when they are ſhut up between the *Fleas* fore Legs, all the four make but one Proboſcis.

Beſides theſe two Legs before ſpoken of, which adhere to the Head of this little Creature, it has four others, which are join'd to its Breaſt; theſe ſix Legs the *Flea* clitches up altogether; and when he leaps, ſprings them all out at the ſame Inſtant, and thereby exerts his whole Strength at once, which carries him to a ſurprizing Diſtance, above 100 times its own Length. Its Legs have ſeveral hairy Joints, which terminate in long hooked Claws; as in Fig. 158.

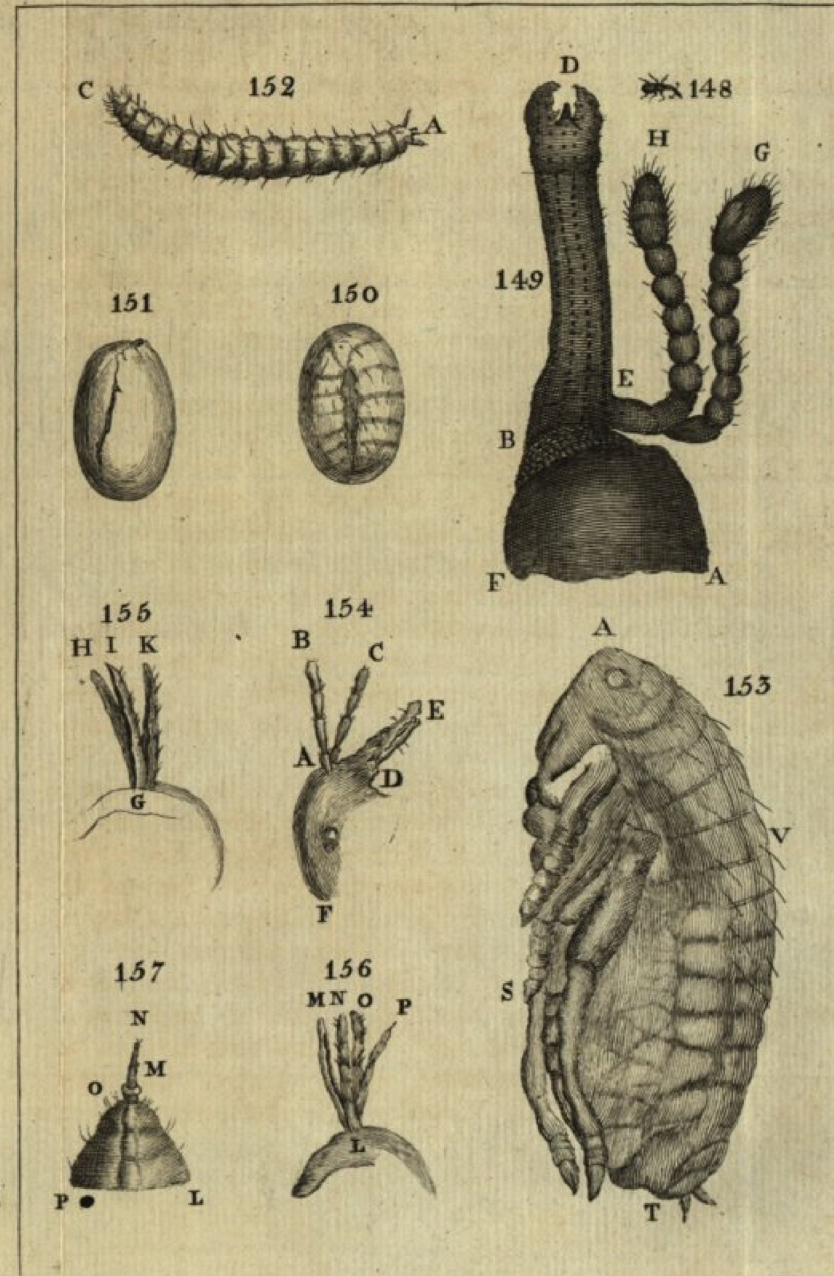
If the Eggs of *Fleas* be kept conſtantly warm in one's Boſom (it has been obſerved that) in the Midſt of Summer, they hatch in four Days; then feed the Maggots with dead Flies, which they greedily ſuck. In eleven Days they come to the full Perfection of the Reptile State, when the Maggot ſpins its Bag, 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 * 28 Days, a *Flea* may come from its Egg, 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.

If you keep *Fleas* in ſuch a Glaſs Tube, as is before deſcribed, 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 ſeveral Days ſucceſſively; which Eggs hatch in the ſame Order.

A Diſſection of the *Flea* may be effected in Water, the † Stomach and Bowels, with their periſtaltick Motion, may plainly be diſtinguiſhed, and alſo the Teſtes and Penis, together with Veins and Arteries, minute beyond Conception. Mr. *Leeuwenhoek* affirms, that he has likewiſe diſcover'd innumerable *Animalcules*, ſhaped like Serpents, in the Semen Maſculinum of a *Flea*.

* *Arc. Nat. Tom.* IV. *p.* 325. † *Ibid. p.* 335.

CHAP.



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CHAP. XXII.

Of the Louse.

THE Transparency of its Skin enables us by the Help of the *Microscope*, to discover the Motion of the Muscles, * (which unite in an oblong dark Spot in the Middle of its Breast) as the *Louse* moves its Legs; and also in the Head, when the Horns are moved, and in the several Articulations of its Legs. The peristaltick Motion of the Intestines is really surprizing, which is continued from the Stomach thro' the Guts to the Anus. The various Ramifications of the Veins and Arteries, which are white, and a regular Pulse may be also discern'd. From its Head proceeds two hairy Horns B B, Fig. 159. with four Joints. Its two black Eyes are shewn at C C, fenced round with several small Hairs; it has six Legs, cover'd with a very transparent Shell, and jointed exactly like a Crab's or Lobster's Claws; each Leg hath five Joints with several small Hairs interspers'd about them; at the End of each is two sharp hooked Claws, as may be seen in the Figure, unequal in Length and Size; one of which resembles that of an Eagle, but the other of the same Foot † stands strait out, and is very small; between these two is a raised Part or Knob, most exquisitely contrived for performing those Motions of walking and climbing up the Hairs of the Head; for when it walks, by having the lesser Claw G set so much short of the bigger H, that the former does not touch, and by Means of the small Joints in the latter, it is able to bend it round, and so with both Claws to grasp and hold fast the Hairs ‖. From its Snout at the Hole D, when the *Louse* is going to feed, it pushes out a pointed Part, which is represented at Fig. 157. whereof L O P is the Snout Part of the Louse's Head. At O is the Nipple, from whence the Sheath, or Case M, and from within this also, the Piercer § or Sucker N is pushed out; at N, its Point is somewhat cleft. These are thrust into the Skin to draw out the Blood and Humours it feeds on; for Mr. *Hook* placed a *Louse* upon the Back of his Hand that had been fasting two or three Days, which immediately thrust its Sucker into the Skin, and he could plainly see a small Current of Blood come directly from its Snout in a fine Stream to the fore Part of the Head, and then to fall into a roundish Cavity; it passes again in a like Stream to another circular Receptacle in the Middle of the Head at A, 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

* *Philos. Trans.* No. 284. † *Ibid.* No. 94. ‖ *Hook's Microf. p.* 212. § *Leewenh. Exp. & Con. p.* 354.

little upwards. In the Breaſt and Gut the Blood without Intermiſſion is moved with great Force, and in the Gut with ſuch a ſtrong Propulſion downwards, and ſuch a Contraction of the Gut as is ſurpriſing. In the upper Part of the crooked aſcending Gut the propelled Blood ſtands ſtill, and ſeems to undergo a Separation; * part of it becoming clear and wateriſh, while certain little black Particles paſs downwards to the Anus. The Thorax is caſed with a tranſparent horny Subſtance, through which the Blood was variouſly diſtributed; and at I, appeared a pretty big white Subſtance; many very ſmall milk-white † Veſſels were diſcernable between its Legs, out of which on either Side were many minute Branchings. The Belly is covered with a thin tranſparent Skin; at the upper End of this its Stomach K K is placed, and the white Spot L; at the Extremity of the Tail are two ſemicircular Parts covered all over with Hair.

Place a *Louſe* on its Back and two darkiſh bloody Spots will 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 lie. This Motion of Syſtole and Diaſtole is ſeen beſt when the Louſe is grown weak; the white pulſing Bladder ſeems to be the Heart, for on pricking it the Louſe inſtantly dies. The lower darkiſh Spot is thought to be the Excrement in the Guts.

The Males have Stings ‖ in their Tails, the Females none: The Females lay Eggs or Nits, from whence Lice are produced perfect in all their Members, and undergo no farther Change.

Mr. *Leeuwenhoek* obſerved that in ſix Days one of them had laid 50 Eggs, and diſſecting it, he ſaw as many more in the Ovary; concluding from thence that it would have laid 100 Eggs in 12 Days. Theſe Eggs hatch'd in ſix Days, would probably produce 50 Males and as many Females; and theſe Females coming to their full Growth in 18 Days, might in 12 Days more probably lay 100 Eggs alſo, which Eggs in ſix Days farther, the Time required to hatch them, might produce a young Brood of 5000; ſo that in eight Weeks a *Louſe* may ſee 5000 ** of its own Deſcendants.

Upon the oblong Slip of Glaſs R, Fig. 2. a *Louſe* may be eaſily diſſected in a ſmall Drop of Water and applied to the *Microſcope*; thus five or ſix Eggs ready to be laid may be found in the Ovary of a Female, with many other of a leſs Size. In the Male the Penis is remarkable, and alſo the Teſtes, whereof it has a double Pair. The Females appear very white if faſting, and even when fed are leſs red than the Males.

* *Phi. Tran. No.* 102. † *Hook's Micro. p.* 213. ‡ *Pow. Mi. Ob. p.* 9. ‖ *Arc. Nat. Tom.* II. *p.* 77. § *Ibid. p.* 77. ** *Ar. Nat Tom.* I. *p.* 78.

The

The Vermin adhering to and feeding on the Bodies of different Animals, are commonly called Lice.

Insects are infected with Vermin that feed * on and torment them; sever- Beetles have Lice on them.

The Earwig is troubled with minute Insects, which stick like Lice on the several Parts of the Body, especially under the setting on of its Head. They are white like Mites, but smaller; are round back'd, flat bellied, long legged, especially the two foremost, the same has not been observed on any other Animal.

Snails of all Kinds have Insects feeding on them. Small red Lice are frequently to be seen about the Legs of Spiders.

White Lice are commonly found on Humble-Bees, on Ants, on Fishes, *&c.* and probably very few Creatures are free from them.

The Polipe also is not exempt from Vermin of this Sort.

There is another Sort of Louse found about unclean People, called a Crab-louse.

Seignior *Redi* at the End of his Treatise *de Generatione Insecto*, hath obliged us with Microscopick Drawings of several Sorts of Lice, that feed upon the Bodies of different Animals, to which I refer the Reader.

In the Hawk and Turkey Hen he observed three Sorts, four in the Wild Duck, in the Wild Goose, Swan, Kestrel and Plover two; yet there are several Sorts of Birds, which have either the same Sort of *Lice*, or some nearly like them. The Kestrel hath a sort of *Lice* differing only in Colour from those of the Raven; and the Raven others, like those found upon the Egret: On the Wood-pecker and Chafinch are some resembling those of the Starling; on the large Wild Duck are some much like those of the Wild Goose. It is also observable, that the Bigness of each Bird's *Lice* bears no adequate Proportion to the Bigness of the Birds they are found upon; but that on the largest Birds both large and small *Lice* of different Kinds may be found; for on the Black-bird hath been seen some as large as those on the Swan.

There is also a little Animal in Shape and Colour like a Louse, commonly found among the Leaves and Covers of Books, and in rotten Wood; it has a swift Motion and runs by Starts; it is called a *Wood-louse* † or *Wood-mite.* If this Animal be stuck upon the Point of a very fine sewing Needle with a little Turpentine, it will be found a very curious Object; its whole Body being cased in annulary Circles, full of Silver Hairs, especially towards the Tail, with six Legs, that terminate in two Talons; it hath two Horns, but pointing backwards; its Eyes are of a golden Colour, and pushed out or drawn in at Pleasure; it hath also two Pointers before like a Pair of Pincers.

* *Phi. Tran. No.* 288. † *Pow. Mi. Ob. p.* 10.

CHAP. XXIII.
Of Mites.

Sect. I.

THEY are cruſtaceous Animals, having a ſmall Head in proportion to their Bodies, a ſharp Snout and Mouth like that of a Mole, * when open it appears red; they have two little Eyes, ſome have ſix Legs, others eight, each of which terminate in two hooked Claws: The Diviſions of the Head, Neck and Body are eaſily diſcernable by the Microſcope; the hinder Part of its Body is plump, and of an oval Form, with a few exceeding ſmall Hairs iſſuing therefrom, and from other Parts of its Body alſo. The Female lays Eggs, the young ones iſſue forth with all their Members perfect, though extremely minute; they caſt their Skins ſeveral Times before they attain their full Growth.

Fig. 160. repreſents one of the *Mites* in *Cheeſe*; its Head is ſeen at A, and exactly anſwers the Deſcription before given. One of a Mite's Eggs is ſeen at Fig. 165.

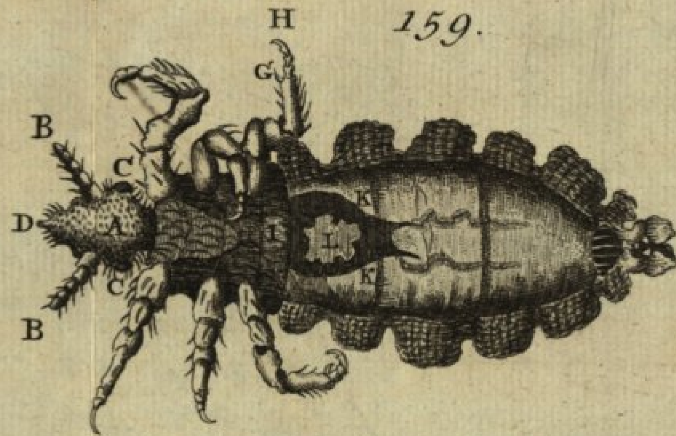
They may be kept alive many Months between two concave Glaſſes, and applied at Pleaſure to the Microſcope; by often looking at them they may frequently be ſeen *in coitu*, † conjoin'd Tail to Tail, for though the Penis of the Male be in the Middle of the Belly, it turns backwards like the Rhinoceros. The Coitus is performed with an incredible ſwift Motion. In warm Weather their Eggs hatch in 12 or 14 Days; but in Winter-time and cold Weather not under ſeveral Weeks: The young ones may be frequently ſeen near a Day ſtruggling to get clear of their Egg-ſhell.

Sect. II.
Of the wandering Mite.

THESE Creatures appear to the naked Eye to be a kind of *black Mite*, though much nimbler and ſtronger than the Cheeſe *Mites*, but on viewing them in the *Microſcope*, they will be found to be a very fine cruſtaceous Inſect, like Fig. 161. with a protuberant oval Shell indented with ſeveral ſmall Pits, covered all over with white Briſtles, they have eight Legs, each of them furniſhed with a ſharp Claw at the End. The

* *Pow. Mi. Ob. p.* 16. † *Arc. Nat. Tom.* IV. *p.* 360.

159.



158.

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Thorax was cover'd by two Shells, its Snout taper with a knobbed Ridge * running along the Middle of it; juſt over each of its Eyes aroſe two very long and ſtrong Briſtles, its Eyes black and ſmooth like thoſe of bigger Inſects. Theſe Mites are to be met with on almoſt any Subſtance where they can get Food.

Another Sort of *Mite* as delineated by Dr. *Hook*, is repreſented in Fig. 162, cover'd with a curiouſly poliſhed Shell, which reflected the Light from all Sides.

Theſe Creatures are very much diverſified in Shape and Colour, and in ſeveral other Circumſtances, according to the Nature of the Subſtance out of which they ſeem to be fed, † being in one longer, in another rounder, in ſome more hairy, in others ſmoother, in this nimble, in that ſlow, here pale and whiter, there browner, blacker, or more tranſparent. They are to be met with almoſt on all Kinds of Subſtances, that are mouldy or putrifying, in *Oatmeal*, and in *Malt-Duſt*; there are Mites bred among *Figs*, ‖ in *Hay*, and in the Powder that falls off dried Roots ‡. They are voracious Animals, and devour not only Cheeſe, but alſo all Sorts of dried Fleſh, Fiſh, Fruits, and Grain, and almoſt every Thing beſides that has a certain Degree of Moiſture, without being over-wet. Fig. 164. repreſents a ſmall Hair of a *Mite* as delineated by Mr. *Leeuwenhoek*, which a certain Gentleman compared to an *Indian* or *Japan Cane*,†† with ſeveral Joints, and ſaid it appeared to him through the *Microſcope* as if ſharp Twigs were ſprouting out of each Joint. And Fig. 163, repreſents another Hair or Briſtle of a *Mite* magnified, which was ſpicated, or bearded like the Ear on the Seed-beard ** of ſome Graſs. Every Briſtle on its Body and Legs had the ſame Formation; yet all Mites are not ſo; for of ſeven or eight which were incloſed together, but one of them was found whoſe Briſtles were all of this Make, in the reſt the Horns only were ſpicated.

Their Mouths open horizontally to the Right and Left, like that of a Waſp; ſeveral of them being ſhut up together without Food for ſome Days, ſome were found dead, and the Survivors preying on them; by which Means their manner of feeding ‡‡ was obſerved, which is very remarkable; for they thruſt one Mandible forwards, and draw the other backwards at the ſame Time, and thus they do alternately; ſo that they ſeem to grind their Food. After feeding they munch or chew the Cud.

Mr. *Leeuwenhoek* hath obſerved that *Mites* in Cheeſe turn into *Aurelias*, and from thence to *Flies*; when they turn into *Aurelias* ‖‖ they are incloſed in a thin tranſparent Membrane, which in ſome meaſure ſcreens them from the Inſults of the Maggots that ſwarm in Cheeſes. He alſo obſerved ſome

* *Hook*'s *Mi. p.* 206. † *Ibid. p.* 214. ‖ *Ph. Tran. No.* 333. ‡ *Power*'s *Mi. Ob. p.* 18.
** *Ibid. No.* 284. †† *Ibid. No.* 333. ‡‡ *Ibid. No.* 284. ‖‖ *Ibid. No.* 262.

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of the Flies produced from these Cheese-Worms, that he kept in a Glass-Tube in which he had put Cheese for them to feed upon, had coupled; and soon after laid Eggs of an oblong Figure, and then died: From these Eggs came young Worms, which also fed on the Cheese, and when he judged them to be at their full Growth, and the Weather began to be cold, he took six of the biggest, and carried them about him; and a few Days after he observed that four of them were changed into *Aurelias*, that two Worms were dead, and two *Flies* skipping about the Glass; he repeated the same Thing in *January*, and with the like Success; when he kept them in the Cold, little or no Sign of Life or Motion appeared; but as soon as he put them into his Pocket, they were as brisk as in Summer. Upon opening an Aurelia that had never produced a Fly, a dead one was found within it, which had been making its Efforts to get out, but was not strong enough to effect it.

These Vermin creep into the Cabinets of the Curious, and destroy their choice Collections of Insects: But to prevent this, keep in your Drawers, &c. a continual Supply of Camphire, whose hot and dry Effluvia will penetrate, shrivel up, and destroy the tender Bodies of these little mischievous Plunderers.

SECT. III.

Of a Crab-like Insect.

THIS Insect is about the Bigness of a large *Mite*, and of a very curious Form, as delineated in Fig. 166, it had ten Legs, eight of which a a a a terminated in very sharp but double hooked Claws, being those it walked upon, which were shaped much like those of a Crab: the two other Claws A A, that were the foremost of all the ten, seemed to branch out from its Head, and were exactly formed like Crabs, or Lobsters Claws, as are expressed in the Figure, whose Ends terminated in a Pair of Pincers, (with which I have often seen him stroke those other Claws E E) which grew out of his Snout; in walking the Creature elevated the former above its Head and Body; its Eyes were situated about d d, its Head was covered with a kind of scaly * Shell at F, its Thorax G G with two smooth Scales, and its Back with eight knobbed ones H H. These Insects are frequently to be met with amongst Books and Papers that come from *China*, when first unpacked.

* *Hook's Micr. p.* 208.

CHAP. XXIV.

Of the Semen Masculinum.

SPontaneous Generation, is a Doctrine so generally exploded, that a Disproof of it is altogether needless in this Place, it being put beyond all Dispute that all *Animals* and *Vegetables* owe their Production to parent Animals and Vegetables; and that Animals are from *Animalcula*.* These *Animalcula* being originally in the *Semen* of the *Male*, and not in the *Female*; therefore can never come forward or be formed into Animals of their respective Kinds, without the Ova in the Female †.

By the Assistance of a good Microscope, Myriads of *Animalcules* may be discovered in the *Semen Masculinum* of Animals, alive and vigorous; though so exceedingly minute, that it has been computed 3,000,000,000 of them are not equal to a Grain ‡ of Sand.

The general Appearance of the *Animalcules* in the *Semen Masculinum* of different Creatures is very much the same, that is, their Bodies all seem to be of an oval Form, with long tapering slender Tails issuing therefrom, somewhat resembling Tadpoles: Though their Tails in Proportion to their Bodies are much longer than those of Tadpoles. And the *Animalcules* in the *Semen* of *Fishes* have Tails still longer and slenderer than either, insomuch that the Extremity of them is rarely to be discerned. Their general Appearance as above described is shewn Fig. 187.

Mr. *Leeuwenhoek*, upon viewing the Milt of a *Cod Fish* ‖ with a *Microscope*, observed therein such prodigious Numbers of living *Animalcula*, with long Tails incessantly moving to and fro, (he observed the same Thing in the Milts of Pikes or Jacks) that according to his Computation 10,000 of them might be contained in the Quantity of one *Grain* of *Sand* §. Whence he argues, that there are more living *Animalcula* in the *Milt* of one *Cod-fish*, than there are *People* alive upon the Face of the whole *Earth*, at one and the same Time. He computes one hundred Grains of Sand to make the Diameter of an Inch, then a cubic Inch will contain a Million of such Sands. And as he found the Milt of the Cod-fish to contain 15 Inches, it must contain 15 Millions of Quantities as big as a Grain of Sand; and if each of these Quantities contain 10,000 *Animalcules*, the whole must contain one hundred and fifty thousand Millions. Then to calculate the Number of People, he reckons a great Circle to contain 5,400 *Dutch* square Miles: Whence he calculates the Earth's Surface to contain 9,276,218 such square Miles: And supposing one Third of the whole or 3,092,072 Miles

* *Phi. Tr.* No. 192. † *Vide Harris*'s *Lex. Tech.* *under the Word* Generation. ‡ *Vide Keil. Anat. p.* 116. ‖ *Ph. Collections*, No. I. *p.* 3. § *Arc. Nat. Tom.* I. *Par* II. *p.* 9.

to be dry Land; and of this $\frac{2}{3}$ or 2,061,382 Miles to be inhabited. And ſuppoſes farther, that *Holland* and *Weſt-Frizeland* are 22 Miles long, and 7 broad, which make 154 ſquare Miles: The habitable Part of the World is then 13,385 times the Bigneſs of thoſe Places.

If the *People* in theſe two *Provinces* are ſuppos'd a Million, and that all the other Parts of the World are as populous as theſe, which is improbable, there would be 13,385 Millions of People on the Face of the whole Earth: But the Milt of this Fiſh contain'd 150,000 Millions of *Animalcules*, which is 10 times more than the Number of Mankind.

The *Seminal Veſſels* of a *Cock* * being opened, and a ſmall Drop of the *Semen* ſqueezed out, and apply'd to the *Microſcope*, great Numbers of Animals were ſeen ſwimming therein in Legions, and croſſing one another like Clouds in a ſtormy Day, as briſk as if the *Cock* was but newly dead, † altho' it was killed the Day before; they appear as at Fig. 168. if viewed with due Attention, and with the greateſt Magnifiers, otherwiſe only in the Form of Eels.

Mr. *Leeuwenhoek*, in the Spring-time, when the *Frogs* engender, open'd the Teſticles of the Male, ‖ and on applying ſome of the *ſeminal* Matter to the *Microſcope*, Multitudes of *Animalcules* appear'd therein, about $\frac{1}{1000}$th Part of the Thickneſs of a human Hair; and there ſeemed to be ten thouſand of them at leaſt to each one of the Female *Ova*, their Form is as repreſented in Fig. 169.

Mr. *Leeuwenhoek*'s Method of computing the Size of *Animalcules* was this, he placed an Hair § of his Head near them, which Hair appear'd an Inch in Breadth; and being ſatisfied that 60 of theſe Animalcules could lie within that Diameter; whence their Bodies being ſpherical, 216,000 of them are but equal to a Globe, whoſe Diameter is no more than the Breadth of ſuch an Hair. Another Method of his alſo follows.

He firſt ſuppos'd a Drop of Water equal to a Pea; then took a little Quantity of Water, of a round Figure, as big as a Millet Grain; and reckoned this tobe $\frac{1}{91}$ of a Pea; ‡ for when the Axis of a Millet Seed makes 1, that of a Pea will make $4\frac{1}{2}$, whence it follows, that the Seed of a Millet is at leaſt the $\frac{1}{91}$ of a Pea; this ſmall Quantity of Water he put into a very ſlender Glaſs Tube, dividing by this Means that little Water into 25 or 30 Parts, and found more than 100 Animalcula in the $\frac{1}{30}$ Part of Water, equalling the Bigneſs of a Millet Seed. Whence it appears, that if 1000 are to be ſeen in the $\frac{1}{30}$ Part of a Millet Seed, there may be ſeen 30,000 in one ſuch whole Seed; and conſequently in a Drop of Water 91 times bigger, there may be ſeen 2,730,000. Beſides he compared the Water to the Bulk of a Grain of Sand; that if the Axis of a Grain of Sand be 1, that

* *Phil. Tranſ.* No. 279. † *Arc. Nat. Tom.* II. *Part* II. *p.* 369. ‖ *Arc. Nat. Tom.* I. *Part* I. *p.* 51. § *Phil. Tranſ.* No. 270. ‡ *Ibid.* No. 131.

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of a Drop of Water is at leaſt 10, conſequently a Drop 1000 times bigger than that Grain of Sand, and therefore there are 1,000,000 of Animalcula in one Drop of Water, at the Rate of 1000 little Animals in that Quantity of Water.

* In the ſame Manner he alſo computed that 4,096,000 Eggs were in the Roe of a *Crab*. Each of which received its Nouriſhment by a String from the Crab's Body.

To view the *Animalcules* in the Milt or ſoft Roes of Fiſhes, ſqueeze out a little of it, and putting the Quantity of a Pin's Head upon the Glaſs R, dilute it with River or Rain-Water, till they have ſufficient Room to ſwim freely about, and ſhew themſelves to Advantage.

N. B. The Eggs † in the Roe 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.

Some of the ſeminal Matter taken from the Teſticles of a *Dog*, ‖abounded with Animalcules in Form of Fig. 170. and ſome of them remain'd alive after having been kept ſeven § Days in a Glaſs Tube.

The Teſticles of a *Hare*, altho' four Days ‡ dead, were found to be exceeding full of Animalcules, like thoſe in Dogs, ſwimming in a clear Liquor, but without Motion.

A Female *Rabbit* being killed immediately after the *Coitus*, and the *Uterus* opened, innumerable Quantities of *Animalcules* were found in a ſmall Drop taken from the Mouth of the *Fallopian Tube*, where it opens into the *Matrix*; but none were diſcern'd in the *Uterus* itſelf, or farther along the Tube; they had long Tails, and moſtly ** ſix tranſparent Globules appear'd on the Body of each, as in Fig. 171. A; tho' ſome had only one Globule at the End of the Body, and another in the Tail, as Fig. 171. B.

A *Buck* being killed in Rutting-Time, the *Vaſa Deferentia* were found turgid, and full of a milky Fluid, a Drop of which diluted with a Drop of warm Water, juſt enough to change its Colour, and then applied before the *Microſcope*, appear'd full of *Animalcules* moving very briſkly ‖‖.

A Drop of the ſeminal Matter taken from the Teſticles of a *Ram*, flowed with *Animalcules* in as great Numbers as that of other Creatures; but with this Difference, that they ſwam in Droves together the ſame Way, and ſeem'd to follow their Leader §§ as Sheep do. Mr. *Leeuwenhoek* found ſo much Pleaſure in this Obſervation, that he called in ſome Neighbours to ſhare it with him.

This ingenious Enquirer after Nature, opened the Uterus of an *Ewe*, about ſeventeen Days after ſhe had been coupled with a Ram; and in one

* *Arc. Nat. Tom.* I. *Part* II. *p.* 339. † *Ibid. Tom.* III. *p.* 188. ‖ *Ibid. Tom.* I. *Part* II. *p.* 160. § *Ibid. p.* 150, and 49. ‡ *Ibid. Tom*, I. *Part* II. *p.* 160. ** *Ibid. Tom.* I. *Part* II. *p.* 168. ‖‖ *Phil. Tranſ.* No. 284. §§ *Leeuwenh. Epiſt. Phy. p.* 388.

of the *Cornea* observed a little reddish fleshy Substance, wherein no Shape could be distinguished, which he extended very gently out of the Round in which it lay, and could plainly perceive the Formation of all the *Vertebræ*, with the *Blood-Vessels* and *Ramifications* passing over them, and could see the *spinal Marrow* in two Places *, and distinguished not only the *Head*, but also the *Mouth*, *Brain*, and *Eyes*, the Bigness of two Grains of Sand, and clear as Crystal; he likewise saw the Ribs and Intestines, tho' the whole Creature was no larger than the eighth Part of a Pea. After which he open'd the *Uterus* of another *Ewe*, † three Days from the *Coitus*, and searching the Liquor coming therefrom with a magnifying Glass, observed a little Particle the Size of a Grain of Sand; and examined it with a very good *Microscope*, and with great Pleasure found it to be an exceeding minute *Lamb*, lying round in its Integuments, and could plainly discern its Mouth and Eyes.

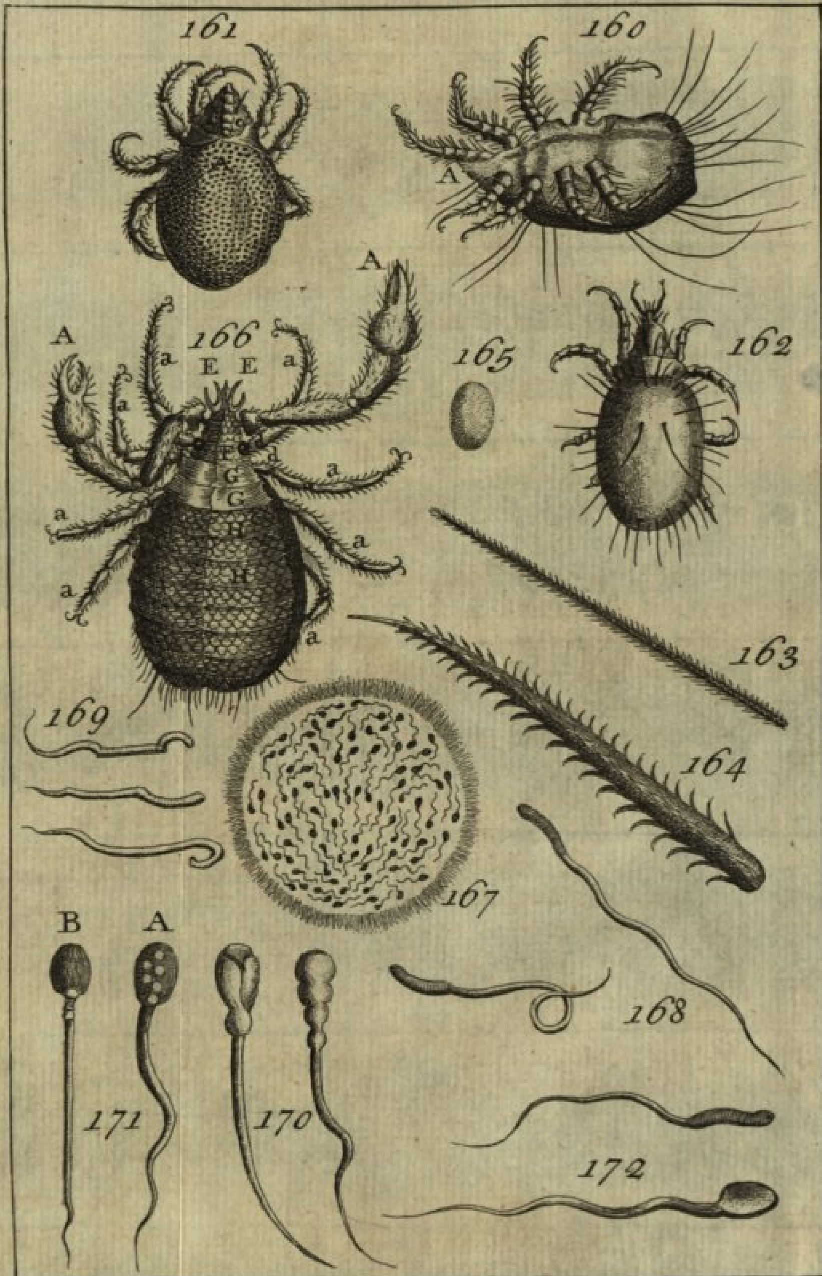
The *human Semen* has also been viewed by the *Microscope*, and found to be as plentifully stocked with *Animalcules*, as that of other Animals: Mr. *Leeuwenhoek* has seen more than 10,000 living Creatures moving in a Quantity of the fluid Part thereof, no bigger than a Grain of Sand: And in the thicker Parts, they were so thronged together, that they could not move for one another; their Size was smaller than the red Globules of the Blood, and even less than a millionth Part of a Grain of ‖ Sand, their Bodies roundish and flat before, as in Fig. 172. but ending sharp behind. Their Tails are exceedingly transparent, and five times longer, and slenderer than their Bodies. They move by the Agitations of their Tails in various Bindings, after the Manner that Eels swim.

The § *Animalcules* in the *Semen Masculinum* of all Creatures differ but little in Shape or Bigness, for which Reason it follows, that the *Animalcules* may be discover'd in the *Semen* of the smallest *Birds*, *Quadrupeds*, and *Fishes*; nay, and even in Insects to. For Mr. *Leeuwenhoek* affirms, that he found in the white Matter he had sometimes squeezed from the hinder Parts of *Male* ‡ *Spiders*, a prodigious Number of *Animalcules*. He found them also 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 many other Insects.

It is observable that amongst the many Species of *Animalcules* found in Waters, and other Infusions, there are none like those in *Semine*; but that these last, in all Sorts of Creatures, have a general Likeness to each other, and

* *Arc. Nat. Tom.* I. *Part* II. *p.* 164. † *Ibid. p.* 173. ‖ *Arc. Nat. Tom.* II. *Part* II. *p.* 61, 96, 286. § *Ibid. Tom.* IV. *p.* 30. ‡ *Phil. Transf.* No. 279. *(a) Arc. Nat. Tom.* I. *Part* II. *p.* 27. *(b) Ibid. Tom.* II. *Part* I. *p.* 144. *(c) Ibid. Part* II. *p.* 442. *(d) Ibid. Tom.* IV. *p.* 19. *(e) Ibid. (f) Ibid. p.* 20. *(g) Ibid. p.* 22. *(h) Ibid. p.* 294.

appear



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appear in continual Motion without any Intermiſſion, if the Fluid be but ſufficient for them to ſwim in.

It is farther obſervable, that no *Animalcules* can be found in the *Blood*, *Spittle*, *Urine*, *Gall*, *Chyle*, or any other of the *Humours*, except the *Semen* only.

CHAP. XXV.

Of the Oyſter.

MANY little round living *Animalcules* have been found in the clear Liquor of an *Oyſter*, * ſuppoſed to be the *Animalcules* in the *Roe* or *Semen*.

Mr. *Leeuwenhoek* open'd an *Oyſter* on the 4th of *Auguſt*, (which is the Time that *Oyſters* are ſuppos'd to breed) and took out of it a prodigious Number of minute *Oyſters*, all alive and ſwimming briſkly in the Liquor, by the Means of exceeding ſmall Organs, extending a little Way beyond their Shells, which he calls their Beards; in theſe 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.

Upon opening a Female *Oyſter*, incredible Multitudes of minute *Oyſters*, cover'd with little Shells, perfectly tranſparent, were plainly ſeen therein; in another they were found of a browniſh Colour, without any apparent Life or Motion.

Monſ. *Azout* obſerved a ſhining clammy Matter, which ſtuck to the Shells of *Oyſters*, and being drawn out, ſhone † in the Air its whole Length, which was four or five Lines, and continued ſo for a conſiderable Time when laid on the Obſerver's Hand, and afterwards opening more than 20 Dozen in the Dark, and then examining ſome of this ſhining Matter with a *Microſcope*, he found it to conſiſt of three Sorts of real Worms. One was whitiſh, having 24 or 25 forked Feet on each Side, with a black Speck on one Side of the Head, taken by him for a Cryſtalline. Its Back like an Eel ſtripp'd of its Skin; the ſecond was red, reſembling the common *Glow-worm*, with Folds on its Back, Legs like the former, and a Noſe like that of a Dog's, and one Eye; the third Sort was ſpeckled, with a Head like a Soal, and many Tufts of whitiſh Hair on its Sides. There was a bigger Species, that was greyiſh with a big Head, and two Horns like thoſe of a Snail; it had ſeven or eight whitiſh Feet, but theſe ſhined not.

The two former conſiſt of a Matter eaſily diſſolvable, the leaſt Touch turning them into a viſcous and aqueous Matter, which falling from

* *Arc. Nat. Tom.* II. *Part* I. *p.* 52. † *Phil. Tranſ.* No. 12. *p.* 203.

the Shell, ſtuck to the Obſerver's Fingers, and ſhone there for 20 Seconds. If any Part of it fell to the Ground it appeared like a ſmall Piece of flaming Brimſtone, and when ſhook off nimbly, it ſeemed a ſmall ſhining Line, which was diſſipated before it reached the Ground. Some of it was whitiſh, ſome reddiſh, but both afforded a violet Colour to the Eye. The Worms give no Light when irritated; and if they do, it laſts but a little while: Whereas in thoſe that are not provoked, it continues a good while.

As tainted *Fleſh*, *rotten Wood*, Bodies of *Lobſters*, and ſome other Kinds of *Fiſhes*, 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 in a Lanthorn*, is nothing elſe but a Swarm of minute Inſects, that emit Light round them in the Manner *Glow-worms* do.

CHAP. XXVI.

Of the Muſcle.

IN a Diſſection of the *Ovarium* of a *Muſcle*, Mr. *Leeuwenhoek* diſcovered Numbers of *Embrio Muſcles*, * which appeared as plainly in the *Microſcope* as the Muſcle does to the naked Eye; lying with their ſharp Ends faſtned to the Strings or Veſſels whereby they received their Nouriſhment. Theſe minute Embrio 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, as Abundance of Muſcle-ſhells when viewed by the *Microſcope* can ſhew. Two or three thouſand of theſe Eggs adhering ſometimes to the Shell of one *Muſcle*; it is not certain they are all fixed there by the *Muſcle* itſelf, but are frequently placed there by another Muſcle. The fringed Edge of the *Muſcle*, called by Mr. *Leeuwenhoek* 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, which one would almoſt imagine to be *Animalcules* †.

The Strings or Threads, 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,

* *Ph. Tran.* No. 336. † *Phi. Tran.* No. 336. *Arc. Nat. Tom.* II. *p.* 19. & *Tom.* IV. *p.* 423.

that

that it may not be waſh'd away. If *Muſcles* be put into Salt and Water, they will faſten themſelves to the Sides of the Veſſel we place them in.

Scallops, *Cockles*, *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.

CHAP. XXVII.

Of the Itch.

DOctor *Bononio* hath diſcovered that this Diſtemper owes its Riſe to little *Inſects* * under the *Cuticula*, whoſe continual Bitings cauſe an Ouſing of the Serum from the *Cutis*, and produce thoſe Puſtules whereby the Diſeaſe is known.

For on obſerving People in this Diſtemper pull out of the Scabs, little Bladders of Water with the Point of a Pin, and crack † them like Lice upon their Nails, from a Place ſcabbed over, and where there was a grievous Itching, he picked out a little *Puſtule*, and from thence ſqueezed a thin Matter, in which he could but juſt diſcern a ſmall white Globule; but on applying it to his *Microſcope*, found it to be a minute *Animal* of a whitiſh Colour, in Shape reſembling a Tortoiſe, but ſomewhat dark on its Back; it is repreſented in Fig. 173, at A and B, they have ſome long Hairs, ſix Legs, a ſharp Head, and two Horns, and are very nimble. He repeated this Experiment on Perſons of all Ages, Sexes, and Complexions, and at all Seaſons of the Year, and found the ſame Sort of Animals in moſt of the watery Puſtules; they begin to enter in the Furrows of the Cuticula by gnawing and working in their Heads till they are quite got under, where they cauſe a grievous *Itching*, and force the infected Perſon to ſcratch, which only heightens the Malady: From his frequent Obſervations he alſo ſaw one of them drop an *Egg*, almoſt tranſparent, from the hinder Part of its Body, and afterwards ſaw ſeveral others of the ſame Sort, one of which is repreſented at C, Fig. 173.

Hence follows the Reaſon why this Diſtemper is ſo very catching, ſince by ſimple Contact theſe Animals can readily paſs from one Perſon to another, not only from their ſwift Motion, but by their clinging to every Thing they touch; and crawling as well upon the Surface of the Body, as under the outward Skin. A few being once lodg'd, they multiply apace by their Eggs; nor is it any Wonder if this Infection is alſo propagated by the

* *Bonani Micro. p.* 91. † *Ph. Tran.* No. 283.

Sheets,

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.

This Diſcovery alſo accounts why this Diſtemper is never cured by internal Medicines, but requires *lixivial Waſhes*, *Baths*, or *Ointments*, made up of *Salts*, *Vitriols*, *Mercury*, *Sulphur*, *Precipitate* or *Sublimate*, or ſuch kinds of corroſive and penetrating Remedies as can powerfully kill theſe Vermin in their Skin. It is neceſſary to continue the Anointing for ſome Days after the Cure ſeems perfected; for though the Ointment may have deſtroyed all the living *Animalcules*, it may not probably have killed their Young in the Eggs, which are laid in Neſts in the Skin, which if ſuffered to be hatched may renew the Diſtemper.

CHAP. XXVIII.

Of Animalcules in the Teeth.

THESE are to be found in great Numbers of different Kinds, in the whitiſh Matter, that ſticks between the Teeth of *Men*, *Women*, and *Children*; * but eſpecially between the Grinders, although they waſh their Teeth frequently; but from People that are more careleſs a Sort of Eels are found. The firſt Sort A, Fig. 174. move along very ſwiftly, in Spittle or Water without Bubbles. The ſecond Sort ſeen at B, Fig. 174. move in the Direction of the doted Line. The third Sort is ſeen at E, and the fourth Sort at F.

They all die if Vinegar be put to them; from whence it ſeems probable, that if the Teeth and Gums be frequently waſhed with it, it may be a Means to preſerve them from theſe Creatures.

CHAP. XXIX.

Of the Snail.

THIS ſlow paced ſlimy Animal hath many curious Obſervables. The firſt are its four *Eyes*, like atramentous Spots, fixed at the Ends of its Horns, or rather at the Ends of thoſe black Filaments, or optick *Nerves* † that are ſheathed in its Horns, which it can thruſt out, draw in, turn, or direct as it finds Occaſion. If when the Horns are fully extended, you nimbly clip off their Extremity, and place them before the *Micro-*

* *Leeu. Ex. & Cont. p.* 40. *Tom.* IV. † *Pow. Mi. Ob. p.* 36. *Spect. de la Nat. Dialo.* XI.

ſcope,

ſcope, either upon the Object carrying Glaſs R, Fig. 2. or ſtick the End of them with a little Turpentine to the Point, they may eaſily be examined in the *Univerſal Microſcope*, with all the Magnifiers, and will be found to be two *Hemiſpherical Eyes*. And when the Stump is re-extended, it will appear evidently hollow, or tubular to the naked Eye.

Snails partake of the Nature of both *Sexes*, inſomuch that as ſoon as one has impregnated the other, the ſame Act of Generation is immediately returned; each of them, eighteen Days after theſe Approaches, drop and conceal their Eggs in the Earth; the Young of which, when hatched, appear with Shells compleatly formed *.

If you would view the internal Fabrick of this Animal, the *Microſcope* will after a dextrous Diſſection diſcover to you the *Heart*, juſt againſt a round Hole near the Neck, which probably is the Place of Reſpiration, the Heart may be ſeen to beat near a Quarter of an Hour after Diſſection.† Its Guts are green (from the Herbs it eats) and curiouſly branched over with fine capillary white Veins. This Creature, how contemptible ſoever it may ſeem, hath a compleat Sett of the ſame Parts and Organs with other Animals, as *Heart*, *Liver*, *Spleen*, *Stomach*, *Guts*, *Veins* and *Arteries*.

If the Head be cut off, a little Stone will be found, ſaid to be of a diuretick Quality, and of ſingular Service in gravelly Diſorders.

They have a Mouth like a Hare or Rabbit, and Teeth as repreſented in Fig. 175. whereof A B C ſhew the upper Jaw, which is white and of a ſemicircular Form; the lower black Part C D E, hath ſeveral prominent Parts or Teeth F F F, but all fixed together ſo as to compoſe the ſame Bone. Mr. *Hook* obſerved this very *Snail* (of which the Figure now before us is a Picture of its Teeth) to feed on the Leaves of a Roſe-tree, and to bite out half-round Bits of the Size and Shape of the Letter C.

If a *Snail* be ſuffered to creep upon a Bit of Glaſs, you may by the naked Eye (but better if you apply the Hand-Glaſs of your Microſcope to view it through) obſerve a little cloudy Stream paſſing from its Tail to the Head, that never returns the ſame Way; and this as long as the *Snail* is in Motion.

CHAP. XXX.

Of the Scales of Fiſhes.

THE outſide Coverings of Fiſhes are *Scales*, formed with inconceivable Beauty and Regularity; ſome longiſh, ſome round, ſome triangular, ſome ſquare, and ſome or other of all the Variety of Shapes imagin-

* *Nat. Delin. p.* 148. † *Pow. Ob. p.* 38.

able.

able: Some again are armed with ſharp Prickles, as thoſe of the *Perch*, *Soal*, &c. others have ſmooth Edges, as 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 each other.

The *Scale* of a Soal Fiſh is delineated, as it appear'd in the *Microſcope*, at Fig. 176. whereof C D E F repreſents that Part of the *Scale* which ſhews itſelf on the Outſide of the Fiſh, and A B C D, the Part which adheres to the Skin, being as it were furrowed, that it might hold the faſter, * each of which is terminated on the Outſide by pointed Spikes; and every other of theſe much longer than the interjacent ones.

Mr. *Leeuwenhoek* ſuppoſes theſe *Scales* not to be ſhed during the whole Life of the Animal; but to have an annual Addition of a new Scale growing over the old one, and extending every Way beyond its Edges, in Proportion to the Fiſhes Growth: Somewhat in the ſame Manner as the Wood of Trees enlarge yearly by the Addition of a new Circle next the Bark; and as the Age of a Tree may be known by its Number of Ringlets; ſo in Fiſhes the Number of Plates † compoſing their Scales, denote to us their Age.

To prepare Scales for the *Microſcope*, take them carefully off with a Pair of Nippers, and waſh them very clean, and place them in a ſmooth Paper, between the Leaves of a Book to make them dry and flat, and then place them in Sliders between the Talcs for Examination.

The *Eel*, *Snake*, *Viper*, *Lizard*, *Slow Worm*, and the *Eft*, &c. afford a great Variety of Scales. The *Dog-Fiſh Scales* conſiſt of a great Number of horny Points, which appear in the *Microſcope* to be curiouſly ridged or carved.

CHAP. XXXI.

Of Spiders.

THERE are ſo many different Sorts of *Spiders*, and their Form ſo generally known, that a Deſcription of them in this Place, cannot be expected. I ſhall therefore proceed to deſcribe ſome of thoſe Particulars of this Creature, that are only to be diſcover'd with the Aſſiſtance of the *Microſcope*.

Some *Spiders* have ſix Eyes, others eight, others fewer, and ſome more. They all ſeem to be Creatures of Prey, and to feed on other ſmall Inſects, but their Ways of catching them are very different. The *Shepherd Spider* by

* *Hook's Myc. p.* 162. † *Leeuw. Epiſt. Phyſol. Epiſt.* 24. *Mai.* 1716.

by running on his Prey; the *Hunting Spider* by leaping on it; other Sorts weave Nets, or Cobwebs, whereby they enſnare them. Nature having equipped them both with Materials and Tools, and taught them how to *work* and *weave* their Nets, and lie Perdue, and to watch diligently, and run on any Fly, as ſoon as ever entangled.

Their Eyes are immoveable and tranſparent, but not pearl'd; they are ſituated in a moſt curious Manner, and deſerve the ſtricteſt Examination.

The Way to view them is to cut off the Legs and Tail, and bring only the Head Part before the *Microſcope*, upon the Glaſs R, of Fig. 2. or to ſtick them upon the Point l, or pinch them between the Nippers of the ſame Figure, and ſo apply them to the *Microſcope*.

They have all eight Legs, and two Arms, or ſhorter Legs near their Mouth, that aſſiſt in taking their Prey; they are beſet thickly with Hairs, have each ſix Joints, and end with two hooked Claws, ſerrated, * or having Teeth on their Inſide, whereby they cling faſt to any Thing; and may be often ſeen to hang down from the Branch of a Tree, on a Thread of their own making, aſſiſted by the Help of theſe Claws.

Fig. 177. repreſents Part of the Leg of a *Spider*; B, C, D, ſhew the two extreme Claws armed with Teeth like Saws; E, the third that hath no Teeth. It is certain, that when the *Spider* does not wind itſelf by its Thread upwards, but runs along its Web, it then takes hold of the ſpun Thread with this third Claw. This *Spider* had eight Eyes, two of which were on the Top of the Head, to ſee what paſſes before him; below theſe two others, which look ſtrait forwards; on each Side of the Head were two more, the two foremoſt to ſee collaterally before him, and the two hindmoſt to ſee backwards.

Fig. 182. repreſents that Part of the Head, which contain'd the Eyes ſeparated from the Membrane in which it lay. P Q, the Eyes that look upwards, K L thoſe that look ſtrait forward, I M thoſe that look ſideways forward, H N thoſe that look ſideways backward. They have no Eye-lids, but are fortified with a hard, poliſhed and tranſparent Cruſt: As theſe Eyes are immoveable, Nature hath indulged them with ſo large a Number, to give them Information of any Thing that any Ways concerns them.

Every *Spider* is furniſhed with a Pair of Forceps, repreſented at A B, and C D, Fig. 183. in the fore-part of its Head. They ſtand horizontally, and when not made Uſe of, they let the Claw of them fall down on their reſpective Branches, like a Knife claſped upon its Haft, as at C D, and there they lie between two Rows of Teeth, that are likewiſe employed to hold faſt its Prey.

Authors are divided in their Opinions on the Poiſon of Spiders, ſome calling theſe Forceps Stings; as Mr. *Leeuwenhoek*, who calls the hooked

* *Phil. Tranſ.* No. 272.

Claws A B and C D Stings; and ſays, that towards their Extremity at B and C are two ſmall Holes, from whence, according to all Appearance, when it ſtrikes its Enemy, it therefrom ejects a liquid Matter, we call Poiſon.

He put a Frog and a Spider together into a Glaſs, and having made the Spider ſting * the Frog divers Times, the Frog died in about an Hour's Time.

Dr. *Mead* believes this to be a Miſtake, and that while the Spider bites, a ſhort white Proboſcis † is thruſt out from the Mouth, which inſtils a Liquor into the Wound.

They frequently caſt their Skins, which are to be found in Cobwebs, in which the Forceps may be examined, being always ſhed with the Skins, and eaſier ſeparated than when alive. They are commonly ſpread out to View, and by their Tranſparency, every minute Part is ſeen with much Diſtinctneſs.

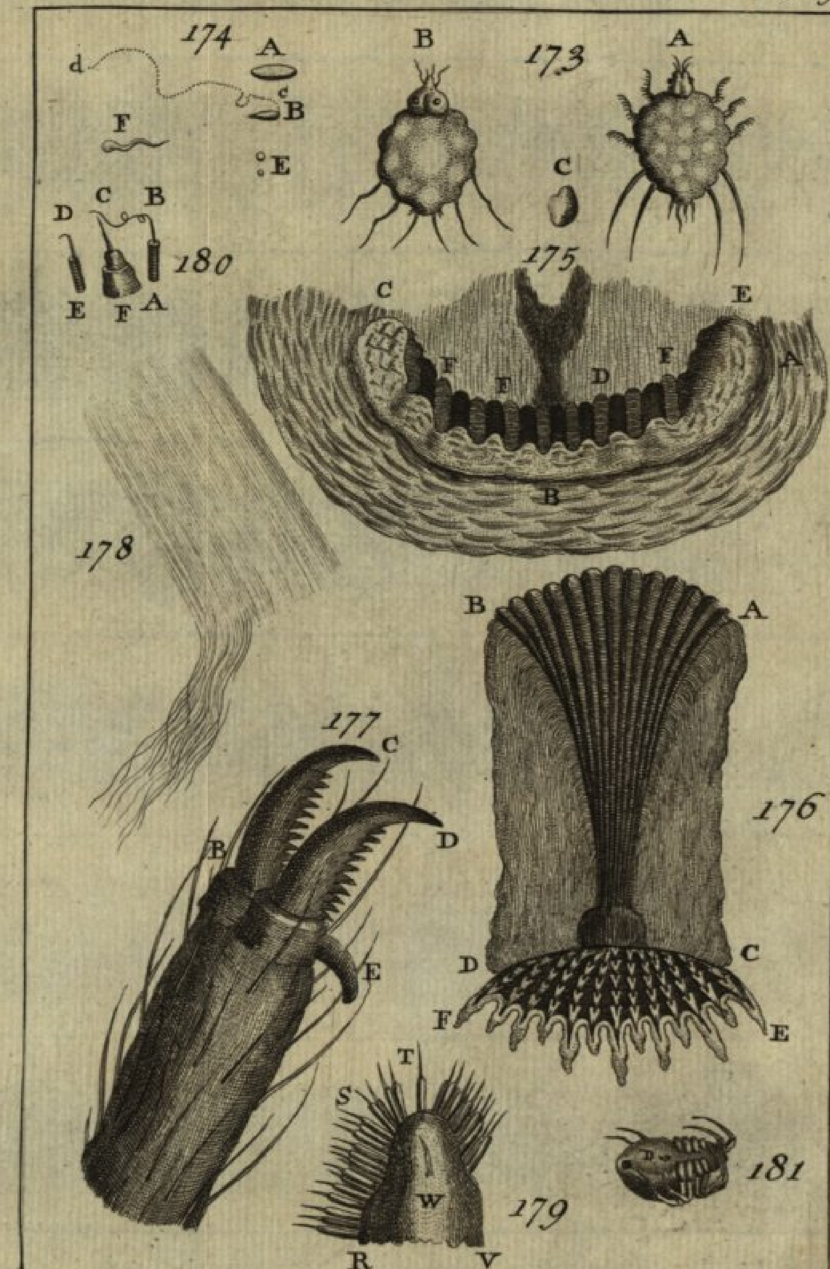
The *Microſcope* hath alſo informed us of the Manner how the Spiders weave their *Webs*, and of their *Contexture*, for the Performance of which, Nature hath endowed them with five little *Teats*, or *Nipples*, near the Extremity of the Tail; whence a gloomy Liquor proceeds, which adheres to any Thing its 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 at two or three Hair's Breadth diſtant from the Body of the *Spider*. The Threads are finer or coarſer, according to the Size of the *Spider* that ſpins them.

Fig. 178. repreſents a Part of the Threads, which came out of two of their working Inſtruments, and were divided from each other, juſt as they iſſued from the Body; and RSTV, Fig. 179. repreſents one of the four outermoſt Inſtruments or Nipples, with its Quills or Reeds, which put together, is not ſo large as a common Grain of Sand; from whence it is eaſy to conceive, how ſmall thoſe Inſtruments muſt be, and how fine the Threads encaſed within them: At W theſe working Inſtruments ſtood as thick by each other, as they are repreſented between R and S. And that Part of the Figure, from the Sight, was not cover'd with thoſe Sort of Quills, but with Hairs only: It is alſo obſervable, that a few of theſe Inſtruments are bigger than the reſt, and conſequently produce a larger Thread. C F, Fig. 180. repreſents one of theſe between two others of the ſmaller Sort D E and A B, one of which had a wrinkled or harled Thread.

Spiders emit their Eggs, not out of the hinder Part of their Body, as in all other Animals, but under that upper Part of the Belly, near the hind Legs, where grows a Kind of Hook, of a particular Figure, which partly

* *Phil. Tranſ.* No. 272. † *Mead* of Poiſon. ‖ *Phil. Tranſ.* No. 272. § *Ibid.* No. 325.

covers



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covers the Aperture, from whence the Eggs iſſue. Fig. 181. repreſents a *Spider* of an ordinary Size, with its Legs contracted, as if it was dead, in order to ſhew the above-mention'd Aperture; and at D the Hook is ſeen.

Fig. 184. G H I K ſhews the Hook ſeparated from the *Spider*'s Body, as it appear'd through the *Microſcope*; between I and K are ſeen the Wrinkles or Folds, which Mr. *Leeuwenhoek* ſuppoſes are made to produce a more than ordinary Motion: E F ſhews the Part that join'd it to the Body, and between F and G are two round Balls. The Uſe of which he could not diſcover.

The Eggs of ſome *Spiders* are a good Object, being flattiſh at one End, and round at the other, with a Depreſſion at the Center of the flattiſh End, and a yellowiſh Circle round it; their Colour is a blueiſh white like counterfeited * Pearl; when they hatch, the little *Spiders* come out perfectly form'd, and very nimble. They depoſite their Eggs to the amount of five or ſix hundred, in a Bag ſtrongly compos'd of their own Web, which the *Spider* either carries under her Belly, and guards with the greateſt Care, or elſe hides it in ſome ſafe Receſs. When juſt hatched, the young *Spiders* make an entertaining Object for the *Microſcope*.

The *Current* of the *Blood* may be ſeen in the Legs and Body of *Spiders*, as has been before hinted; many other Wonders will be diſcover'd by the Curious in the Diſſection and Examination of their ſeveral Parts.

The *Carter*, *Shepherd*, *Field*, or *Long-legged Spider*, is different from moſt other *Spiders* in two Particulars, the firſt, which is only diſcoverable by the *Microſcope*, is the curious Contrivance of its Eyes; it has only two, and thoſe placed upon the Top of a ſmall Pillar, riſing perpendicularly out of the Middle of its Back, or rather the Crown of its Head. † The two Eyes, B B, Fig. 185. were placed Back to Back, with the tranſparent Parts or Pupils more protuberant than the reſt of the circumambient Matter, ‖ looking towards either Side, but ſomething more forward than backwards. C, Fig. 187. ſhews the Column on which they ſtood, and D D the Crown of the Head.

The ſecond Peculiarity is the prodigious Length of its Legs, which are eight in Number, in Proportion to its ſmall round Body. Each Leg of this, of which the Figures 185, and 186, are a Repreſentation, was above 16 times the whole Length of its Body; they are jointed juſt like thoſe of a Crab; each of which proceeds from a ſmall ſhell-like Caſe, of a conical Figure, as at I I I I, *&c.* of Fig. 186. which repreſents the under Part of its Belly, theſe are faſtned on to the protuberant Body of the Inſect, forming a Kind of blunt Cone, whoſe Apex is at M, about which the ſmaller Cones of the Legs are placed, each of them reaching almoſt to the Top, in ſo admirable a Manner, as does not a little manifeſt the Wiſdom of

* *Pow. Mycr. Ob. p.* 15. † *Hook*'s *Mycr. p.* 198. ‖ *Pow. Myc. Ob. p.* 14.

Nature's Almighty Architect, in the Contrivance thereof. It has two fore Claws K K tipped with Black like a Crab's, which open and shut exactly like those in a *Scorpion*, and are Saw-like or indented on the Inside. Its Horns are seen at A A and Mouth at L.

The best Way to observe this Spider is to cut off all its Legs, and place it before the Microscope upon the Object carrying Glass R, of Fig. 2, or upon the black and white Object-Plate.

The little white *Field-Spider* with short Legs, found plentifully among new Hay, whose Body appears like white Amber, embossed with black Knobs, out of each whereof grow Prickles like Whinpricks, some have six, some eight Eyes, that may be distinctly seen, quick and lively; each Eye has a violet blue Pupil, * clear, and admirably 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, together with the great Variety of Colouring all over this Animal, affords a beautiful and delightful Prospect for the Microscope.

There is a red Mite or Louse often found feeding upon Spiders, in Shape much like a Tortoise, † with a little Head, and six long but small Legs; and about the Legs of the Field-Spider they cling exceeding close whilst the Animal is alive, but when dead they all fall off and creep away.

Mr. *Bon* hath made several Pair of Stockings and Gloves, from a Silk ‡ wound off from the Egg Bags of short legged Spiders.

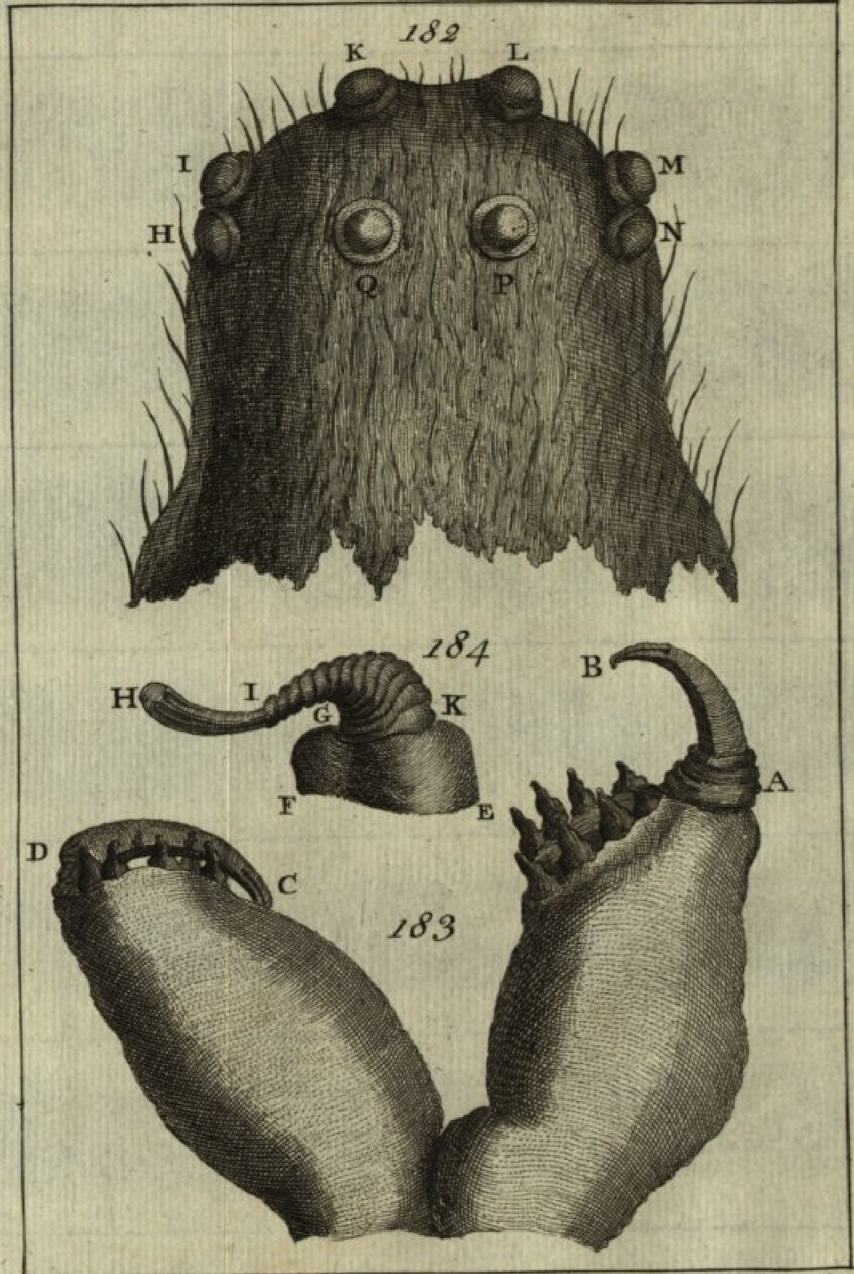
CHAP. XXXII.

Of the Sting and Scraper of a Bee.

AS the Contrivance and Structure of the Stings of most Insects are nearly alike, they will be sufficiently understood by a Description of that of a Bee, as discovered by the Microscope.

A *Bee's Sting* is a horny Sheath or Scabbard, that includes two bearded Darts; this Sheath ends in a 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 immediately after; 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 venemous Juice is injected through the same Sheath, from a little Bag at the Root of the Sting, which occasions an acute Pain, and a Swelling of the Part continues sometimes for several Days after. This is best prevented by

* *Pow. Mi. Ob. p.* 13. † *Pow. Mi. Ob. p.* 19. ‡ *Phi. Tran. No.* 325.



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enlarging the Wound immediately to give it ſome Diſcharge, and anointing it with a little common Oil.

A B C, Fig. 188. repreſents the Sheath or Caſe, out of which the two *Stings* or rather *Spears* are protruded. * E the Cavity, in which they lie. C the Thickneſs of the Caſe below; and about C, A, the two Spears ſhew themſelves each in a ſeparate Place. Fig. 189, ſhews Part of the *Sting* taken out of the Sheath, K its Edge or bearded Part, L its Back without Beards. M N, Fig. 190, repreſents the whole *Sting* taken out of the Sheath with its Back that is without Beards next the Eye; the upper Part M O is incloſed round about and hollow within, the lower Part O P open; P N ſhews Part of the broken Nerve, Q R is Part of the Body faſten'd to the Sting, and placed in the thicker Part of the Caſe D C A, Fig. 188. A B C, Fig. 191, repreſents both the *Darts* as they lie together cloſe againſt the Sheath ‖; yet one of them with its Point a little before that of the other, to be ready (as I conceive) to be darted into the Fleſh. And Fig. 192 ſhews both the Darts in part out of the Sheath; and one a little higher than the other, as if it were at work.

Fig. 193, repreſents one of the two *Arms* wherewith Mr. *Leeuwenhoek* thinks the Bee makes her Honey-Combs, and are furniſh'd with three peculiar Joints as at D, A, B. Fig. 194, is one of the *Scrapers* placed on the fore Part of the Head, by which ſhe ſcrapes the *Wax* from *Flowers*. Fig. 195, is the *Wiper* placed forward on the Head, and with it ſhe wipes the *Honey* off the *Flowers*; all which Inſtruments when the Bee hath done working are ſkilfully ſheathed under her Head. Fig. 196 repreſents the *Scraper* of a *wild Bee*.

When the *Darts* are ſtruck deep in the Fleſh, if the *wounded Perſon* ſtarts before the *Bee* can diſengage them, ſhe leaves her *Sting* behind in the *Wound*; but if he has Patience to wait until ſhe withdraws the *Spears* into their Scabbard, the Wound becomes much leſs painful.

If you divide a *Bee*, eſpecially an *Humble Bee*, § near the Neck, you will ſee the *Heart* beat moſt lively, which is a white pulſing Particle.

Within the *yellow Pluſh* or *Fur* of humble *Bees* you may frequently find a ſmall whitiſh very nimble Animal, ** not much unlike the Shape and Form of a Cheeſe Mite.

The Way to view a *Bee's* Sting with the Microſcope, is to 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; or if you catch a Bee in a Leather Glove, its Sting will be 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,

* *Arc. Nat. Tom.* III. *Ep.* 133. *Phi. Tran. No.* 97. ‖ *Derham Ph. Theo. p.* 240.
§ *Pow. Mi. Ob. p.* 4. ** *Ibid. p.* 20.

you

you may quite extract it with its Darts and Hooks; by ſqueezing the Tail, pulling out the Sting *, and preſſing it at the Bottom, you may likewiſe puſh up the Darts; but without ſome Practice this will be a little difficult.

The poiſonous Juice may eaſily be found in the Bag which contains 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; or if you gently ſqueeze its Tail, you may perceive a Drop of this diaphanous Liquor at the very End of the Sting, which if wiped off will be immediately renew'd.

The Stings of Scorpions may be examined in the like Manner.

The Poiſon of Vipers has alſo been viewed by the Microſcope, but for a Deſcription of this I ſhall refer the Reader to Dr. *Mead*'s Eſſay on Poiſons.

CHAP. XXXIII.

Of Animalcula in Fluids.

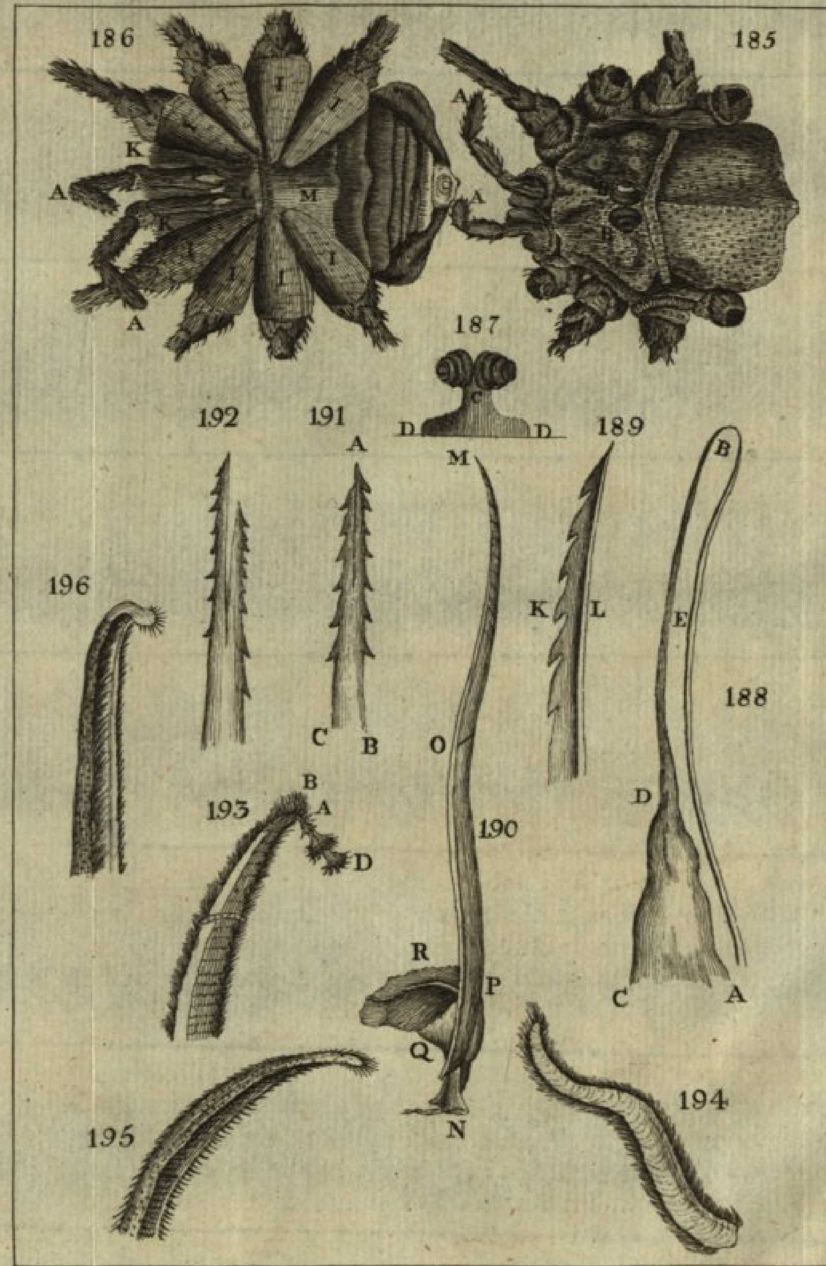
SECT. I.

THE Microſcope hath diſcovered to us that the ſmalleſt of all *living Creatures*, we have been able to trace, are the *Animalcula* in Fluids, which would for ever have remained inviſible, had it not been for the Aſſiſtance of that Inſtrument.

If *Pepper*, *Paſte*, *Vinegar*, *Hay*, *Straw*, *Graſs*, *Oats*, &c. or any other vegetable Production be infuſed a few Days in Water, expoſed all that Time to the open Air; they will abound with inexpreſſible Numbers of minute living Creatures peculiar to themſelves, but of various Forms and Sizes.

Whereof ſeveral of the ſame Species of *Animalcula*, are frequently to be met with in different Infuſions, and even in Waters, that have been expoſed, eſpecially in *September*, without any Mixture; ſuch have been frequently found therein, as are found in the Cavity of a *Cabbage leaf*, or on the *Dipſacus*, † &c. and that certainly ſeveral of theſe are the ſame Animals under different Forms, ſuch a regular Proceſs being obſerved in them, and conſtant Uniformity in their Appearance, makes it probable that moſt of them are produced from the Spawn of ſome inviſible volatile Parents, and generated like *Gnats* and ſeveral other Sorts of Flies, which are bred and undergo ſeveral Changes in the Water before they take Wing; that ſome of them originally may be Water Inſects, or really Fiſh, ſmall enough to

* *Pow. Mi. Ob. p.* 4. † *Ph. Tran.* No. 284.



J. Wigley. Sc.

be raiſed in Spawn with the Vapours, and to fall down again in Rain, and to grow and breed in Water that is kept.

It has been thought that theſe minute Flies, which hover every Way in the Air, when they find a Fluid ſtored with a convenient Nouriſhment for their future Offspring, reſort to it in Swarms to lay their Eggs, which being ſoon hatched, the Animalcula produced therefrom ſwim about, and live happily, till grown to a certain Size, change their Forms, take Wing and fly away.

If the Infuſion is covered only with a fine Lawn or Muſlin, few Animalcules will be found therein; but if it ſtands open it will be full of Life in a few Days: In the leaſt Drop taken from the Surface of ſuch Infuſion, the *Microſcope* will diſcover Millions of living Creatures.

SECT. II.

Of Eels, Serpents, or little worm-like Animalcula, found in Vinegar and Paſte.

IF *Vinegar* be expoſed to the open Air but a few Days in hot Weather, it will abound with *Eel-like Animalcula*, repreſented by Fig. 197, two of which are ſeen at A, making equal Undulations, ſometimes four or five are ſeen to move in the ſame Manner; at B, B, B, B, are ſhewn four others differently coiled, they coil and uncoil themſelves with a ſurpriſing Swiftneſs, at C is a Repreſentation of one with a forked Tail. Monſieur *Joblot* ſaw but one of theſe in 36 Years Obſervation: However, the ſolar Microſcope ſeldom fails of diſcovering ſome of them every Obſervation. That marked D, although its Mouth ſeems different from the reſt, is not ſo, but owing to its not being repreſented in the ſame Poſition. They are to be applied to the Univerſal Microſcope, by taking up a Drop of the Vinegar on a Pin's Head, and placing it upon the Object carrying Glaſs R, Fig. 2. When this Drop begins to evaporate, their Motion will be conſiderably retarded, at which Time their Mouths may be ſeen, and many other Particulars may be obſerved in them.

Some People have imagined, that the Sharpneſs of the Vinegar, is occaſioned by the *Eels* ſtriking their pointed Tails againſt the *Tongue* and *Palate*; but it is very certain that the ioureſt Vinegar hath none of thoſe Eels, and that its Pungency is intirely owing to the pointed Figure of its Salts, which float therein.

Animalcula in the Shape of Eels are often found in many Infuſions but of a different Size.

* *Joblott's Ob. p.* 2. *Imprimé à Paris.* 1718.

Dr. *Powers* obſerves, that if *Vinegar*, in which theſe *Eels* abound, be but moderately heated *, they will all die, and ſink to the Bottom. But Cold does not hurt them, for after ſuch *Vinegar* had been expos'd 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 alſo tells us, that he put ſome *Vinegar* full of theſe *Eels* into an Eſſence Glaſs, and poured thereon about the ſame Quantity of Oil, which floating on the *Vinegar*, all the *Eels* would conſtantly creep up into the Oil, when the *Vinegar* began to freeze, but when it thawed, they as conſtantly returned to it again.

To furniſh yourſelf with minute *Eels*, always ready for the *Microſcope*, boil a little *Flour* and *Water*, till it comes to the Conſiſtence of ſuch *Paſte*, as the *Bookbinders* and *Shoemakers* uſe; expoſe it to the Air in an open Veſſel, and to prevent its hardening, or becoming mouldy on the Surface, beat it well together whenever you find it tends that Way; after a few Days it will turn ſour, and then if it be examined with Attention, you will find *Thouſands* of thoſe *Eels* on the Surface thereof. To preſerve them all the Year, you need only put a little Water to them, if the Paſte grows dry, or a Supply of other Paſte, always obſerving to keep the Surface in a right Condition, which will be eaſily done when it is once ſtored with theſe *Animalcula*. Their continual Motion will prevent any Mouldineſs thereon.

Apply them to the Microſcope upon the Object carrying Glaſs R, Fig. 2. firſt putting on it a Drop of Water, taken up upon the Head of a Pin, for them to ſwim in, and if the Paſte be thick, it muſt be diluted with a ſufficient Quantity of Water to diſentangle the *Eels*, and render them diſtinctly viſible.

They are very entertaining Objects, but more particularly ſo if examined by the ſolar Microſcope, with which they may be magnified to an Inch or more in Diameter. The internal Motion of their Bowels may be very plainly ſeen, and their Mouths to open to a conſiderable Width.

SECT. III.

Of Animalcula in ſeveral cold Infuſions of whole Pepper.

B, D, K, H, O, R, L, Fig. 198. exhibits the firſt Sort of them, each having ſeveral little Spots more tranſparent than the reſt of their Body. The Regularity of the Figure, under which theſe *Animalcula* generally appear, and the Rapidity of their Motion, prevents us from diſcovering on

* *Pow. My. Ob. p.* 34.

what Part of their Body their Head is placed, but after a little Time we are enabled to do it, altho' they continue in Motion; for when the Drop of Water in which they ſwim, is grown thick by the inſenſible Evaporation of its ſubtle Parts, it gradually retards the Motion of theſe minute Fiſh; and affords us ſufficient Time to obſerve many Things, that will teach us to admire the Creator's Wiſdom, even in the ſmalleſt Part of theſe minute Creatures.

You may then perceive that as two of theſe *Animalcula* are advancing forward, one moving along the Line from A to B, and the other from C to D, in turning about the firſt follows the dotted Line B E, and the ſecond moves from D to F.

You may alſo frequently ſee that of two of theſe *Animalcula*, one of them will run as it were along the Line G H, and the other over that of I K, leaving a ſmall Space between them, yet too little for a third L, to find a Paſſage, which thus incloſed between them, ruſhes forwards to ſave himſelf in the Direction of the dotted Arch towards M. Others after having moved along a ſtrait Line, as H G to O, turn about ſo ſwift upon a Point at O, which is their Head, that their oval Figure appears almoſt circular, after which they launch out with an extremely ſwift Motion towards P. Others alſo having run along a Line as Q R, and as it were turning upon their own Center at R, deſcribe ſeveral Circles, then ſhoot forwards with an extraordinary Swiftneſs along the Line S T.

Fig. 199. repreſents another Sort of *Animalcula*, whoſe Head is adorned with Hairs, and Motion generally circular, called *Copple Crown* *. A third Sort repreſented at Fig. 200. called a ſilver Bag-pipe †. A fourth Sort is a Kind of *Water Spider*, with its Mouth open, as at Fig. 201. Two of them are repreſented at Fig. 202. conjoined and turning upon their common Center. Fig. 203. ſhews two more of them alſo coupled as they ſwim in a ſtrait Line. Another Sort is repreſented at Fig. 204. in ſome Meaſure reſembling a Weaver's Shuttle; its hinder Part is tufted with Hairs, which aſſiſt him in ſwimming. Fig. 205. exhibits a Swarm of exceedingly minute Inſects of different Sizes and Shapes, which ſerve for Nouriſhment to the larger Sorts.

* *Jobl. Ob. p.* 14.
† Theſe Names were given to the *Animalcula* of the ſeveral Infuſions, by Monſ. *Joblot*, who endeavour'd to call them after the common Names of Things and Animals, to which theſe *Animalcula* bore ſome Reſemblance.

SECT. IV.

Of White Pepper.

INfuſions made of *whole white Pepper*, produce finer *Animalcula* than the foregoing, but not in ſo ſhort a Time. The large *Bag-pipe* of this Infuſion advances and recedes by Turns, as it ſwims before the *Microſcope*; and juſt before the Water is totally dried, a great Number of Eggs may be ſeen within them, and in the next Moment they will be all dried up, and appear like a confuſed Maſs.

SECT. V.

Of Long Pepper.

LOng Pepper put whole into common Water, produces *Animalcula* no leſs ſurprizing than the two foregoing; in this is ſometimes found an *Animalcule* ſomewhat like a *Caterpillar*; and a different Sort of *Eels*, from thoſe found in *Vinegar* and *Paſte*, being thicker and ſhorter than they, but do not live near ſo long.

On repeating theſe Experiments at different Seaſons in the Year, and in different Years, other Sorts will be found not here repreſented.

Take common *black Pepper* groſly pounded, and put it into a Glaſs Veſſel, as much as will cover the Bottom thereof, about half an Inch thick, on which pour about three or four Times that Depth of Rain or River-Water, ſhake and ſtir the Pepper and Water well together at firſt, but afterwards not at all, and expoſe the Veſſel to the Air uncover'd; in a few Days a little Skin may be ſeen on the Surface of the Water, which, examined by the *Microſcope*, will be found to contain Millions of *Animalcula*, at firſt ſcarce diſcernable, but continually increaſing in Bulk, till they arrive at their full Size. Their Numbers too increaſe prodigiouſly, till at laſt the whole Surface of the Fluid ſeems alive.

This Experiment will ſucceed in Winter, if the Water is not frozen.

The *Animalcula* repreſented by Fig. 206. are very common, and are deſcribed by Mr. *Leeuwenhoek*, who hath ſeen the Tails of ſome of them 9 or 10 times longer than their Bodies, * which are about one Third of an Hair's Breadth, but in general they are 4 or 5 times as long. In moving they

* *Phil. Tranſ.* No. 284.

commonly twitch up their Tail into a ſcrew-like Form, as at b, Fig. 206. and this Spring is ſo ſtrong, that when the Tail is entangled, as it frequently is by the Extremity, they bring back their whole Bodies by the Jerk and Convolution of the Tail, which quickly returns to its firſt Straitneſs. When they lie ſtill, they thruſt out and pull back again a bearded Tongue, and a Current conſtantly runs towards them, occaſioned probably by the Motions of ſome Fins or Legs too fine to be diſcerned.

Thoſe *Animalcula* exhibited by Fig. 207. abound in all Waters, and are largeſt of all; their Length is about an Hair's Breadth, and three or four Times more than their own *, they are very thin and tranſparent, and turn themſelves very quick, ſhewing both Back and Belly, their Edges are adorn'd with a great Number of minute Feet, ſeen chiefly at the two Extremities; at one End there is a Kind of Bruſh reſembling a Tail; they are ſwift in Motion, and by their Turns, Returns, and ſudden Stops, ſeem to be continually hunting for Prey. a repreſents one of them on its Back; b one on its Belly; at c and d, is ſeen how they often appear in other Poſitions.

There is generally another Sort of an oval Shape, as at Fig. 208. a b c, lengthening and ſhortening themſelves as Occaſion requires, and ſometimes two of them may be ſeen conjoined, as at a.

Another Sort are a Kind of *capillary Eels*, they wave their Bodies but little, move equably and ſlow, and ſwim as well backwards as forwards. See Fig. 209.

Several Kinds of Mixtures put amongſt them, while they are before the *Microſcope*, produce different Effects. The ſmalleſt Drop of Spirit of Vitriol, upon the Point of a Pin, being put to them, they immediately tumble down dead; diſſolved Salts kill them, but with this Difference, inſtead of being 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 languid and die, without changing their Shape. Ink kills them, and ſo does freſh Blood, Urine, Spittle, and diſſolved Sugar †.

There is alſo another Sort of *Animalcule*, frequently found in this Infuſion, of a ſpherical Figure, only pointed like a Pear, as at Fig. 210. in which are a vaſt Number of dark Spots, in a confuſed Agitation, they chiefly turn as it were upon a Center, firſt one Way, and then the contrary, ſometimes they take a large Circuit, but always with their pointed End foremoſt.

Another Sort repreſented at Fig. 211. is alſo found in great Numbers, they move briſkly, are very active, contracting, and dilating as they ſwim along, they have ſeveral Feet in their fore Parts very viſible; when the Drop of Water is almoſt evaporated, they ſhrink up into a globular Form,

* *Phil. Tranſ.* No. 284. † *Ibid.* No. 203.

then their Feet ſtanding out, may be ſeen to move nimbly, a, ſhews them at their Length, and b when contracted.

Fig. 212. repreſents another *Animalculum*, not uncommon amongſt the reſt; its Motion very nimble, always keeping its ſharp Extremity foremoſt; ſome are clear and ribb'd from the Point to the thick Extremity, others tranſparent only at the fore Part, as at a and b.

The Water which drains from *Dunghills*, and is of a brown Colour, is generally ſo prodigiouſly ſtored with various Sorts of *Animalcula*, that it muſt be diluted with Water before they can be ſufficiently ſeparated, to diſtinguiſh their different Kinds; one particular Sort is found amongſt theſe, which is very rarely to be met with elſewhere, and are ſhewn at Fig. 213. their middle Part dark, and beſet with Hairs, but both Ends tranſparent, their Tails tapering with a long Sprig at the Extremity thereof, their Motion ſlow and wadling.

SECT. VI.

Of Animalcula in a cold Infuſion of Senna.

ABout the Middle of *July*, as much as could be taken up with two or three Fingers of the *Leaves*, *Stalks*, and *Branches* of *Senna*, was put into cold Water, and in about eight Days, the Surface thereof was ſtored with extremely minute longiſh Bodies, ſeparate from each other, but without Motion. The Corpuſcles repreſented at Fig. 214. were thought to be nothing elſe but Pieces of the Bark from the Branches of the *Senna*; but in about eight Days after, they all diſappear'd, and a ſurprizing Number of worm-like *Animalcula* ſucceeded them, but leſs than the firſt, being alive, and ſwimming a little below the Surface of the Water; one of theſe Worms is ſeen at Fig. 215. Its Head round at I, its Body compos'd of eleven Ringlets, the loweſt Extremity of which ends ſometimes in a Plain perpendicular to its Body. At other Times with three round Protuberances, as at M.

Through the Skin there appears a very white Fibre, branching as it were from each Side of the Tail, in a ſtrait Line towards the Head, where they unite in an Arch, as at N, Fig. 216. This Fibre extends and contracts itſelf alternately, by which Means the Ringlets are drawn nearer to, or puſhed farther from each other; Part of the Water being evaporated by its ſtanding ſeveral Days. A little freſh Water was poured thereon, which cauſed the Skin that ſwam on the Surface of the Infuſion to ſink to the Bottom of the Veſſel; the Infuſion was thereby refined, and more tranſparent than it was before, which occaſioned the Diſcovery of two new Sorts of *Animalcula*, and this in the leaſt Drop that could be applied to the *Microſcope*,

croscope, D, and E F, Fig. 217. are their Repreſentatives. The largeſt of them reſembles the Silver Bag-pipe, each having crooked Heads, as at F; they have alſo two Motions, one ſtrait, and the other circular, ſlow enough to be eaſily obſerved.

Another Kind of fiſh-like *Animalcula* reſembling a *Carp*, is ſhewn at Fig. 218, its Motion was wrigling as the dotted Line a b c d.

In *January* a great Number of another Sort were found in this Infuſion of *Senna*, which ballance themſelves from Right to Left as they ſwim directly forwards. Another Time, after repleniſhing the Water, other minute Animalcules that do not ballance themſelves were found therein, and the ſame Day others alſo ſo exceeding ſmall that their Form could not be diſcerned. A few Days after another Sort ſhaped like Fig. 219, its Head terminated almoſt in a Point. After this Infuſion had ſtood a whole Year, another worm-like Animalcule was found therein, repreſented at Fig. 220, whereof A was its Mouth, which was round; from whence iſſued three Fibres to its forked Tail B B, two other Sorts, as repreſented by K L, Fig. 221, were alſo ſeen in this Infuſion.

Sect. VII.

Of the Water found in Oyſters.

A Dozen of *Oyſters* being opened, all their Liquor was put into a clean drinking Glaſs, which in the Space of two Hours appeared to be upon the Fret, and of a fine Pearl Colour, and its Smell like that of the Sea; on applying ſome of this Liquor to the Microſcope after it had ſtood four Days, a great Number of minute tranſparent *Oyſters* * in rapid Motion were obſerved therein. a b c d, Fig. 222, repreſents one of them, of which a is the Head, their Shape altered as they placed themſelves in different Poſitions before the Eye, their Motion was ſometimes direct, at others circular. The fifth and ſixth Day ſome of them ſeemed to be dead; but, on continuing to obſerve them, were afterwards found to move with a prodigious Swiftneſs, one going one Way, another the contrary, often rubbing and ſtopping againſt each other; then being diſturbed by others ruſhing ſtrongly againſt them, altered the State of their Rencounter, and directed themſelves to another Place; they ſtretch out and ſhorten themſelves conſiderably, and are often ſeen coupled as at a and c, Fig. 223, and Fig. 224. Moving together from a towards b, and from c towards d, they turn much ſlower than thoſe in Pepper-Water, and perform their circular Motion much as they do, turning ſometimes on their own Center, and ſometimes

* *Jobl. Obſerv. p.* 20.

on a Point near the Extremity of their Head. This Liquor being obſerved near eight Days, no other Animals than thoſe of the ſame Figure could be found therein.

In Freſh Oyſter Liquor diluted with common Water, were found Animalcules with two moving Horns in each of their Heads, which formed a kind of Creſcent as at e, in others as at d, Fig. 225, but the Horns are ſo tranſparent, that they muſt be viewed attentively, and that for ſome Time before they can be diſcovered.

On putting the Liquor of ſix or ſeven *Oyſters* into a Glaſs Veſſel one Day at Noon, the next Day at Seven a Quantity of theſe minute *Oyſters* were found ſwimming therein, although the Veſſel was ſtopped: Whence it ſeems not improbable, but that theſe Animals were produced from the Eggs of the *Oyſters* themſelves, and that they do not proceed from other Animals that either fly or float in the Air. Six Days after two different Sorts of new *Animalcula* appeared in the ſame Liquor; the firſt are repreſented at Fig. 226, it ſtretches itſelf out and ſhortens itſelf alternately. The ſecond Sort is ſeen at Fig. 227, which moved ſo ſlow that the following Particulars were obſerved; it had four ſhort Legs near its Head, and five longer behind. In the ſame Liquor was alſo found another Sort repreſented at 228.

In other freſh *Oyſter* Liquor were alſo found different Animalcules, as repreſented at i, l, m, n, o, p, q, Fig. 229. m exhibits a Worm with a ſharp Head and round Tail. Thoſe at n and o ſhew two of the ſame Worms joined together, the ſtrongeſt dragging along the weakeſt. At p is ſeen one of another Figure, and at q are two ſmaller, holding each other by the Beak and ſwimming in Company.

SECT. VIII.

Of an Infuſion of Pinks made in common Water both cold and hot.

SOME *Pinks* not quite blown being ſteeped in cold Water, produced living *Animalcules*, which upon Examination with the Microſcope were found to be of the Shape repreſented by Fig. 230. On the ſixth Day appeared a larger Sort, but fewer, being very tranſparent, and ſtrewed with little Spots, Fig. 231. The eighth Day the larger Sort appeared finer and longer than before, and moved after a different Manner; in fifteen Days the Surface of the Liquor was covered with little white Worms, ſomewhat below which was a prodigious Number of minute *Animalcules*. The 28th Day a large Worm ſhewed itſelf under the Form of Fig. 232. The 48th ſome *Eels*, like thoſe in Vinegar. The 50th Day a little white Worm was

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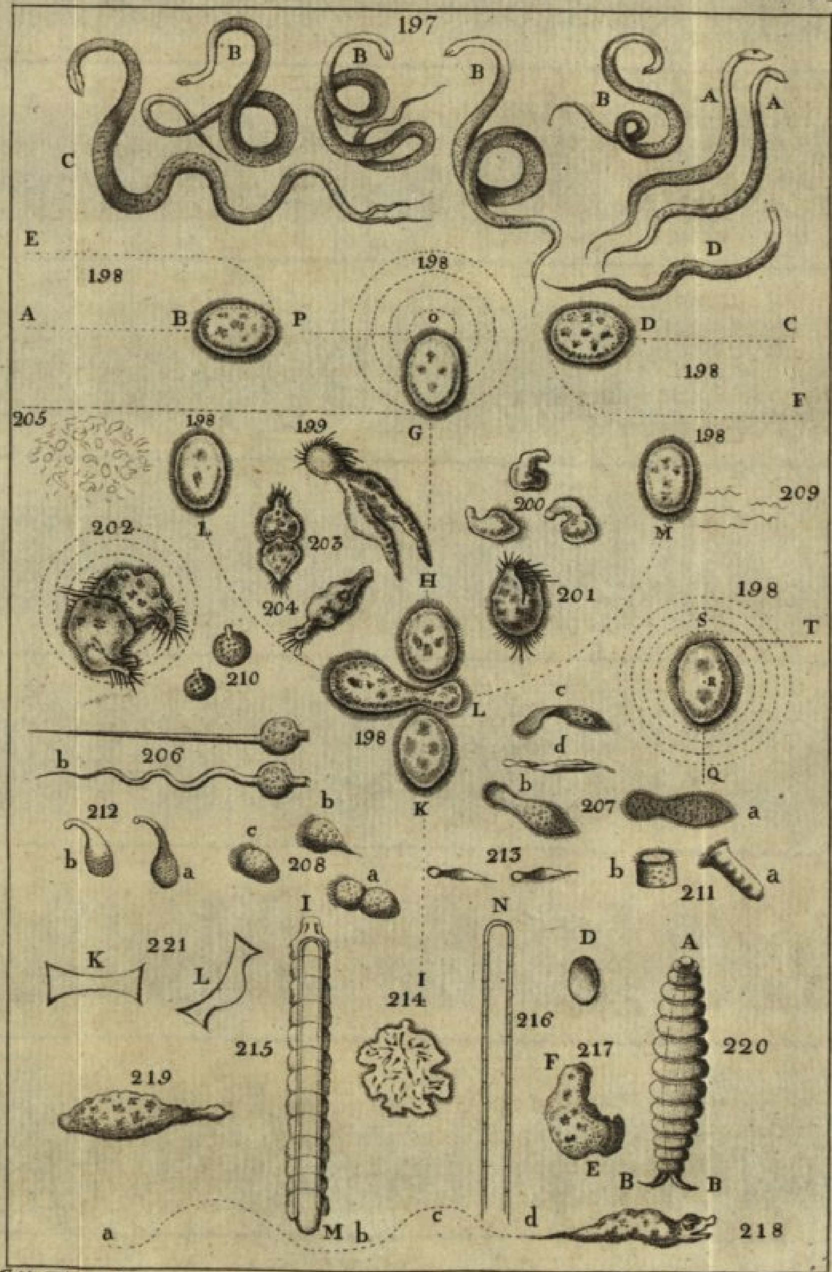
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taken upon the Surface of this Water, * its Body ſo tranſparent, that ſeveral little white Fibres were diſcovered therein, the two middlemoſt of which being a little ſeparated, and proceeding from the Extremity of the Body, run parallel to each other, and are united by an Arch near the Head: It hath two black Eyes, and two Hooks in the fore Part of its Head, as repreſented at Fig. 233. At G of the ſame Fig. is ſeen another of a curious Form, found alſo in this Infuſion.

Some *Pinks* being infuſed in boiling Water, which in eleven Days Time ſwarmed with *Animalcules*, but very ſmall, and on the 15th Day were not to be found, only ſome Worms might be ſeen on the Surface thereof with the naked Eye.

SECT. IX.

Of a cold Infuſion made of a Noſegay, compoſed of Pinks, Roſes and Jeſſamin.

THIS Infuſion was made the 11th of *May*, and the *Noſegay* cut into Pieces for the better placing it in the Veſſel, and in about three or four Days a great Number of minute Animalcules, and ſome larger ones, were found therein; their Figures, Colour and Motions are ſo various, that it would be a Taſk too long to undertake a Deſcription thereof. Nevertheleſs I cannot paſs over in Silence, an Animalcule that was found in this Liquor on the Beginning of *September*. It conſiſted of three diſtinct Parts, Fig. 234. The firſt Part A is its Head, which advances and retires by Jerks. B, the Trunk of its Body, and C its Tail, it is of a tranſparent White, and often draws its Tail in, at the End of which are two black Hairs D D.

SECT. X.

Of an Infuſion of Blue-Bottles.

THE Stalks of a large Noſegay of *Blue-bottles* with ſome of the Flowers, were put into cold Water on the ſecond Day of *June*, and at the ſame Time ſome of the *Flowers* by themſelves were put into a Glaſs of Water; in 12 Hours Time the Microſcope diſcovered ſeveral Animalcules of the Form of Fig. 235, in a ſmall Drop of this Liquor. And the next Evening four other Sorts, very tranſparent, of an oval Figure, unequal in

* *Jobl. Obſerv. p.* 28.

Size,

Size, and different in their Motion. The 5th of the ſame Month, another Sort of the Shape of Fig. 236. appear'd therein; and on the Sixth a new Sort, A B C, Fig. 237. with an oval Head, and a Tail, which terminated in a Point, being five or ſix times longer than its Body. On the ſeventh Day, one of theſe laſt was obſerved to drag after it a Bunch of the Sediment of the Infuſion, which ſunk to the Bottom of the Concave, upon which the Drop of Liquor was placed for Obſervation. It is very pleaſant to behold ſo ſmall an Animal endeavouring to pull this Bunch about, which he is ſcarce able to move, as at I, drawing himſelf back, and wriggling its Tail, as at M. Sometimes five or ſix of theſe *Animalcules* may be ſeen faſtened by the Tail, to a great Bunch of this Sediment, that ſticks to the Bottom of the Object carrying Glaſs, drawing themſelves nearer to, and retiring farther from it by Turns. During this Exerciſe, they change their firſt Figure, and recover it again alternately; and as their Tail is naturally ſtrait, as at I, they endeavour to drag the Lump after them in a right Line.

It is remarkable, that extremely hot Weather kills them, and in five or ſix Days they are ſucceeded by others.

We have no Reaſon to doubt, but theſe minute *Animalcules* are furniſhed with Eyes, for two of the ſame Figure are often ſeen to approach each other without touching, and then turning with a prodigious Swiftneſs about their own Center.

Another Sort is ſometimes found in this Infuſion, whoſe Extremities are terminated by two plane Surfaces, parallel to each other, as at Fig. 238.

SECT. XI.

An Infuſion of Tea.

HAving put into the Tea-Pot, as much *Tea*, and a ſufficient Quantity of boiling Water, as would make ſix large Cups, on the 15th of *July*; the *Tea-Leaves* which remain'd after the hot Infuſion, were put into a large Glaſs Jar, filled with Spring-Water, and expoſed to the open Air for about ten Days; after which, in the leaſt Drop that could be taken up, when applied to the Microſcope, were found a Swarm * of exceedingly minute *Animalcules*, of a round Figure, moving ſlowly. Some Days after they were fewer in Number, but increas'd in Size, clearer, much more diſtinct, and of an oval Figure, as at Fig. 239. the Circumference of their Body appear'd black, but all the reſt perfectly white and tranſparent, and now ſwam with a ſurprizing Swiftneſs. Their Bodies were of ſo delicate

* *Job. Obſer. p.* 34.

a Con-a Consistence, as that their natural Figure was preserved for the Space of two or three Minutes after they were dead.

The 23d of *September*, three other Sorts of more minute *Animalcules* were found in this Liquor, and some of the Eel-Kind also.

Sect. XII.

An Infusion of Rasberry Stalks.

THIS Infusion is one of them which does not cause a disagreeable Smell, nevertheless it produces in about 24 Hours Time, the finest * *Animalcules* that are to be met with in Fluids, and in as great Numbers. Their Representation is at o o, Fig. 240. they are at first very white and transparent, but more so in some Places than in others, with little Marks upon them, and at length this Whiteness changes into a transparent yellow Colour. They may be seen stretching out, and shortening themselves from oval to round, by Means of Obstacles, which they find in their Way. They are often seen to hold each other by the Beak, and in that Posture they move exceeding fast, without quitting their Hold, as at P. Another Sort of *Animalcule* was found in this Infusion, of the Shape represented at Q; between the Middle of its Body, and the Head, was a transparent Substance, regularly beating, but so quick, that the Shape of it could not be discern'd.

Sect. XIII.

Infusions of Fennel, Sage, Melon, sour Grapes, Stalks, and Leaves of Marigolds.

FEnnel, with its large and small Stalks, was put into cold Water to infuse, *August* 11. and on the 13th following, in the smallest Drop that could possibly be taken up, and placed upon the Object carrying Glass, might be seen a Swarm of an almost innumerable Quantity of little Animals, represented at Fig. 241. amongst which were others of a round Figure, and about five or six times longer.

The 22d of *August*, some Sage Leaves were infused in cold Water, and retain'd their natural Smell all the Time of the Infusion, which was about 12 Days; nothing was seen in this Liquor but some little *Animolcules* † that appear'd no bigger when magnified, than a Grain of Millet does to the naked Eye; and an infinite Number much smaller, that when magnified, appear'd no bigger than the smallest Dot that can be made upon Paper, with the finest Pen, and a little below the Surface of the Liquor, was found three very small but white Worms.

* *Jobl. Obs. p.* 35. † *Ibid. p.* 37.

The 28th of *September*, in a Drop of this Infusion, was found two Sorts of minute *Animalcules*, represented at Fig. 242.

The 22d of *August*, some *Barberries* were put into cold Water, which produced *Animalcula* of the Shape of T, Fig. 243. in 24 Hours Time.

The 25th of the same Month, a Bit of the *Rind* of a *Melon*, with a little of the *Pulp*, and a few of its Seeds were put into cold Water; the next Morning appear'd some fine transparent *Animalcules*, whose Form is shewn at V, Fig. 243. Many little white longish Bodies were also found therein, whose Figures are seen at X; and other less Bodies marked T, without any sensible Motion.

Some *sour Grapes* were also infus'd in cold Water, on the 14th of *August*, and on the 20th, a great Number of *Animalcules* appear'd therein, but so exceedingly minute, that their Shape could not be distinguished; on the 25th two Sorts presented themselves, one as small as the last; the other at Y, Fig. 244. The 4th of *September* these little *Animalcula* were exceedingly multiplied and increased in Size, some of them were join'd together in the Form of a Figure of 8, as at P, Fig. 244. and moved sometimes circular and sometimes in a right Line; on the 8th of *September* were found upon the Crust, which swarm upon this Infusion, some minute Worms, and also in a Drop of the Liquor a considerable Quantity of other Eel-like *Animalcula*.

On the 25th of *August*, some of the Stalks and Leaves of *Marigolds*, were put to steep in cold Water, and eight Days after there was three Sorts of Animalcula found therein; the first is represented at Z, Fig. 245. the second at R, of the same Figure; and the last, for which there was no Room in this Plate, were of the Eel-Kind, different from those in Vinegar, and different also from those in Paste.

SECT. XIV.

First Infusion of new Hay in cold Water.

THIS Infusion stood but 24 Hours before it was filled with Life, and at the End of five or six Days, in the most minute Drop of this Water, five or six Sorts of living Animalcula were discoverable; different in Colour, Size, Figure, and Motion.

The Smell of this Infusion is very strong in hot Weather, but decays as the Infusion grows old, Animalcules are very rarely to be met with in any other Infusion that are larger, finer, more transparent, or that live so long as those found in this.

SECT.

Sect. XV.

The ſecond Infuſion of new Hay.

THE 4th of *October* ſome new Hay being put into cold Water in two different Veſſels, one of which was ſtopped cloſe with a Piece of Vellum, made very wet, and the other left open: Two Days after, three Sorts of Animalcula were diſcover'd in each Infuſion, and alſo a ſufficient Quantity of them: This Experiment is a Proof, that thoſe Animalcules were produced from Eggs, which had been depoſited by their parent * Animals upon the Hay, and alſo that they were not wafted thither in the Air.

The 10th of the ſame Month, more of theſe Animalcula were found in one Drop of that Infuſion, which had been covered, than could be ſeen in the like Quantity not covered.

Sect. XVI.

The third Experiment made upon the ſame Hay.

THE 13th of *October* ſome of the ſame *new Hay* was boiled in common Water, above a Quarter of an Hour, and an equal Quantity of it put into two Veſſels, nearly of the ſame Size, one of which was immediately cover'd, even before it was cold, and the other left open, in which was found ſome Animalcula, at the End of a few Days, and not one in the Infuſion, which had been covered; † after which great Care was taken to keep it cloſe for a conſiderable Time, to try if there were any living Animalcula therein, but none could be found, at length it was left open, and in a few Days, ſome Animalcules were found therein, which determined that theſe Animals proceeded from the Eggs of their parent Animals, wafted thither in the Air, ſince thoſe which had been brought there in the Hay, were totally deſtroy'd by its being boil'd in Water.

Sect. XVII.

A Compoſition of ſeveral Infuſions mixed together in one Veſſel.

TAKE equal Parts of an Infuſion of *Senna*, of *Raſberry Stalks*, and of *Hay*, &c. mix theſe all together, and half an Hour afterwards take as uſual a ſmall Drop of this Mixture, which being put upon the Object carrying Glaſs,

* *Jobl. Ob. p.* 39. † *Ibid. p.* 40.

and placed before the Microscope, will give you the Pleasure of seeing in this little Drop, the Animalcula of all the Infusions you have mix'd together. * And here it is proper to take Notice, that all these different Animalcula cannot subsist long in this Mixture, each being desirous to remain in its first Infusion, therefore all Sorts of Infusions are not proper to afford the Pleasure of this Sight, for they ought to contain in them something upon which the Animals can subsist.

SECT. XVIII.

An Infusion of Rhubarb.

Rhubarb is a purgative Drug, and must be a long Time infused in Water, before any Animalcula can be found therein, or any disagreeable Smell, for in about five Weeks there was found only one Sort of Animalcula, which does not merit a particular Description; we shall only say that the Mixture of a Drop of this Infusion, with as much of that of *Senna*, does not destroy the Animalcula in either; and that at the End of 15 Days the Animalcula in the Infusion of *Rhubarb* † were all dead.

SECT. XIX.

Of an Infusion of Mushrooms.

A Large *Mushroom* being infused in cold Water, produced from one Day to another an astonishing Multitude of infinitely small Animalcules, of a round Figure, which appear'd in a Microscope that magnified twenty-five thousand times, of the same Size, that a Grain of Rape-Seed does to the naked Eye ‖.

The third Day some of a larger Size were found therein, with a crooked Neck, and very transparent; soon after a third Sort was discovered of an oval Figure, and fluttering Motion.

SECT. XX.

Of the little Flowers of different Colours that are found in Meadows.

If some of these *Flowers*, when they are just blown, be put into cold Water, in a few Days a particular Sort of Animalcule will be found therein, resembling the Sole of a Shoe, one of which is represented at Fig. 246. Its Motion

* *Jobl. Ob. p.* 40. † *Ibid. p.* 48. ‖ *Ibid. p.* 48.

tion is ſlow, and its Head directly under the Letter A; it inclines itſelf towards B and C, ſtretching itſelf out, and contracting alternately; ſometimes all its Body appears as round as a Bowl, at which Time the Surface thereof is uneven: Their Body is marked with longiſh Spots, and is ſo tranſparent, that all their Inteſtines, and the periſtaltick Motion may be diſtinguiſhed, which are a very agreeable Sight. * Theſe larger Sort appear at the Beginning of the Infuſion, but at the End of fifteen Days, a great Number of thoſe repreſented at Fig. 247. was ſeen therein, which is contrary to what generally happens in other Infuſions, where the ſmalleſt appear firſt.

SECT. XXI.

Of an Infuſion of ſweet Baſil, which ſmells like Citron.

THREE Sorts of Animalcules ſhew themſelves in a few Days after ſweet Baſil hath been infuſed in common Water; the firſt are ſeen at A, Fig. 248. the ſecond at B, and thoſe of the third Sort almoſt like that repreſented at C. This laſt ſwims in a ſpiral Line, folding and unfolding its Body every Way.

A, B, C, Fig. 249. repreſent the Animalcules found in the Infuſion of new Hay, the Colour of one, and Figure of the other, was the Occaſion of calling one golden, and the other ſilver Bag-pipe. That Sort repreſented at D E, are called Clubs; the Head whereof is ſeen at D. Theſe Animalcules extend and contract, twiſt and untwiſt themſelves ſeveral Ways.

SECT. XXII.

Infuſion of Blue Bottles.

FIG. 250. repreſents a new Sort of Animalcula found in this Infuſion of *Blue Bottles*. A ſhews the Head, B its Tail, C D its Breadth, which ſeems divided throughout its whole Length by a curved Line, drawn from B towards A, that Part of the Body marked C, ſeem'd to be filled with ſeveral little Globules, leſs tranſparent on this Side, than on that marked D; the Neck of this Animal, which is very long, ſhortens itſelf from Time to Time, as does alſo the hinder Part, marked B. † It ſwims extraordinary ſlow, and does not live upon the Object carrying Glaſs above 5 or 6 Minutes, but two of theſe were diſcovered in 5 or 6 Drops, and the ſecond, Fig. 251. was ſomething different from the firſt, for its Body B C was furniſhed with little Globules, that render'd it leſs tranſparent than the firſt was, at A B and C D.

* *Jobl. Ob. p.* 49. † *Ibid. p.* 51.

SECT. XXIII.

Infusion of old Hay.

IN this Infusion were two Sorts of Animalcules that merit a particular Description. The least is seen at Fig. 252. it was of a transparent White; A its Head, B its forked Tail, with which it pushes itself forward; and it swims so steadily that no particular Motion of its Body can be discerned.

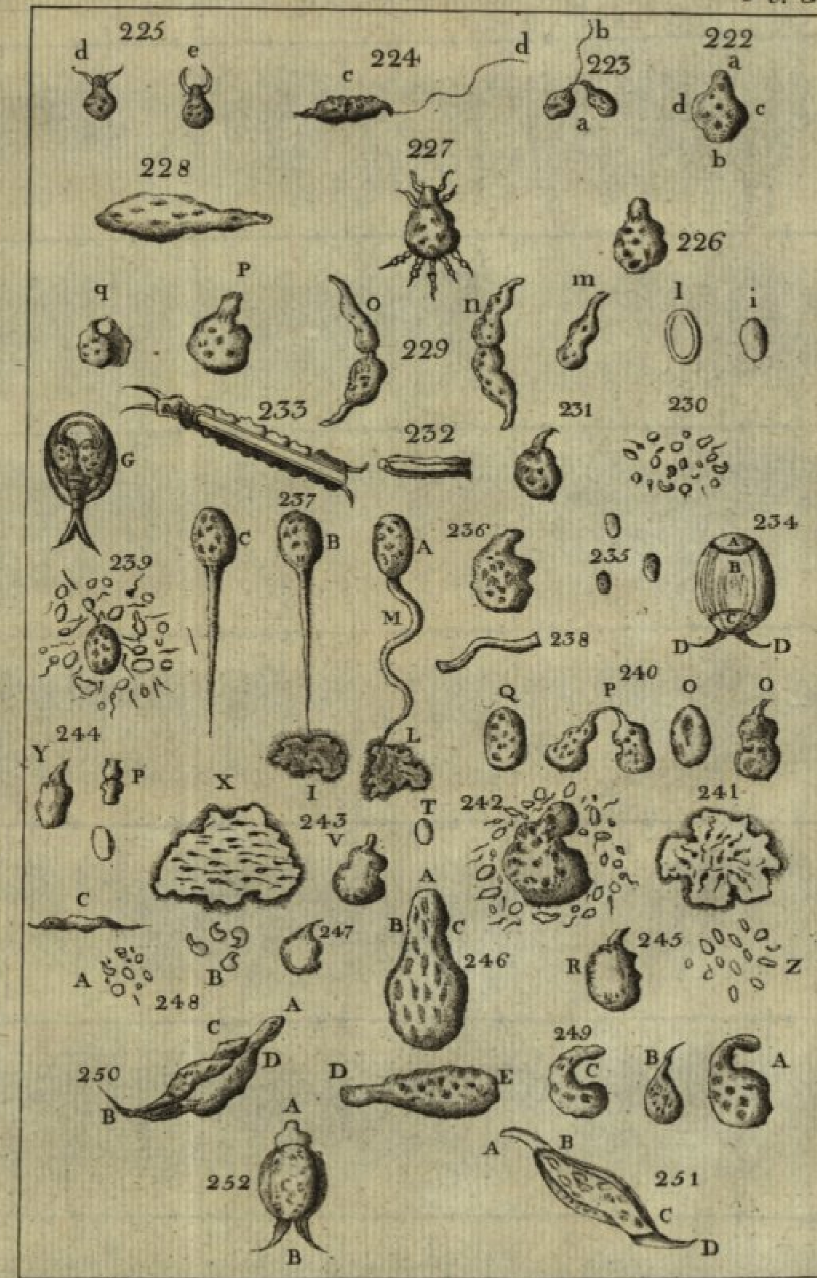
The second Sort are more extraordinary and surprising, as well in Size as other Circumstances; two of them are represented at Fig. 253 and 254, marked A, C, D B, and A C E F B; A shews the Head, B its forked Tail, C its Heart, which may be seen in a regular Motion, and D its Intestines. It is called an *aquatick Caterpillar*, there are two different Colours of them, one of a transparent White, the other of a pale Yellow. In moving on the Object carrying Glass, they first fix the Points B, and then extending their Body as much as possible, rest the fore Part upon another Place, and draw up the hinder Part, and then again fix the Point B as before and so on; they also fix the Points of their Tail to the Object carrying Glass, and stretch out and retract themselves by Jerks, and sometimes turn round about upon the Point B, at other Times they spring forwards with a sudden Jerk, and swim about for some Time.

When they rest themselves, they commonly open their Mouths very wide as at A, Fig. 254. its Lips also are furnished with Hairs, as expressed in the Figure, which move very quick; it is really surprising to see how hastily they swallow down other smaller Animalcula that happens to be within the Reach of their Mouths. At certain Times all the Hairs at the hinder Part of their Body which stand upright, are seen to lie down from EF to B. The Circumference of the Body seemed indented like the Teeth of a Saw, which upon a closer Examination was discovered to be Ringlets lying one over another, coming out with a surprising Swiftness, and sometimes even the nervous Fibres were visible, extending from Head to Tail, swelling and contracting alternately as they crawled along.

A Mixture of the Infusions of Hay and Celery, does no Hurt to either of the Animalcula of the two Liquors; but the least Drop of this Mixture affords a very pleasant Prospect to the Spectator, who will in an Instant discover Variety of these fish-like Animalcules of different Sorts, moving in all Directions.

See also a Design of another aquatick Caterpillar at Fig. 255. it was fished out of an Infusion made of the Stalks of a Nosegay composed of Pinks, Jessamin, Tuberose and other Flowers; this differs from the foregoing: First,

Pl. 33.



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first, in being longer; second, that its Tail marked I, is composed of three Points instead of two; third, that it hath two little Arms L M, one on each Side its Heart a; fourth, that its Intestines marked b are without any visible Separation; and lastly, that neither Ringlets, saw-like Teeth, nervous Fibres, nor Hairs in the Length of its Tail could be discovered in this Animalcule, but in all other Respects it was the same as the foregoing *Caterpillar*.

SECT. XXIV.

An Infusion of Citron Flowers.

IN *August* some of these Flowers were put into cold Water, in a few Days three Sorts of Animalcules were seen therein, which did not merit a figurative Representation. But some Time after others appeared, called Tortoise, one of which is represented at Fig. 256. Its Head, though large, is very short, and adorned with two Horns like those of a Deer: Its Body seemed to be covered with Scales, its Tail very long, and swift in Motion.

SECT. XXV.

Infusion of Animony.

NAture is pleased to diversify all her Productions, and is surprisingly admirable in all her Works, by continuing to give us Proofs thereof in this Infusion of *Animony* prepared after the ordinary Manner with cold Water, which at the End of eight Days afforded a new Animalcule, represented at Fig. 257.*

All the Surface of its Back is covered with a very fine Mask in Form of a *human Face* perfectly well made, as appears in the Figure. It hath three Feet on each Side, and a Tail coming out from under the Mask.

SECT. XXVI.

Infusions of three different Portions of Celery Stalks and Leaves, put separately into different Glasses.

ON the 1st of *November* some of the Stalks of *Celery* were broke into little Pieces, and put into the first Glass, and common Water poured

* *Jobl. Ob. p.* 57.

thereon,

thereon, and alſo upon the green Leaves in the ſecond Glaſs, and in the third Glaſs ſome Pieces of the Stalks with ſome of their Leaves with Water.

Seven Days after theſe Preparations, ſome Animalcules were found in each of them, two Sorts in the firſt, and but one only Sort in both the other: But in about a Month's Time all the three Infuſions contained ten different Sorts both in Shape and Size.

Thoſe of Fig. 258, and 259, are the ſmalleſt; but in Number they exceed all the other, when coupled they reſemble a Figure of 8, as at a, Fig. 259. Theſe alſo are called *Bag-pipes*; they couple by the Beak, which is a little crooked and ſharp, and notwithſtanding this Coupling they ſwim very faſt, diving to the Bottom of the Drop of Liquor which is placed upon the Object carrying Glaſs, and riſing up again to the Top thereof alternately; they ſeparate from, and approach each other, without Intermiſſion. Theſe *Bagpipe-like* Animalcules are not entirely alike; but there is in theſe as in all other Animals, different Sorts of them.

Some of them ſwim alone with a ſurpriſing Rapidity, while others advance with a moderate Swiftneſs, ſome go very ſlow, and others reſt quiet for a long Time together; but the greater Part of them are in a perpetual Agitation, ſome of them are long, ſome ſhort, others as white as Silver, ſome of a golden Colour, and others brown.

It is a ſingular Curioſity to obſerve what paſſes upon the Surface and all around the Circumference of a Maſs of Matter which hath formed itſelf into a very little Bit of thin Skin, ſo ſmall, that the beſt Eyes are not able to ſee it without a Microſcope: They are found by Chance on the Surface of the Infuſion, and are generally faſtened to the End of the Stalks. If a Bit thereof be taken out with the Point of a Pin, and placed upon the Object carrying Glaſs before the Microſcope, there will be ſeen Swarms of all theſe Animalcules we have been ſpeaking of. There are ſuch great Numbers of them moving with ſo much Celerity, that it is troubleſome to turn the Eye upon a Sight ſo new and ſurpriſing. In certain Places thereof there are ſeen ſome differently coupled. Others alſo, that reſt themſelves, and keep the Watch as Soldiers do, which ſeem apprehenſive of being ſurpriſed; whilſt others go out a good Way from the Maſs as though they would make ſome Diſcovery, then they return again as if they had ſomething to relate to thoſe which kept the Watch, and this is ſeen all round the Maſs.

In another Drop, taken from another Place of the ſame Veſſel, has been often ſeen another new and curious Sight, *viz.* that Sort of Animalcula which are long and flat, called Soles, and are repreſented by A B C D, in Fig. 260. The Sides of this Animalcula is very ſharp; the Head and all the reſt of its Body is tranſparent, except a few brown Spots which appear within. The different Poſtures, and the Variety of Motions obſervable in theſe Animalcula, cauſe much Pleaſure in beholding them through a *Microſcope*,

croſcope, and afford much greater Satisfaction than can poſſibly be imagined by reading the moſt particular Deſcription of them.

In the Glaſs where only the Leaves were infuſed, there were amongſt others ſome Animalcules like thoſe expreſſed at E, F, G, Fig. 261, at one End of each of theſe Figures may be ſeen a conſiderable Opening which is their Mouth, and appears ſometimes round as at F, and ſometimes ovaliſh as at E and G; at other Times it is ſo firmly cloſed as not to be diſcovered. It ſwims by Jolts, and Ballancing from Right to Left, conducting itſelf in Appearance by a circular Motion of its Head. It alſo changes its Figure by folding, unfolding, and ſuddenly rolling itſelf up in the Form of a Ball, and then alternately ſtretching out again very quick into its natural State.

There is another Sort of Animalcula that appears to have neither Head nor Eyes, and are repreſented at H I K, Fig. 262. their Body ends in a long tranſparent Tail, and Motion generally very ſlow. They are frequently obſerved to have a Bit of the Skin (which is formed on the Surface of the Infuſion) ſticking to their Tail as at L, ſometimes they drag it after them, at other Times it happens to ſtick to the Object carrying Glaſs, at which Time they draw themſelves back on a ſudden towards it, and then ſtretch out again very ſlowly.

In the leaſt Drop that could be taken up from the third Glaſs, wherein the Leaves, Stalks, and Roots were mixed, was ſuch an infinite Number of thoſe little Animalcula repreſented at Fig. 258. that they could ſcarce find Room enough to paſs between each other.

There was alſo a large oval Animalcule, as at M N, Fig. 263. its Head could not be diſtinguiſhed.

In a ſecond Infuſion of the Leaves of Celery was a new Animalcule, repreſented at Fig. 264. its Head is ſeen at O, and is beſet with long Hairs that move alternately, its Motion is ſlow and Figure uncertain, appearing ſometimes under the Form of a Bag-pipe, and at others, under that of a Croſs.

Fig. 265. repreſents another Sort of Animalcule of a ſpheroidical Figure. Another Sort at Fig. 266. and others like Fig. 267. this laſt moves with a ſurprizing Velocity, and frequently turns itſelf upſide down.

Amongſt other Infuſions of Celery, was found an Animalcule in the Shape of a Bottle, as at Fig. 268. Fig. 269. exhibits another Sort of the Bagpipe-like Animalcules, two of which are ſeen at P, differently coupled from any of the foregoing.

Laſtly, at Fig. 270. is repreſented a moſt extraordinary Animalcule, almoſt round, its Body cover'd with Hairs and Motion circular.

Sect. XXVII.

Of Infusions of Straw and the Ears of Wheat.

IN the Beginning of *March*, ſome wheaten Straw, and two Ears of Wheat were put into cold Water, the ſecond whereof produced Animalcules, of the Shape of Fig. 269.

Others alſo were found therein, repreſented at Fig. 271. its Mouth is ſeen at A, the Inſide of its Body was filled with a Quantity of little white and brown tranſparent Corpuſcles.

A third Sort is repreſented at Fig. 272. turning according to the Order of the Letters A B C, and moving ſlowly, its Colour like that of unpoliſhed Silver, ſtrewed with little brown Spots. Its Head is ſeen at A, Tail at B, and Back at C.

Another Sort of Animalcule is ſeen therein of an oval Form, and one called a golden Bottle, repreſented at Fig. 276. its Mouth is ſometimes fixed to a round Body, to which it ſtrongly adheres, as at Fig. 273.

Another Sort called *Soals*, contracting and ſtretching themſelves out as they ſwim along, which is very quick, are repreſented at Fig. 274.

See alſo another Sort, at Fig. 275. their Mouth is at A, which is ſometimes extended to a great Width. B C is the Tail.

Fig. 277. repreſents an Animalcule with a Swan-like Neck. A is its Head; B its Tail, and C its Body. They are of two Sorts, one very tranſparent, and the Inſide of the Body of the other browniſh. Their Inteſtines may be ſeen in Motion.

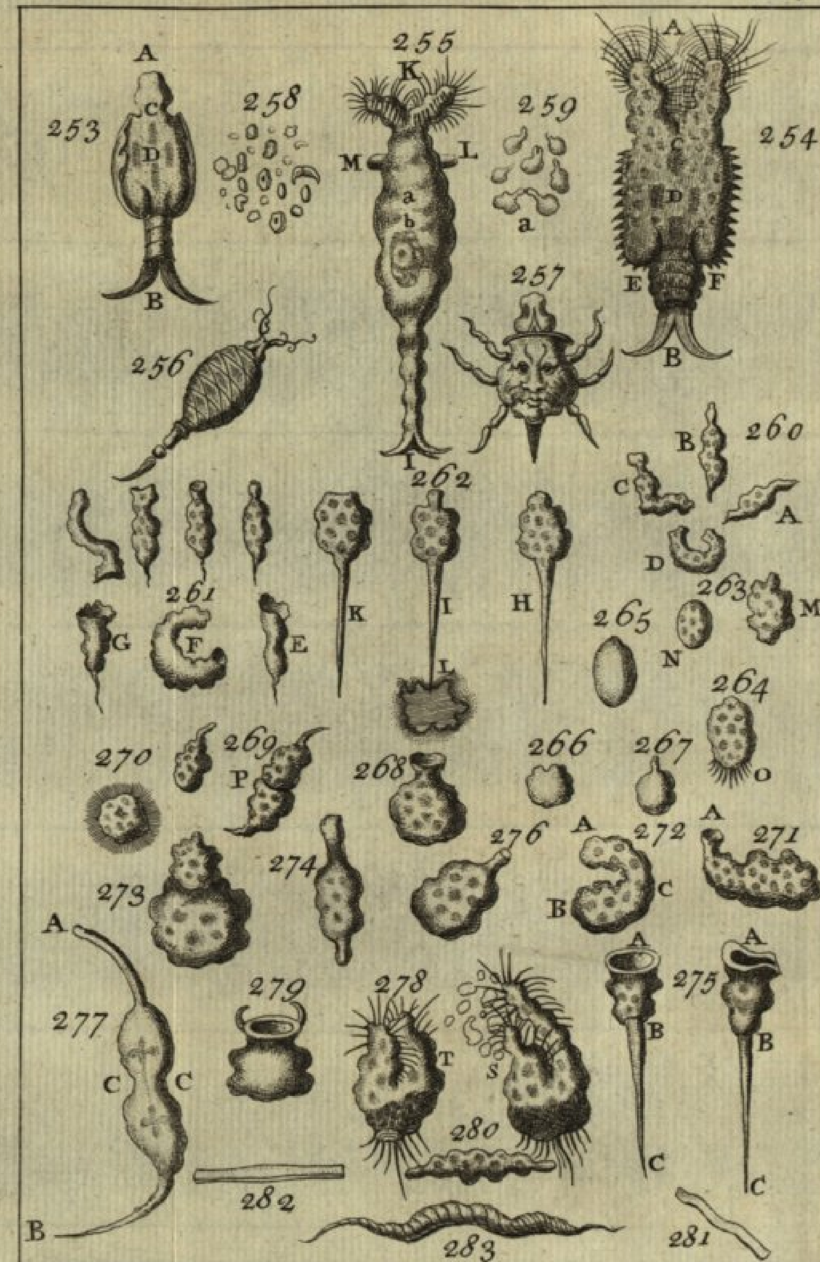
The Animalcula S and T, Fig. 278. are thoſe which were before call'd *Water-Spiders*, or rather *greedy Guts*, from the Quantity of other minute Animalcula they ſwallow.

That repreſented Fig. 279. is the only one of its Sort found in the Infuſion of wheaten Straw. Its Figure is like a Purſe, its Mouth large, and here repreſented open; but when it ſtretches itſelf out for ſwimming, it is ſo neatly ſhut, as to encloſe its Horns.

Fig. 280. exhibits an Animalcule, called a *little Soal*; and at Fig. 281, and 282. are two others that move extreamly ſlow; and are 1000 times ſmaller than an Hair *.

Fig. 283. repreſents a Worm-like Animalcule, compoſed of a great Number of very ſmall ſpiral Rings, whoſe Extremities are terminated in very long, and exceeding fine Points.

* *Jobl. Obſ. p.* 67.



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Sect. XXVIII.

Of aquatic Pomegranates.

THIS Name of *aquatick Pomegranates*, *crowned* and *bearded*, is given to the Animalcula, which are repreſented by the Figures 284, 285, 286, 287, 288, and 289, becauſe their Shape in ſome Meaſure reſembles that Fruit; * they were found in a ſmall Drop of an Infuſion of wheaten Straw, and ſeen with a Lens, $\frac{1}{8}$th of an Inch Focus.

They appear'd of a fine tranſparent amber Colour, which therefore affords a curious Sight of their Inteſtines, the ſeveral Forms under which this Animalcule appears, require a particular Deſcription, which take as follows:

In Fig. 284. under the Letters A B C D, are ſhewn four little Eminencies, adorned with Hairs, which remain but a ſhort Time in this Situation, for that marked B joins A, and C unites with D ſo cloſely, that they then appear as at A D, Fig. 285. Theſe increaſed Eminencies, form the ſeparated Lips of this Animalcule, and the regular Motion of the Hairs with which they are adorned, obliges all minute Bodies, at a ſmall Diſtance from theſe Lips, to enter into its Mouth. Part of which is alſo as ſtrongly repelled, as it was greedily ſwallowed.

All the Protuberances A, B, C, D, of Fig. 284. or the two of Fig. 285. contracting themſelves a little towards E, diſcover a Sort of Crown, with four Points, repreſented at Fig. 286. which are preſently cover'd again with theſe Eminencies, and then expoſed again, and ſo on.

In each of theſe Figures, at E, is ſeen a regular Pulſation, ſuppoſed to be its Heart; it ſeems to be embraced by two Lobes, that ſeparate and join alternately, which probably are the Lungs; from theſe proceed two little Ligaments at G, towards the Inteſtines, whoſe periſtaltick Motion is alſo very regular.

The Tail of this Animalcule appear'd ſometimes round and cloſe, at other Times open, when two little Points, as at H, Fig. 284. might be ſeen.

One of theſe Animalcules had four of thoſe ſharp Points, Fig. 287. placed two on each Side the Anus; between which a long Tail I L is protruded, and drawn in again with great Swiftneſs: The End L, in ſome of theſe Animalcules, appeared forked, as Fig. 285. the Tail can be entirely drawn into the Body, at which Time the Rings that compoſe it, ſlide one over the other, and cauſe it to become opake.

* *Jobl. Ob. p.* 68.

 Their

Their Eggs are frequently ſeen faſtened to their Breech by ſmall Threads; ſome of the Females carry but one, as at M, Fig. 289. others two, Fig. 285, and ſome others ſix, Fig. 286; but this is ſeldom, and then alſo they are ſmaller. They rub their Eggs with their Tail, which as it enters into, and goes out from the Body, turns from one Side to the other with a great deal of Pliableneſs; thoſe Eggs which are full, appear hanging down, and are very regular and bright, thoſe that are empty are ſeen quite flat, and of an oval Form, and more tranſparent than the others, and although empty, their Mothers carry them almoſt always faſtened to their Breech, as at Fig. 286. Two of theſe Eggs were ſeen in the Body of one of theſe Animalcules, and appeared as at G G, Fig. 288.

Theſe Animalcules are a delightful Object for the Microſcope, particularly when they tumble over Head and Tail, becauſe they do it dextrouſly. Some turn themſelves circularly, as much on one Side as the other, and about the Point F, which is the Center of Gravity of their Bodies.

SECT. XXIX.

Infuſion of the Bark of an Oak.

SOME of this Bark being put into cold Water, the 15th of *December*, and examined ſeveral Times for the Space of a whole Year, during which Time the following Animalcules were diſcovered. The firſt was called a Tortoiſe with an umbelical Tail, Fig. 290. This Inſect ſtretches out and contracts itſelf very eaſily, ſometimes aſſuming a round Figure, which it does not retain above a Moment; then opening its Mouth to a ſurprizing Width, forms nearly the Circumference of a Circle; its Lips are furniſhed with Hairs, whoſe Motion is very pleaſant, becauſe it obliges ſome of the adjacent little Bodies, to precipitate into its Stomach, where that which is fit for Food remains, while the other is repelled with great Velocity; its Motion is very ſurpriſing and ſingular.

Fig. 291. is another Sort of Animalcula with an umbelical Tail, differing only from the former in having its Mouth fixed, and Tail without any Separation.

Fig. 292. repreſents another of the ſame Sort, although under a Form ſomewhat different; the Top of its Head is double, and two Prominencies appear thereon under the Form of Horns, which were intirely covered in the other.

That repreſented at Fig. 293. is called a Water-Rat, its Head well ſhaped, and Lips adorned with long Hairs.

Another Sort at Fig. 294. is called a Crab's Claw, becauſe of its two crooked

crooked Beaks, whofe Motion as well as that of its Body is very flow, its Body is adorned with a great Number of fhining Globules.

Fig. 295. is called a Club, its Head large in Proportion to its Body, which ends in a Point, the Infide of which is ftrewed with little Grains both tranfparent and opake.

That Sort exhibited by Fig. 296. is called a Silk-worm's Bag, becaufe its Body is compofed of feveral Rings and longitudinal Fibres, the Shape of its Head is fo nearly like that of the Tail, that it can only be diftinguifhed by its Swimming.

The Animalcule, Fig. 297. is called a Spheroid, its Head is feen at A, a little below which may be feen its Heart regularly beating; and feveral round Bodies of different Sizes, which probably were its Eggs.

There are in this Infufion feveral Sorts of Eels, different amongft themfelves, and different alfo from thofe found in Vinegar.

Fig. 298. reprefents one of them very thick with refpect to its Length, which was ftored with a confiderable Number of exceeding fmall Fibres, and others alfo that ran fpirally from near its Head towards the Tail.

At Fig. 299. is exhibited another kind of Eel-like Animalcula of great Vivacity.

Another of a larger Size is alfo reprefented at Fig. 300. that had been dead for fome Time, when by Chance a little Eel * was difcovered fluttering very much to get out of the Belly of its Mother, but not being able to do it, at laft died therein.

This Obfervation is a fufficient Proof that the Eggs of thefe Eel-like Animalcula are hatched in their Mother's Body.

Fig. 301. reprefents an Animalcule, called a Weaver's Shuttle; it fwims fmoothly, having in the Middle of its Body feveral little Corpufcles refembling Eggs.

Fig. 302. is called the Beak of an Halbert, its Head ends in a Point; the other Extremity of its Body is like a Drop, and upon the Throat are feveral long Hairs.

Fig. 303. is called a Water-Spider, it is of a fpherical Figure, with feveral brown parallel Lines; between which are fome Spots browner than the reft of their Bodies.

Fig. 304. is called a Drop, its Body uniform and tranfparent, its Neck long, but a little crooked.

Fig. 305. is called a Slug, its Head is round, Tail fharp, Body large in Proportion to its Length, and becomes fo fhort in Motion as to appear pretty regular.

Fig. 306. is called a Water Caterpillar, they are found of different Sorts, and in feveral Infufions of Plants it has been before obferved, that the

* *Job. Ob. p.* 76.

Hairs,

Hairs, of which we have elsewhere spoke, are planted on the two Lips of this Caterpillar, which seem to turn at certain Times like the Rowel of a Spur.

Fig. 307. is called the great aquatic Spider, its Figure somewhat ovalish, Mouth a little sunk, which appears sometimes to reach to the Middle of its Body, its Lips are adorned with Hairs in Motion, which seem to have a Communication with a little Part that probably may be the Heart, and Lungs surrounding it; its hinder Part is also furnished with Hairs that form a kind of Tail; a little above the Anus is a brown Spot, supposed to be the Excrement; the rest of their Body is generally stored with little regular Corpuscles.

This Sort of Animalcule is also found in Iufusions of *wheaten Straw*, in that of *Barley* mixt with some of the Ears; in *Turkey Corn*, *Indian Cane*, in the *Wood* and *Bark* of *Acaias*, or in that of *whole Pepper*, &c. All these different Sorts of Water-Spiders, have Hairs round their Body, inclining a little from their Head towards their Tail, and may be seen with a Lens of $\frac{1}{12}$ of an Inch Focus.

Fig. 308. is called great Mouth, because its Mouth takes up about half the Length of its Body; its upper Lip is much longer than the lower, and are each adorned with little Hairs; its Inside is filled with darkish Spots, and hinder Part terminated with a singular Tail.

Fig. 309, ABC, is named a Funnel, and is here represented under three different Forms, in the middle one the Mouth is open and round, the Inside of its Lips are adorned with little Hairs, which have a quick Motion; the Inside of its Body strewed with many little irregular Spots, and its long Tail generally drags after it little Pieces of Skin fastened to its Extremity. The second is seen at A with its Mouth shut; and the third at C, whose Body is rounder, and its Tail at certain Times twisted in the Form of a Cork-screw.

Fig. 310. hath a Head like Clover Grass, and a forked Tail; its Mouth very small and round.

Fig. 311. is called a Sock, the Inside of its Body is adorned with several transparent Spots, which appear like Eggs.

At the Time this Infusion was intended to be thrown away, it was thought proper to put a Drop of it upon the Object carrying Glass, and to examine it by the Microscope, whereupon one of the most particular of all the foregoing Animalcula was found therein. It is a kind of Water Caterpillar, and so scarce, that no more than seven or eight could be found in many Trials during three Days. Fig. 312. shews three Representations of one of them; in that exhibited by AB, its Body is seen to be composed of several Ringlets, that enter one into the other, as the Animalcula contracts itself; it pushes out of its Mouth a Snout composed of several Pieces sheathed in each other, which are shewn at AC and D. The Extremity of this

this Snout appears to be perforated in ſome Poſitions as at D; it is ſometimes ſplit in two Parts, at other Times into three, as at A, where they form two or three little Protuberances. At L L are ſeen two Lips furniſhed with moveable Hairs. In other Poſitions not one Hair can be ſeen. While theſe Things were obſerving, a kind of Horn F, was ſuddenly protruded from its Breaſt: Its whole Length appear'd to be compoſed of ſeveral Furbelows of unequal Thickneſſes, which go one into another like the Drawers of a Pocket Teleſcope: At its Tail are two very ſharp Points as at B E, and in ſome particular Poſitions it appears in three Parts as at I.

SECT. XXX.

Infuſion of the Bark of a young Oak.

ABOUT the 25th of *December* ſeveral little Pieces of the Bark taken from off a Branch of young Oaks were put into cold Water, and in two Hours after ſome of thoſe Animalcules called Silver Bag-pipes was ſeen therein, and on the 15th of *January* in a very ſmall Drop was ſeen ſeveral new ones. Some of them Mr. *Joblot* called Caterpillars, others Stockings, Stirrup-Stockings, *&c.*

Thoſe repreſented at Fig. 313, are called golden Caterpillars, being of an Amber-colour, the longitudinal Fibres are ſeen from one End of its Body to the other, between which are little irregular Globules.

Fig. 314. is called a Stirrup-Stocking; at C is a great Opening which changed its Shape every Moment, and appeared to be its Mouth; the Lips were ſometimes ſo extended as to ſerve it for a Rudder to ſteer its Courſe, its Body was beſet with extremely ſmall Hairs.

That repreſented at Fig. 315, is in the Form of a Fiſhing-Net.

Fig. 316. is another, of which the Part G H reſembles an ill-ſhaped Leg, the Middle of its Body appeared to be tied with an inviſible Ligature.

Fig. 317, is called a Club, its Mouth intirely cloſe, and Body ſhaped like one, ſeveral little Globules were ſeen within-ſide, ſuppoſed to be Eggs.

Laſtly, at Fig. 318, is one of another kind of the Bottle Sort, which ſwam amongſt the preceding ones; and alſo a great Number of other Sorts which do not merit a Deſcription. The cold Weather increaſed ſo faſt, that in 15 Days Time all the *Animalcules* in this Infuſion were deſtroyed.

SECT. XXXI.

Of ſome other larger aquatic Animals.

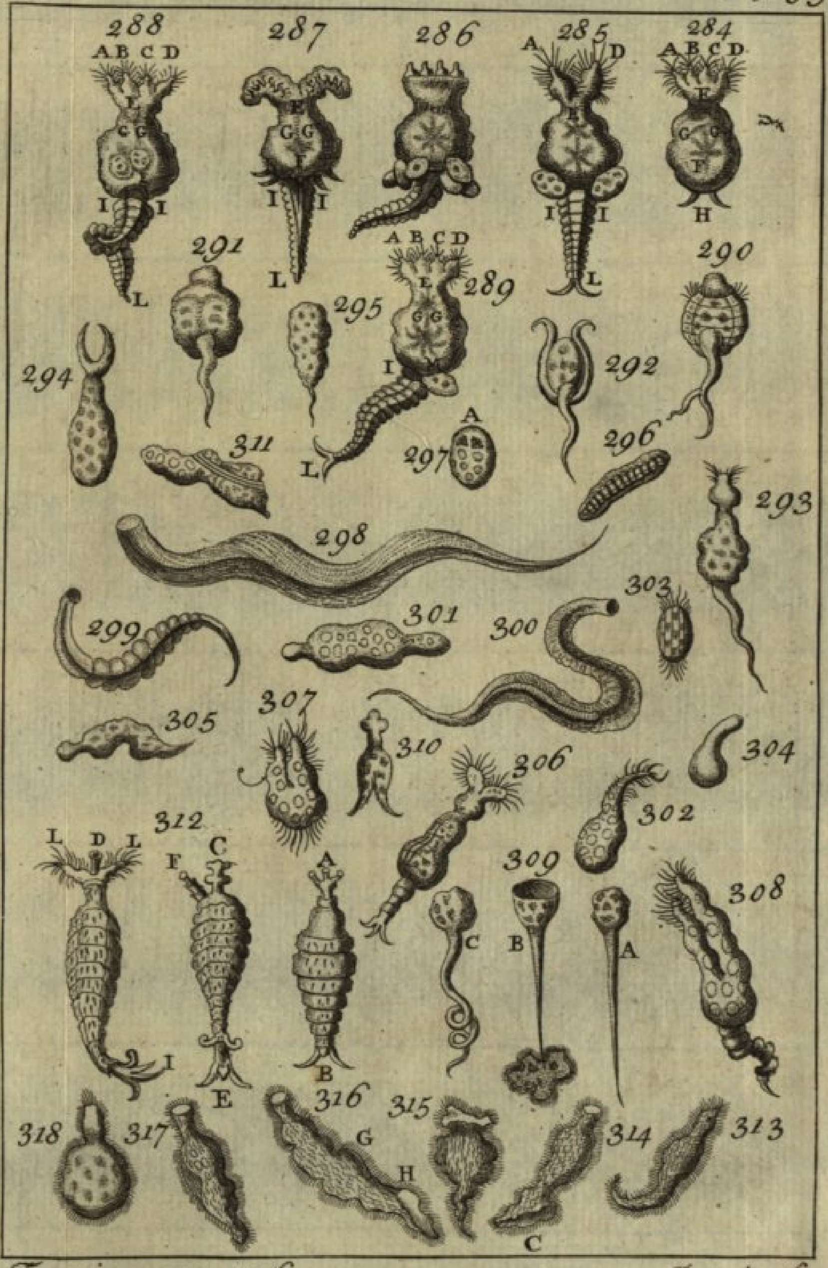
THE *Waters* every where are ſtocked with Life, which makes the Subject endleſs for the Employment of the Microſcope, *Seas, Rivers, Ponds, Ditches*, and almoſt every *Puddle*, can preſent us with living Wonders; but as theſe Examinations have been very little attended too even by thoſe who are ſupplied with Microſcopes, I hope theſe Directions and the new *Univerſal Microſcope*, will be a Means to whet the Inclinations of the induſtrious Enquirer, the Difficulties in the Uſe of the common Inſtruments being here removed.

Mr. *Leeuwenhoek* found ſome ſurpriſing *Animalcules*, adhering to the *Lens Paluſtris* * or *Duck-weed*, which he examined in a Glaſs Tube filled with Water; one Sort of theſe were ſhaped like Bells, with long Tails, whereby they faſtened themſelves to the Roots of theſe Weeds. HM, Fig. 319, repreſents a ſmall Part of the Root as it appear'd in the Microſcope, ſuppoſed to be almoſt withered and over-grown, with a great many long Particles which are ſeen between K and L. The *Animalcula* repreſenting little Bells, † are ſeen at IST.

On ſeveral of theſe Roots were obſerved one, and ſometimes two Sheaths or Caſes of various Sizes, faſtened thereto by the ſmall End: The largeſt is exhibited at RXY, out of which Sheath appeared a little Animal, whoſe fore Part was roundiſh as at XYZ, from whence proceeded two little Wheels that had a ſwift Gyration always one and the ſame Way, and were thickly ſet with Teeth or Notches as at PQRS. When they have for ſome Time exerted their circular Motion, they draw the Wheels into their Bodies, and their Bodies wholly into their Sheath, and ſoon after thruſt themſelves out again and renew the aforeſaid Motion. Mr. *Leeuwenhoek* obſerved the Caſe of one of theſe *Animalcules* to be compoſed of round Bubbles, ‡ as is repreſented at N, O, T. When this Animalcule had thruſt that Part of its Body from O to P, out of its Sheath NO; it extruded at the ſame Time that ſurpriſing Wheel-work (which before was taken for two diſtinct little Wheels, and was here plainly ſeen to be but one and the ſame Circumvolution) that conſiſted of four round Parts PQRS, three of which were to be ſeen, the fourth being almoſt hid; its Motion was from P to Q, according to the Order of the Letters. Fig. 320, repreſents the Wheel-work by itſelf, and larger than it appeared to the Sight.

Mr. *Leeuwenhoek* found ſeveral Kinds of theſe Wheel-work Animalcula, in

* *Phi. Tranſ. No.* 283, 295, 337. † *Ibid. No.* 283. ‡ *Ibid. No.* 295.



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in the ſlimy Matter which is to be found in leaden Pipes, or * Gutters, when the Water dries away they contract themſelves into an oval Figure, and a reddiſh Colour, and become fixed in the dry Dirt, which grows as hard as Clay; but if to this Dirt you put Water, in about half an Hour's Time they open, and by Degrees extend their Bodies and ſwim about; and this they did after ſome of this Gutter-dirt had been kept dry for 21 Months together: Whence he concludes, that the Pores of their Skin are ſo perfectly cloſed 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. 321 and 322, repreſents two of them in different Poſitions, and Fig. 323 ſhews how they appear when dry and contracted.

Several Species both of cruſtaceous and teſtaceous Animalcules are to be found in the Waters of Ditches; two of the former Sort are repreſented in Fig. 324 and 325, in the Poſture they ſwim with their Backs next the Eye, their Legs are ſomething like thoſe of Shrimps or Lobſters, but of a Structure much more curious; they are leſs than a very ſmall Flea, are all Breeders † and carry their Spawn in two Bags, which hang from their Sides, or under their Tail, as in Fig. 325. Theſe Bags are ſometimes ſeen broke, and the Spawn ſcattered about the Water. There is a third Sort amongſt theſe as beautiful as the foregoing, but not near ſo large; its Shape nearly reſembles a Shrimp, and carries its Spawn as the Shrimp does. Theſe three Kinds of *Animalcula* have but one Eye, and that placed in the Middle of their Forehead; they are often to be found ſo tranſparent, that the Motion of their Bowels is very plainly diſcovered by the Microſcope, together with a regular Pulſation in a little Part, which we may ſuppoſe the Heart.

In the Summer-time it is common for the Water in Ditches to appear ſometimes of a greeniſh, and ſometimes of a browniſh Colour, which upon Examination by the Microſcope is found to conſiſt in infinite Numbers of *Animalcula*, blended together on the Surface of it, and giving it ſuch an Appearance; their Shape is oval, but the Middle either green or red, and ſeems to be compoſed of Globules, reſembling the Roes or Spawn of Fiſhes.

* *Leeuw. Arc. Nat. Tom.* II. *Epiſt.* 149. † *Phil. Tranſ. No.* 288.

CHAP. XXXIV.

Of the fresh Water Polipe, with Arms in Form of Horns.

SECT. I.

Of their Motion and Structure.

THE Nature of this Insect is both extraordinary, and contrary to the general received Opinions of Animal Life, and requires the most convincing Proofs to persuade many People into a Belief thereof. In order therefore to clear up this peculiar Affair, I shall lay before the Reader the following Observations, which were made by Mr. *Trembley*, and also assure him, that I have repeated the major Part of his Experiments on this Animal with the same Success.

And first these Animals were not hitherto entirely unknown, for Mr. *Leeuwenhoek* gives a Description of a surprising Sort of minute Animal, in the *Philosophical Transactions*, Number 283. It is represented at Fig. 328, as it appeared fastened to a Root of *Duckweed*, whilst in the Water, and about three Times bigger than it appeared to the naked Eye; this was a large one of the Sort, and had eight Horns: At C is shewn a very small *Animalcule* coming out of the other's Body, supposed at first to be fastned thereto by some Accident; but on a closer Examination, was found to be a young one in the Birth, although it had at first but four small Horns; after 16 Hours its Horns and Body was grown much larger, and in four Hours more was quite excluded its Mother's Body; against this on the other Side appeared a little round Knob, which gradually increased in Bigness, and in a few Hours was pointed as at D, Fig. 328; about 14 Hours after it was grown much larger, and had two Horns; three Hours after it also fell off from its Mother and shifted for itself.

An *English* Gentleman * discovered one of them in some clear Water taken out of a Ditch; but with the utmost Attention he could find no more therein. It appeared the first Day as at Fig. 326, but varied every Moment, and the Knob at a, looked like the Gut Cenum; two or three Days after he observed some white Fibres at the Extremity of the Knob; on the fourth it was extended at full Length, and appeared as Fig. 327; which then convinced him this Excrescence was really an Animalcule of the

* *Phil. Trans. No.* 288.

same

ſame Species, having ſix Horns; next Day he found it ſeparated from its Mother; it is ſeen in its contracted State as delineated by this Gentleman at Fig. 329 and 330.

There is a near Agreement between the Obſervations of theſe two Gentlemen, both of them having diſcovered the moſt remarkable Prôperty of the *Polypes*, that is to ſay, their *natural* Manner of *multiplying*. They have alſo given us their exterior Figure, and ſome of their Motions; but their more ſurpriſing Properties, were reſerved for the Diſcovery of the *inquiſitive* and *happy Genius* of Mr. *Trembley*. It was alſo known to ſeveral other Gentlemen before him, but none of them diſcovered this *remarkable Re-production*, which is found in the *different Parts* of a *Polype* after they are *ſeparated*, each diſtinct Piece becoming as perfect an Animal as that of *which* it was only a *Part*.

Mr. *Trembley* having taken Notice of ſome Plants, which he had taken out of a Ditch, and put into a large Glaſs full of Water, and employing himſelf in conſidering the Inſects therein contained, he caſt his Eye upon a *Polype*, which was fix'd to the Stalk of an aquatick Plant, and is repreſented at Fig. 331.

Their Bodies a b are very ſmall, and from one of their Extremities at a, proceed ſeveral Horns a, c, which ſerve them for Feet and Arms, and are much ſmaller than their Bodies. I call the Extremity a, *anterior*, becauſe it is the *Polype's* Head; and the oppoſite Extremity b *poſterior*.

The firſt Sort of *Polypes* Mr. *Trembley* found, were of a fine green Colour, and in the Poſture of thoſe repreſented by Fig. 331. The firſt Motion he obſerved in them was that of their Arms, which they extend and contract, bend and wind divers Ways; they alſo contract their Bodies upon the leaſt Touch, ſo ſhort that they appear only like a Grain of Matter. They conſtantly turn themſelves towards the Light; for if that Part of the Glaſs in which they are, be frequently turned from the Light, they will be found the next Day to have removed themſelves to the light Side of the Glaſs, the dark Side being quite depopulated.

For Mr. *Trembley* incloſed a great Glaſs well ſtored with green *Polypes*, in a *Paſte-board Box*, which had a Hole cut on one Side in the Form of a *Chevron*, that exactly anſwered to the Middle of the Glaſs in which the *Polypes* were: When this Hole was turned to the Light, it always happened, that the *Polypes* aſſembled themſelves together at that Side of the Glaſs, and alſo in the Form of the *Chevron*; although the Glaſs was turned ſeveral Times in this Box, yet at the End of a few Days the *Polypes* were always found ranged as before. To vary this Experiment, he turned the Chevron upſide-down, and notwithſtanding this, the Polypes always aſſembled themſelves together, and in the Form of the Chevron, whether *right* or *inverted*.

The 25th of *November* 1740, Mr. *Trembley* cut a *Polype* tranſverſly (for

 the

the firſt Time) but the Head Part a little ſhorter than the Tail Part, and put the two Parts into a flat Glaſs, in which the Height of the Water did not exceed a quarter of an Inch, by which Means they might be eaſily obſerved with a pretty deep magnifying Glaſs.

In that Inſtant the *Polype* was cut, both Parts contracted, and ſunk to the Bottom of the Glaſs, like two little Grains of green Matter. Some few Hours after both the Parts ſtretched themſelves out, and were eaſily to be diſtinguiſhed from each other, the anterior End of the firſt being furniſhed with Horns, whereas the other had none at all.

The firſt Part moved its Arms, and the next Day he ſaw it change its Place in the Glaſs, and both were obſerved to extend and contract themſelves for ſeveral Days.

He only looked upon the Motion of theſe two Parts, as Signs of the weak Remains of Life, eſpecially with reſpect to the hinder Part, and therefore obſerved it only to know how long it would remain alive, not in the leaſt hoping to be the Spectator of this *ſo marvellous a Re production.*

But obſerving the cut Pieces on the 9th Day with a magnifying Glaſs, perceived three little Points coming out from the Edges of the anterior End of the ſecond Part, which had neither Head nor Arms. The next Day he was convinced they were Arms, and the Day following *two new Arms* came out, and ſome Days after *three more*; this ſecond Part had then *eight*, which in a little Time was as long as thoſe of the firſt Part, ſo that now there was no Difference between the ſecond Part and a *Polype* that had never been cut. They both appeared ſenſible, being each of them compleat *Polypes*, and performing all the known Functions of *ſtretching* themſelves out, *contracting* and *walking*.

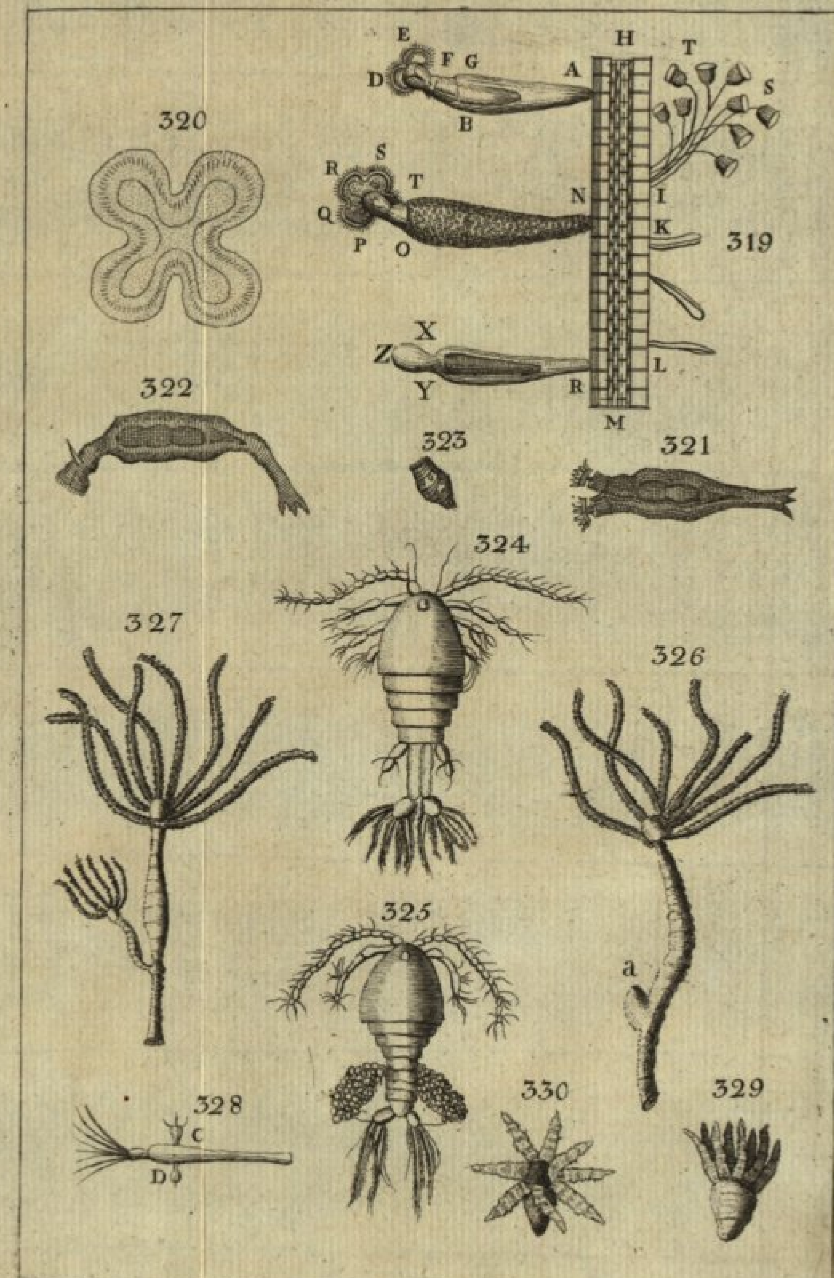
After this he diſcovered one in a great Glaſs he had by him, which was well ſtored with green *Polypes*, from which young ones began to ſhoot.

In the Month of *April* he found a new Sort of *Polypes*, repreſented at Fig. 332. and ſoon after ſaw them *eat* and ſwallow down *Worms longer than themſelves*, and to digeſt them and be nouriſhed therewith: Therefore this is a certain Proof of their being *Animals*.

They are to be found indifferently upon all Sorts of *aquatick Plants*, and other Bodies that are in the Water (upon which they fix themſelves by the *Tail)* at the Bottom of *Ditches*, and are ſuſpended upon the Surface of the Water, upon *Branches* of *Trees*, *Boards*, *rotten Leaves*, Bits of *Straw*, *Stones*, and many of them Mr. *Trembley* hath found on the Bodies of divers *Animals*, as on the Shells of Snails, *&c.*

The beſt Way to find them, is to take up theſe different Bodies and put them in Glaſſes full of Water, and if there are any *Polypes*, they will ſoon be perceived adhering to thoſe Bodies and moving their Arms.

Mr. *Trembley* hath alſo taken the Trouble of going often to the Sides of the *Ditch* in which he found them, at a Time when the Sun ſhone upon the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J. Wigley. Sc.

the *Bottom* of the *Water*, and chose those *Places where* the *Water* was *clear*, and that had an easy Declivity, and says, he hath distinctly seen them at the Bottom of the Water, on all the Bodies that were therein, and on its Superficies; by which Means he acquired those Ideas concerning them, he could never have attained to without this Precaution.

The most common Posture they are generally found in, whether in their ordinary Places of Abode, or in Glasses, is represented by the Figures 331, and 332. The *posterior* End b, of the *Polype* a b, is fixed against a Plant e f, Fig. 331, or against a Straw g h, Fig. 332, the Body a b, and Arms a c, being extended in the Water.

The general Figure of the *Polype's* Body in this Attitude is not perfectly the same; in the three Kinds of Polypes here described, the Body of the green ones, Fig. 331. diminish from their *anterior* to their *posterior* End, the Diminution being almost insensible.

That Sort represented Fig. 332, are the same; but those of the third Sort, Fig. 333, differ from the two preceding ones in this Respect, that their Body does not diminish insensibly, but from the anterior Extremity a, to the Part d, and sometimes even to two Thirds of the Length of their Body; as at d, Fig. 334, becoming from this Point much finer, and do not diminish from thence to the posterior End. They wave their *Arms* in all Directions, as at a, i, k, Fig. 331, at a and e, Fig. 332. and at a, Fig. 333 and 334. The Number of their Horns in these three Sorts of *Polypes*, is generally at least six, and at most 12 or 13, yet nevertheless there are some few of the second Sort which have 18 Arms. They can contract their Bodies till they are not above the 10th of an Inch or thereabouts in Length: For Example, that represented at Fig. 333, could contract itself so as to become like those two Representations Fig. 335. They can also stop at any Degree either of Extension or Contraction, from the greatest to the least.

The green ones are generally about half an Inch in Length when stretched out. Those of the second and third Sort are most commonly between ¾ of an Inch and an Inch; but some may be found of both Sorts, whose Bodies are an Inch and half long.

They grow smaller as they extend, and increase in Bulk as they contract themselves. The Figures 331, 332, and 333 represent the general and natural Size of these three Sorts of Polypes; and at Fig. 362. is an exact Representation of one, as it appears in the Microscope.

You may oblige them to contract more or less, in Proportion as they are touched, or as the Water in which they are, is agitated more or less. Every *Polype*, when taken out of the Water, contracts itself in such Sort, as to appear like a mere Lump of Jelly on the Body it is fastened to, as at Fig. 336. which Figure is so different from what it bears when stretched out, that it can scarce be known at first Sight, but when the Eye is once accustomed to it, they are easily distinguished from all other Bodies that are out of the Water.

Heat and *Cold* hath the same *Effects* on the *Polypes*, as it hath upon all other *Land* and *Water Insects*. *Heat* animates, and *Cold* benumbs, or makes them *faint* and *languid*; yet nevertheless it requires a considerable Degree of *Cold*, to reduce them to a *motionless State*, and that must be very near to that of *Freezing*. At which Time they are more or less contracted, and so remain; but as soon as the Water in which they are, acquires some Degree of Warmth, they stretch themselves out, and move proportionably to the Heat thereof. It is not necessary that this Degree of Heat be very considerable, but is sufficient for them, if the Water be of a *temperate Heat*, which is exactly shewn by the 48th Degree on *Farenheidt*'s Thermometer *.

The Arms of the green *Polypes* seldom exceed the Length of their Bodies, as at Fig. 331. An Inch is commonly the Length of the Arms of the second Sort, as at Fig. 332. tho' some are longer. The Arms of the third Sort are generally about eight Inches, Fig. 333. for which Reason Mr. *Trembley* calls them *long arm'd Polypes*.

The *Polype* can extend and contract its Arms, without extending or contracting its Body; and its Body, without any Alteration in the Arms, it can also extend and contract all or some of its Arms, independant of the others.

Its Body and Arms are also capable of bending in all possible Directions, some of which are represented by Fig. 337. in which Attitude they are sometimes found; the Body and Arms can also twist themselves, as at Fig. 338, and 334. It is likewise remarkable, that the Arms of the 2d and 3d Sorts of *Polypes*, generally bend at some Distance from their joining to the Body.

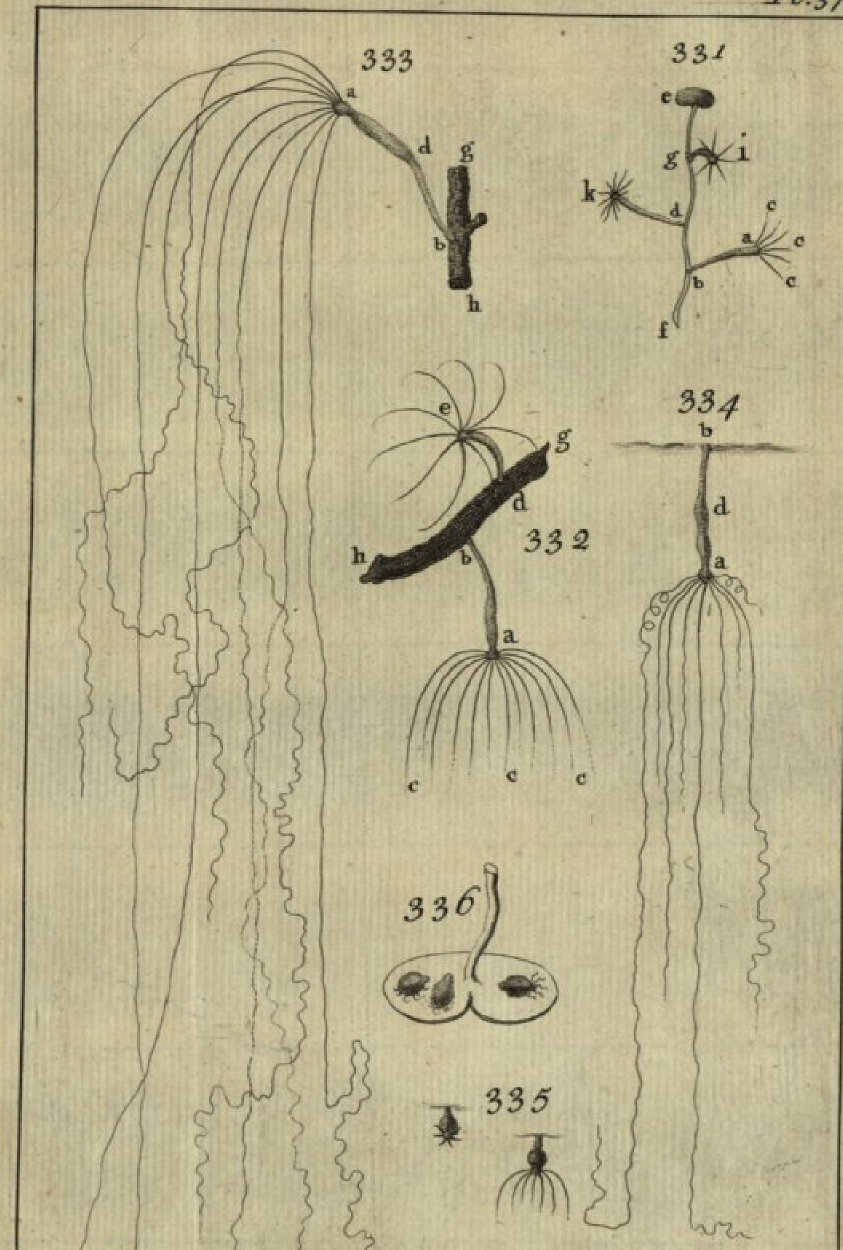
The third Sort, for the most Part, let their Arms hang down, making different Turns and Returns, as at Fig. 333. and sometimes they direct some of them towards the Top of the Water.

Their progressive Motion is performed by Means of that Faculty they have of stretching out, contracting, and turning themselves every Way. For let the *Polype* a b, Fig. 349. be fixed by its posterior End b, having its Body a b, and Arms extended in the Water. In order to advance, it draws itself together, by bending its Body on whatever it moves; and then fixing its anterior End a upon this Body, sometimes the anterior End only, at other Times some of its Arms, and at others the Arms and anterior End a, as at Fig. 350. When the anterior End is well fixed, it loosens the posterior End b, and draws it to the anterior a, fastening the End b, as at Fig. 351. after which it again loosens its anterior End a, and stretches it out, as at Fig. 352. Thus much for a general Description of the common Steps a Polype makes in moving from Place to Place.

They walk very slow, and often stop in the Middle of a Step, disposing of, and winding their Body and Arms every Way; as at Fig. 338.

* *Farenheidt*'s *Thermometers*, as well as those of Sir *Isaac Newton*, Mr. *Reaumeur*, *D'Lisle*, and others may be had at my *Shop*, made after the BEST *Manner*, and *graduated myself* from *actual Experiments*; at *Tycho Brahe's Head*, in *Fleet-street*, LONDON.

Some-



Frontˢ. Pag. 142. Bowles sc.

Sometimes they make an extraordinary Step, as follows, Let the *Polype* a b, Fig. 353. be fixed by its *posterior* End b, and its Body and Arms extended in the Water. First it bends its anterior End a, towards the Body upon which it moves, and fixes it at a, Fig. 354. after which it loosens its *posterior* End b, and raises it up perpendicularly, as at Fig. 355. then bending its Body to the other Side, fixes the *posterior* End b, as at Fig. 356. and loosening the anterior End a, raises it up again, as at Fig. 357.

The third Kind of Step the *Polype* makes, is in the following Manner, let the *Polype* a b, Fig. 358. be fixed by its *posterior* End b against the Side of a Glass. Its Body, and most of its Arms being stretched out forwards, and one of its Arms a c, fixed against the Glass at c: When the *Polype* is in this Attitude, it loosens its *posterior* End b, and contracting its Body, draws it up a little nearer to the Point c, and fixes it against the Glass at d, after which it repeats the same and fixes its *posterior* End at e, and so on. All that is here said of the *Polypes* progressive Motion equally respects the three Sorts.

They descend to the Bottom of the Water, and come up either by the Sides, or upon aquatick Plants, and often hang down from the Surface thereof, by their posterior End, as at b, Fig. 334. and are often seen to suspend themselves by one Arm only, as at c, Fig. 339. They walk as well upon the Superficies of the Water, as upon those Bodies just mentioned; and perform the same Motions in a Glass, as they do in greater Waters: They pass over Plants or other Bodies; they go up the Sides of Glass, even to the Surface of the Water, and pass either under or over it, and sometimes rest themselves there; then they march to the opposite Side of the Glass, and so descend to the Bottom.

If you examine the Extremity of a *Polypes* Tail, while it is suspended, as at b, Fig. 334. (from the Surface of the Water) with a magnifying Glass, it will be found a little out of the Water, somewhat concave and dry, as at b and c, Fig. 359. and to prove that this Circumstance is absolutely necessary to support them at the Superficies of the Water, only wet the dry End with a Drop of Water, and the *Polype* will immediately fall to the Bottom.

When a *Polype* designs to pass from the Sides of a Glass, to the Superficies of the Water, it need only put that Part out of the Water by which it would be supported, and give it Time to dry, which is what it always does, and what may easily be observed. If, for Example, a *Polype* is fixed against the Sides of a Glass, near the Superficies of the Water, (on which it intends to go) as at e f, Fig. 359. in order to convey itself thither, it raises up its *anterior* End, and puts it out of the Water, there letting it dry, then loosening its posterior End f, from the Glass, draws it up, and puts it above the Water, where it also becomes dry in an Instant, and capable to support the *Polype*, upon which it draws its *anterior* End under Water, and remains suspended

 from

from its Surface, as at c and b, often extending its Body and Arms.

It has been often found neceſſary, in the Courſe of theſe Experiments, to ſuſpend a *Polype* from the Surface of the Water, becauſe they are not always to be found ſuſpended there of themſelves. To effect which, take in one Hand an Hair-Pencil, and in the other a *pointed Quill*, or a *Tooth-pick*; with the *Pencil* looſen the *Polype* from the *Glaſs*, and gradually raiſe it near the Top of the *Water*, in ſuch a Manner, that the *anterior* End of the *Polype* be next the Point of the *Pencil*; then lift it out of the Water, and keep it ſo for a *Moment*, nay a Minute if you will; after which thruſt the Point of the *Pencil*, together with the *anterior* End of the *Polype*, by little and little under the Water, until no more than about half the Tenth of an Inch of the *Polype's Tail* remains above its Surface; at this Inſtant, with the pointed Quill, remove that Part of the *Polype* from the Pencil, which is already in the Water. And at the ſame Time blowing againſt the *Polype*, its Tail will be alſo looſen'd, and remain out of the Water.

A *Polype*, that is already ſuſpended, may be removed from a Glaſs of dirty Water, to a clean one with freſh Water, by endeavouring to place the Pencil parallel to the *Polype*, and in this Poſition to advance it gradually till it touches him, he will then apply himſelf againſt the Pencil, and on being drawn out of the Water, its Tail, which was dry before, will remain ſo; and it may be immediately put into the clean Water, by obſerving the foregoing Directions.

Polypes commonly fix their Tails to *Stones*, or *aquatick Plants*, &c. ſo faſt as to prevent their being drove away by the Stream, and are ſometimes fixed not only by their Tails, but by two or three of their Arms alſo, which they direct different Ways; and being thus fixed cannot be toſſed about by the Motion of the Water.

Two long armed *Polypes* ſuſpended from the Surface of the Water in a Glaſs, are repreſented exactly in the Poſition they were found, at a, b, and c, d, Fig. 359. One of them d c, had two of its Arms d, i, and d, k, fixed againſt the Bottom of the Glaſs, but on oppoſite Sides thereof, at i and k. The other a b had alſo one Arm a g, fixed againſt the Bottom of the Glaſs, at g, and its other Arm a h, fixed againſt the Side at h; they held themſelves ſo faſt in this Poſition, that the Glaſs was forcibly ſhaken before they quitted their Hold.

The *Polype*'s Mouth is ſituated at the anterior End of its Body, in the Middle between the ſhooting forth of the Arms. It is very often ſtretched out, at which Time it repreſents a little conical Nipple, as at a, Fig. 333, and Fig. 343. The Cone it forms appears ſometimes truncated, as at a, Fig. 362. At other Times no Nipple can be diſcovered, the Interval between the Arms being cloſed, as at a, Fig. 338, and 344. in other Circumſtances it is hollow, being open, and a little widen'd, as at i, Fig. 331. or at e, Fig. 332. and a, Fig. 362. it is not only open in this Circumſtance,

ſtance, for if it is obſerved with a magnifying Glaſs, when flat, or when it forms a truncated Cone, a little Hole is generally ſeen at the End thereof, which is repreſented, as it appears when magnified at a, Fig. 362.

The different Opening of the Mouth and Lips, are ſeen Fig. 343, 344, and 345.

The *Polype*'s Mouth opens into its Stomach, forming a Kind of Bag or Gut, from Head to Tail. The naked Eye may be convinced of this, but much better if it be armed with a Microſcope. It is exactly repreſented as it appears through the Microſcope at a b, Fig. 262.

Mr. *Trembley* not being ſatisfied that the *Polype* was perforated from End to End, by only obſerving it from without, cut one tranſverſly into three Parts, each Piece immediately contracted itſelf, and remained very ſhort, and being all three placed on the flat Bottom of a ſhallow Glaſs full of Water, and viewed through a Microſcope, from the upper End, the Bottom of the Glaſs was ſeen through the lower, ſo that all the three were viſibly perforated; they are repreſented as they appeared in the Microſcope, by the Figures 340, 341, and 342. Its Mouth was at the anterior End of one of theſe Parts a, Fig. 340. and was then wide open. The poſterior Extremity was at the End b of the third Part, Fig. 342. as this Piece was perforated thro', it plainly appears, that the Tails of the *Polypes* are alſo open.

This Perforation which is continued from one End to the other of the *Polype*, is called the Stomach, becauſe it contains and digeſts the Aliments, and the Skin which incloſes the Stomach, and forms this Bag, is the very Skin of the *Polype*. Therefore the whole Animal conſiſts but of one Skin, diſpoſed in the Form of a Tube or Gut, open at both Ends.

If a *Polype* be obſerved with the Microſcope, its whole Body appears like Shagreen, or as if it were ſtrewed with little Grains, as repreſented at Fig. 362. both when contracted or extended, it is more or leſs varied according to theſe or other Circumſtances.

If the Lips of a *Polype* be cut tranſverſly and placed upon the Object carrying Glaſs, in ſuch a Manner as that the cut Part of the Skin a, Fig. 341, may lie directly before the Microſcope, it will be found to conſiſt of an infinite Number of thoſe little Grains throughout the whole Thickneſs of the Skin: Therefore, in order to know whether the Inſide of the Stomach had any of the like Grains; Mr. *Trembley* opened ſeveral of them in the following Manner; by putting a *Polype* upon his Hand, he made it, by touching, to contract as much as poſſible, and then he introduced a very fine Point of a Pair of Sciſſars into its Mouth, and forcing it out at the Tail, and immediately cloſed the Sciſſars, which cut one Side of the *Polype*'s Skin from the Top to the Bottom, and laying it open from one End to the other diſcovered the interior Superficies thereof, which is repreſented as it appeared in the Microſcope at Fig. 346; and this was alſo compoſed of as great a Quantity of the ſame Grains as the exterior Superficies and the Edge a, of the cut Piece of Skin, Fig. 346. To examine theſe Particulars a little farther, a Bit of the Skin was laid upon the Object carrying Glaſs in a Drop of Water, and placed before the Microſcope, a, Fig. 347. and ſome of theſe Grains ſeparated therefrom, as at b, c, d, by preſſing them with the Point of a Pin, ſtriking them againſt the Glaſs, and endeavouring to tear them in Pieces; the Grains ſpread themſelves to all Parts of the Water, and at laſt remained in Heaps as at e and f.

If a *Polype* be carefully placed before the Microſcope, ſo as not to wound him, you'll ſeldom be diſappointed of ſeeing thoſe Grains ſeparate from ſome Part or other, and that in the moſt healthy *Polypes*; but when they ſeparate in large Quantities, it is a certain Symptom of a dangerous Illneſs. The Surface of the Polype from which they fall becomes irregular, and is no more terminated as before. The Grains fall off from all Sides, it contracts itſelf, the Body and Arms ſwell and loſe their ſhining Whiteneſs, and at laſt their Form, as at a, Fig. 348, and nothing is to be found in its Place but an Heap of Grains as at b.

The Structure of the *Polypes* Arms bears a near Reſemblance to that of its Body; and when obſerved with the Microſcope, we find their exterior Surface to appear ſhagreened alſo, Fig. 362, an Arm much contracted appears extremely ſo, and even much more ſo than the *Polype's* Body.

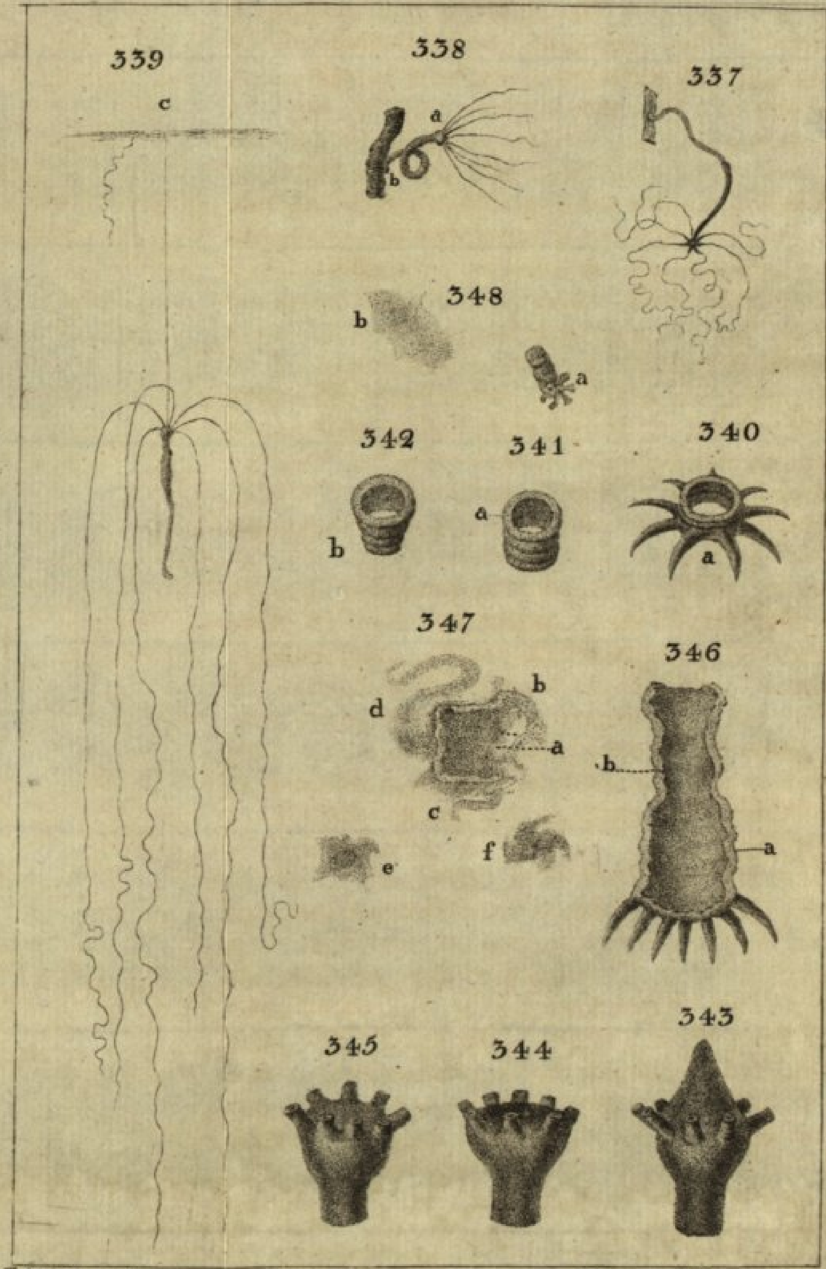
If a ſuſpended Arm that extends itſelf be obſerved, the Grains may be ſeen a little aſunder, which when contracted almoſt touch, but ſo that Intervals are left between them, as at Fig. 363. When at a certain Degree of Extenſion, its Surface ſeems only to be ſtrewed with Pimples as at Fig. 364, which continue ſtill to ſeparate, as the Arms extend, and are at laſt placed upon a Thread e e e, Fig. 365. Theſe Pimples are formed by the Re-union of many Grains, and at the firſt Glance appear like a String of Beads, Fig. 365.

The different States of a *Polype*'s Arm, may be obſerved at the ſame Time, in the ſame Arm, but at different Places thereof, by caſting the Eye, armed with a Microſcope from one End of the Arm to the other, and eſpecially if the ſeveral Portions thereof be carefully obſerved with a large Magnifier, they will appear as at Fig. 363. which repreſents that Part of the Arm ſtretched out, which is near the *Polype*'s Head, the Grains thereof being but little ſeparated, but are farther aſunder in Fig. 364. which is about the Middle of the Arm; and Fig. 365. ſhews the Grains as if they were ſtrung upon a Thread, as they are ſeen upon the Extremity of a *Polype's* Arm.

This Extremity is often terminated by a Knob, and the Hairs marked e, e, e, Fig. 364, 365. are tranſparent, and may be ſeen with the firſt and ſecond Magnifiers.

The

Pl. 38.



T. Wigley. Sc. Front.⁹ Page. 146.

The beſt Method to obſerve a *Polype*'s Arm, is to chooſe one that is fixed to the Side of a Glaſs, and near the Superficies of the Water; at which Moment, any one of its Arms being very well extended, take a Pair of Nippers in one Hand, and a Slip of Glaſs, about two or three Inches long, and half an Inch broad in the other, holding it at one End between the Finger and Thumb; then with the Nippers, or a pointed Quill, pull the End of the Arm gently out of the Water, and the reſt will follow. If it is not ſtretched enough, ſtretch it more, by drawing it out, the *Polype* ſtill remaining fixed to the Glaſs, put the Arm upon the Slip of Glaſs, and turn it under till it meets itſelf again; then giving it a Jirk, the Arm will break off on both Sides the Slip of Glaſs, one Part remaining with the *Polype*, and the other in the Forceps, and the middle Part will ſtick upon the Glaſs Slip, in which Manner it may be applied to the Microſcope, and preſerved for ſeveral Days, as well as when it is at firſt taken out of the Water, for when once dry it does not change for a conſiderable Time.

SECT. II.

Of the Polypes Food, and Manner of their ſeizing upon, and ſwallowing their Prey.

IT was ſome Time after the Diſcovery of the ſecond Sort of *Polypes*, before Mr. *Trembley* could find out a proper Food to nouriſh them, but the Water at that Time happen'd to be plentifully ſtored with a Sort of Millepedes, Fig. 360. ſmall enough, and about $\frac{3}{4}$ths of an Inch in Length. They are remarkable for a Horn, or fleſhy Dart, proceeding from the fore Part of their Head at d. Mr. *Reaumeur* hath called them darted Millepedes. They ſupport themſelves, and ſwim in the Water by Means of the ſeveral ſwift Inflections they make with their Bodies; they reſt themſelves, and creep upon all the Bodies they meet with, and are often found in great Numbers upon aquatick Plants, thoſe upon which the firſt *Polypes* of the ſecond Sort were found, were well ſtocked with theſe Millepedes, and were taken out of the Water together with them, and put into the ſame Glaſs without any Deſign.

A few Days after the anterior End a, of a *Polype*, Fig. 366. was obſerved, with one of theſe Millepedes partly within its Mouth, and the other Part yet without it at m, not knowing at firſt whether the *Polype* was eating the Millepedes, or whether the Millepedes had introduced itſelf voluntarily into the *Polype*'s Stomach, to be nouriſhed there, to lodge its Eggs, or depoſite its Young therein, but at laſt it was entirely enter'd into the *Polype*'s Body.

The long arm'd *Polypes* being the moſt remarkable in their feeding, *&c.*

for that Reason principally, Mr. *Trembley* thought proper to describe these Experiments, upon that Sort, from which one may easily judge the same of the other two Sorts.

To see these Polypes seize their Prey with their Arms extended, they must be put into a Glass, 7 or 8 Inches deep, if the Polypes are fixed to the Top of the Glass, their Arms for the most Part hang down towards the Bottom. This is then the most convenient Situation to give them Food, and to observe how they manage it. To this End one might cause them to hang from the Surface of the Water, but this Expedient is not always best.

The Polypes we breed, and feed, are commonly infested with little Lice, it is therefore necessary to cleanse them from these Tormentors, by rubbing them with an Hair Pencil, and if the Polypes suspend themselves from the Surface of the Water, it is scarce possible for them to be freed from these Lice. In that Case make the Polypes fix themselves to a Packthread, or fix them to it, as at Fig. 367. at the Place b, letting the two Ends h f, and k g hang down over the Edges of the Glass. One may then stroke them even something rudely, backwards and forwards, with an Hair Pencil, without pulling them off, and in changing the Water, only take hold of each End of the Pack-thread, draw it gently out of the Water, and put it immediately into another Glass, prepared for its Reception. If several of these Pack-thread Strings are put into a Glass well stored with Polypes, there will be always some that will fix * themselves thereto.

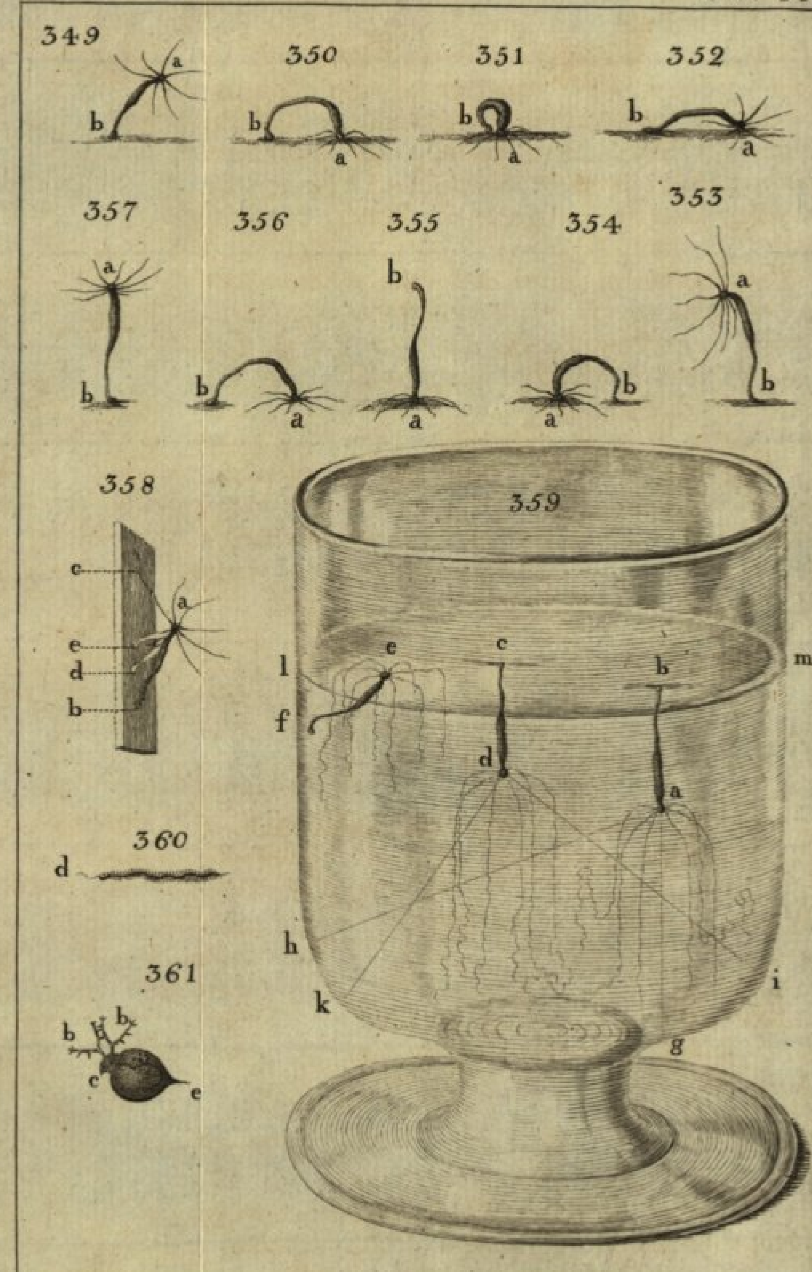
When the Arms of the Polype are well extended, put a Millipedes, or any other Worm into the Glass, and with the Point of a Pencil, push it to one of the Arms, which it no sooner touches, but it is seized, and when the Millipedes m, c, n, or Worm perceives itself taken, it endeavours by very quick and strong Efforts to disengage itself, often swimming and dragging the Arm a c, Fig. 367. from one Side of the Glass to the other; this violent Motion of the Millipedes, obliges the Polype to contract its Arm, in the Performance of which he often disposes them in the Form of a Cork-screw, o i, which also contributes to the shortening of it. The Millipedes by its continual Struggles, entangles itself in the Arm that holds it, m i n, and often meeting with other Arms, they also assist, and with a sudden Pull, enable the Polype to contract himself, or to draw near his Prey, and in an Instant the entangled Millipedes is convey'd to the Mouth, against which it is held and subdued.

When a Polype hath nothing to eat, its Mouth is generally open, but that so small that it cannot be seen without the Assistance of a magnifying Glass: Whereas, as soon as the Arms have conveyed a Prey to the Mouth, it opens itself more, and always in Proportion to the Size of the Animal

* *Hist. de Polyp. p.* 85.

that

Pl. 39.



I. Wigley. Sc.

Front. Page. 148.

that is to be devoured; its Lips gradually dilate, and precisely adjust themselves, to the Figure of their Prey.

All the Worms which are seized by the Polypes, do not present themselves in the same Manner to their Mouth; for if the Worm presents itself by one of its Extremities, it is not requisite the Polype should open its Mouth considerably, neither does it open otherwise, but precisely to give Entrance to the Worm, Fig. 366.

If the Worm is not too long for the Stomach, it remains therein extended; but if longer, that End which first entered bends, and when it is entirely swallowed it may be seen folded within the Polype, Fig. 379.

When the Middle or any other Part of the Worm is presented to the Polypes Mouth, it seizes this Part with its Lips, extending them on both Sides, and applying them against the Worm; at which Time its Mouth takes the Form of a Boat pointed at each End, Fig. 368, after which the Polype gradually closes the two Points of its Boat-like Lips, which doubles the Worm in that Part, and so it is swallowed, Fig. 369.

As soon as the Stomach is filled, its Capacity and the Skin thereof is augmented, and the Body becomes short, Fig. 372. its Arms also are for the most part contracted. The Polype hangs down without Motion, and appears to be in a State of Numbness, and in Shape very different from that of its Extension, Fig. 367. As the Food digests, and it voids that which does not serve for Nourishment; its Body lengthens, and gradually recovers its natural Form.

Mr. *Trembley* finding these Millepedes a proper Food for the Polypes, he collected a great Quantity of them, to feed those he kept in Glasses, and found them in Swarms at the Sides of Ditches, creeping on Plants, and all other Bodies that were in the Water.

Also on observing how voraciously the Polypes eat these Millipedes, he imagined it was not the only agreeable Food to them, and was therefore desirous of finding out other Animals to nourish them withal, besides the Trouble of getting a sufficient Quantity of Millipedes from other Places took up too much Time; upon which he opened a Polype that was taken out of the Water, with its Belly full of Food; from whence came out little Insects, which he calls *Pucerons* or *Fleas*, and amongst these another Sort that multiply extremely, and are often easily to be procured in great Quantities; see the Fig. marked p, at the End of one of the Arms, Fig. 367, which represents one of these Fleas of its natural Size, and as it appeared in the Microscope at Fig. 361: They are exactly described by *Swammerdam*, * and are remarkable for two branching Arms, which proceed from their Head, which serve them instead of Fins. The Arms inclined *Swam-*

* *Swam. Hist. de Insect. p.* 86. *&c. Edit. de Leid.* 1737.

merdam

merdam to call them by the Name of *Puceron branchus*, they are continually ſkipping about the Water, and are generally ſomewhat reddiſh.

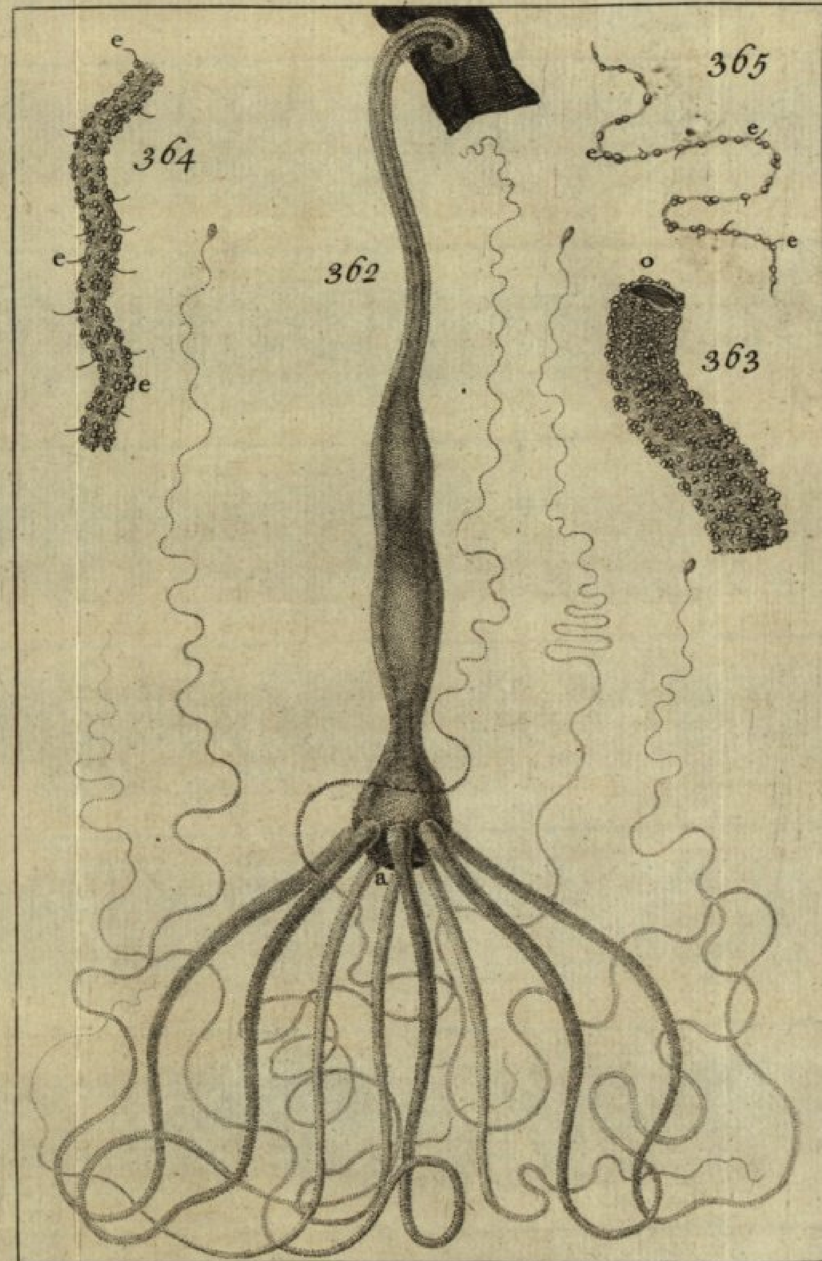
On putting ſome of theſe *Pucerons* into a Glaſs with Polypes, they preſently ſeized on ſome of them, and began to extend their Mouths, firſt in the Form of a Concave, in which Part of the *Flea* is lodged, as at a, Fig. 370. the Lips continue to enlarge, till they included the *Puceron*, and then entirely cloſe themſelves again.

The Polypes are not content with two or three of theſe *Pucerons*, but will continue to ſwallow them till the Sides of their Stomach are ſo increaſed, as to contain two of theſe *Fleas* in Breadth one by the Side of the other, as at Fig. 371. which was abſolutely full from Head to Tail. If it be one of the third Sort, the narrow Part of its Body b d, Fig. 372. generally remains empty, but ſometimes this alſo is forced to increaſe and receive ſome of thoſe *Fleas*. When the Polype hath ſwallowed no more of theſe *Fleas* than can be contained within its Stomach; its Body, in that Caſe, becomes very ſmall near the Head, and forms in that Place a Kind of remarkable Neck c, Fig. 373.

If a Number of theſe little *Fleas* be haſtily thrown into a Glaſs of hungry Polypes, their Arms are ſoon ſo loaded with them, that one can ſee nothing but a confuſed Maſs of theſe *Pucerons* gathered together, near the Polype's Mouth a, Fig. 375. which they ſwallow one after another till they are entirely full.

So long as theſe *Pucerons* could be procured, he fed his Polypes with nothing elſe: His Method of fiſhing them out of the Water, was with a ſmall Hoop, of about 8 or 10 Inches Diameter, made of Braſs, or Iron Wire, to which was faſtened a Pouch of Linen Cloth, and the whole tied to the End of a Stick. This being put ſlope-wiſe into the Water, where there is a Quantity of theſe Animals, may be eaſily moved to and fro, any Way you ſee Occaſion, by which Means the *Fleas* will be gathered together into the Hoop. You may then put them into a Glaſs of Water, which will ſwarm therewith from the Beginning of *June* to the End of *September*; theſe were eaſily to be procured, but when they began to fail, he was at a Loſs to find out other Nouriſhment for his Polypes.

He went ſeveral times a Day to the Water-ſide, which had before for a long Time furniſhed him with *Fleas*, and ſtooped down near the Surface of the Water, endeavouring to diſcover young ones, but all in vain; nevertheleſs in ſeeking theſe he ſaw ſeveral Places at the Bottom of the Water, with Worms all ſtanding an End, one End of which was in the Earth, and the other End out of the Earth in the Water, making continual Undulations, Fig. 376. He thought, as ſoon as he ſaw theſe Worms, they would ſerve to nouriſh the Polypes, and to make up for the *Fleas* he wanted, and the Millepedes which could at that Time be found only in ſmall Quantities; it was with a great deal of Trouble that he took up ſome of thoſe Worms,



Front.g Pag. 150.   T. Bowles sc.

Worms, which he gave to the Polypes who eat them. Therefore, to procure as many of these Worms as you may have occasion for, you need only fix a Circle of Iron Wire, two or three Inches Diameter, to the End of a Stick, and putting this into the Water, and about half of it under the Earth, run it along a little Way, always holding it in the same Position, and that a little inclin'd; this will meet the Worms, and drag them along with it, and bring up a large Quantity thereof, which on shaking the Wire Circle in a Glass of Water, will all fall to the Bottom. If the Ditches where you fish for these Worms should be cover'd with Leaves and Herbs, it is necessary first to cleanse them with a Rake, before you put in the Iron Circle, otherwise you'll get but few Worms at a Time. There are also other Places so muddy, as to hinder the Wire from holding the Worms; in this Case it is expedient, that you throw upon the Mud some Inches of Sand, for as the Worms are obliged to keep Part of their Bodies above the Superficies of the Earth, they quit the Dirt, and pass into the Sand, and remain near the Superficies thereof. They may be taken in very great Quantities, after preparing the Bottom of the Water in this Manner.

These Worms are found in great Abundance in the Mud of the River *Thames*; when the Tide is out, they rise in such Swarms on the Surface thereof, that it appears of a red Colour.

You may give to each Polype a Worm much longer, and also a little thicker than the Polype is when extended; but then Care must be taken to let the Worm fall upon their Arms, otherwise they will miss of them, because they fall directly to the Bottom. Their Sense of Feeling is so delicate, that if a Worm touches even the utmost Extremity of these very slender Arms, they immediately by clasping them about it, invelope and fetter it in so many Places, that it is soon render'd uncapable of struggling to any Purpose, it easily yields, and at last is swallowed into the Polype's Stomach, Fig. 380. where it may be discern'd thro' the Polype's Skin.

These Worms are the best Nourishment for the Polypes, especially in the Winter, therefore if you gather a sufficient Quantity of them in *November*, and put them into large Glasses full of Water, with three or four Inches of Earth at the Bottom, you will have a Supply for the Polypes all the Winter, and may fish them up out of these Glasses, as out of the River.

Sometimes a pretty thick red Worm, about half an Inch long, is taken up with the rest, and is represented at c d, Fig. 382. It is the same as that described by Mr. *Reaumer*, in the *First Memoir of the 5th Tome of his History of Insects. Page* 29.

Polypes may also be nourished by these Worms, but they are more difficult for them to digest, and not at all fit Food for them in Winter.

Mr. *Trembley* hath also seen them eat a Worm, which he calls a transpa-

rent

rent *Tipula*, of which Mr. *Reaumer* ſpeaks in the 40th Page of the Memoir juſt cited.

Having in the Month of *June* taken a great Quantity of little Fiſh, about four Tenths of an Inch long, and given ſome of them to the Polypes, but the extreme Vivacity of this Fiſh, was almoſt too much for them to encounter with; however, all the Polypes that ſeized them, did ſwallow them, and the Tails of the long armed Sort were obliged to ſtretch open to receive the Fiſh: One of the ſecond Sort is repreſented at Fig. 377. which had ſwallowed one of theſe little Fiſh; and as its Skin a b, was ſo tranſparent, and flexible, it took the Form thereof, and appear'd like a Fiſh with long Whiſkers.

The *Polypes* eat the major Part of thoſe little Inſects that are found in freſh Water, they are very well nouriſhed with *Worms*, and the *Nymphs* of *Gnats*, and other *Flies*; they will alſo eat larger Animals if they are cut into little Pieces, as *Snails*, and other larger *aquatick Inſects*, and *Earth Worms*, the Entrails of *Freſh-Water Fiſh*, and *Butcher's Meat*, as *Mutton*, *Beef*, and *Veal*.

Mr. *Trembley* put into the Bottom of a Veſſel, ſome of the Earth taken out of a Ditch, imagining, that a great Number of little Inſects might be lodged therein, or at leaſt the Eggs of ſome; which Experiment ſucceeded very well, for from the End of *February* 1742. it was ſtored with various Sorts of little Animals; but particularly with one Sort, which is incloſed in a two-fold Shell; when this Shell was but a little opened, they put forth ſeveral minute Feet or Arms, that move exceeding quick, and by Means of this Motion they ſwim. Theſe Animals place themſelves upon all Bodies they meet with, and are about the Bigneſs of a Grain of Sand; ſome Polypes being put into this Veſſel, without taking any other Care of them, were nouriſhed therein, and multiplied for eight Months.

Whence it appears, that large Glaſſes or Pails, thus prepared with Earth, (at the Bottom of them) taken out of Ditches in the Summer-Time, will be a convenient Reſidence for the Polypes; for beſides thoſe Inſect Eggs that are contain'd in this Earth, may be very often ſeen (eſpecially if the Water in the Glaſs be expoſed to the Air) the Spawn and Nymphs of *Gnats*, and of *Tupula*, or *Water-Spiders*, &c. Theſe Veſſels may then be ſucceſsfully employed, and will ſave the Trouble of feeding the Polypes we intend to preſerve, and alſo of often changing the Water. But when it is not changed and cleanſed for ſome Time, it is generally filled with an Herb, as fine as Hairs, in which the Polypes entangle themſelves, and by which we are hinder'd from looking within-ſide, if the Veſſel be not made of Glaſs; however this Inconveniency is prevented by putting into each Veſſel a few *aquatick Snails*, more or leſs in Proportion to its Size; they will eat theſe Plants as faſt as they grow, whereby the Water, and the Sides of the Veſſel, will always remain clean.

Some-

Sometimes two Polypes ſeize the ſame Worm, and each begins to ſwallow its own End of the Worm, continuing to do ſo till their Mouths meet, Fig. 378. In this Poſture they remain for ſome Time, after which the Worm breaks, and each Polype hath its Share; but at other Times the Battle does not end there, for each of them continuing to diſpute the Prey, one of the Polypes opens its Mouth advantageouſly, and attempts to *ſwallow* the other Polype with its Portion of the *Worm*, which he effects in ſome Degree, and ſometimes almoſt entirely as at Fig. 380. Nevertheleſs this Combat ends more happily than we can at firſt believe, in Behalf of the devoured Polype; for the other gets the Prey entirely out of its Stomach, and the devour'd one comes forth again ſound and ſafe from the Body of its Enemy, after having been detain'd there above an Hour.

Polypes can eat a great deal at a Time, and they can faſt a great while; and they void their Excrements at their Mouth.

After a Worm is ſwallowed, the Tranſparency of the Polype's Skin will permit us to ſee it diſtinctly, as at Fig. 379. the Worm gradually loſes its Form, and is at firſt macerated in the Stomach of the Polype, the Juice nouriſhes, and being ſeparated, the Remains thereof are thrown out at the Mouth, as at Fig. 381.

It is alſo obſervable, that their Aliments are puſhed backwards and forwards, from one Extremity of the Stomach to the other, which contributes much to its Digeſtion; which Motion may be ſeen in the Microſcope, if you chooſe a Polype that is not too full. This Kind of periſtaltick Motion ſpreads the nouriſhing Juice all over the Stomach. But for an Obſervation of this Kind, it is beſt to feed the Polypes with ſuch *Aliments* as can beſtow a *lively colour'd Juice*; for Example, thoſe *Worms* whoſe Inteſtines are full of a *red* Matter, for by this Means we may ſee, that this alimental Moiſture is conveyed not only to the Extremity of the Body, but alſo into its Arms; whence it is plain, that a Polype's Arms are perforated, each of them forming a Kind of Gut, which communicates with that of the Body.

This was confirmed by examining a Polype, which had ſucked the red Matter contained in the Inteſtines of a flat Worm, Fig. 383. Its Body is of a tranſparent White, and Inteſtines extreamly viſible, and of a crimſon Red; Care muſt be taken to chooſe thoſe which are of a proper Size for the Polypes to ſwallow; they come out of the Polype's Body without being macerated, the red Matter which was in their Inteſtines being only extracted from them.

But this Experiment was yet better confirm'd on giving a Polype ſome Bits of the Skin of a little *black*, *flat Snail*, to be met with in great Abundance in *Ditches*. The Matter of this Skin was ſoon reduced in the Polype's Stomach to a Kind of Pap, principally compoſed of little black Fragments, and on examining their Motion attentively with the Microſcope, were ſeen to be drove about in their Stomach, and to paſs from Head to Tail, and into their Arms, even to a Thread; and afterwards were ſent back into the Stomach, and chaſed from thence to the Extremity of the Tail, and were again repelled from thence towards its Mouth, and into the Arms, and ſo on continually.

Theſe Experiments were ſeveral Times repeated, and ſucceeded in the ſame Manner.

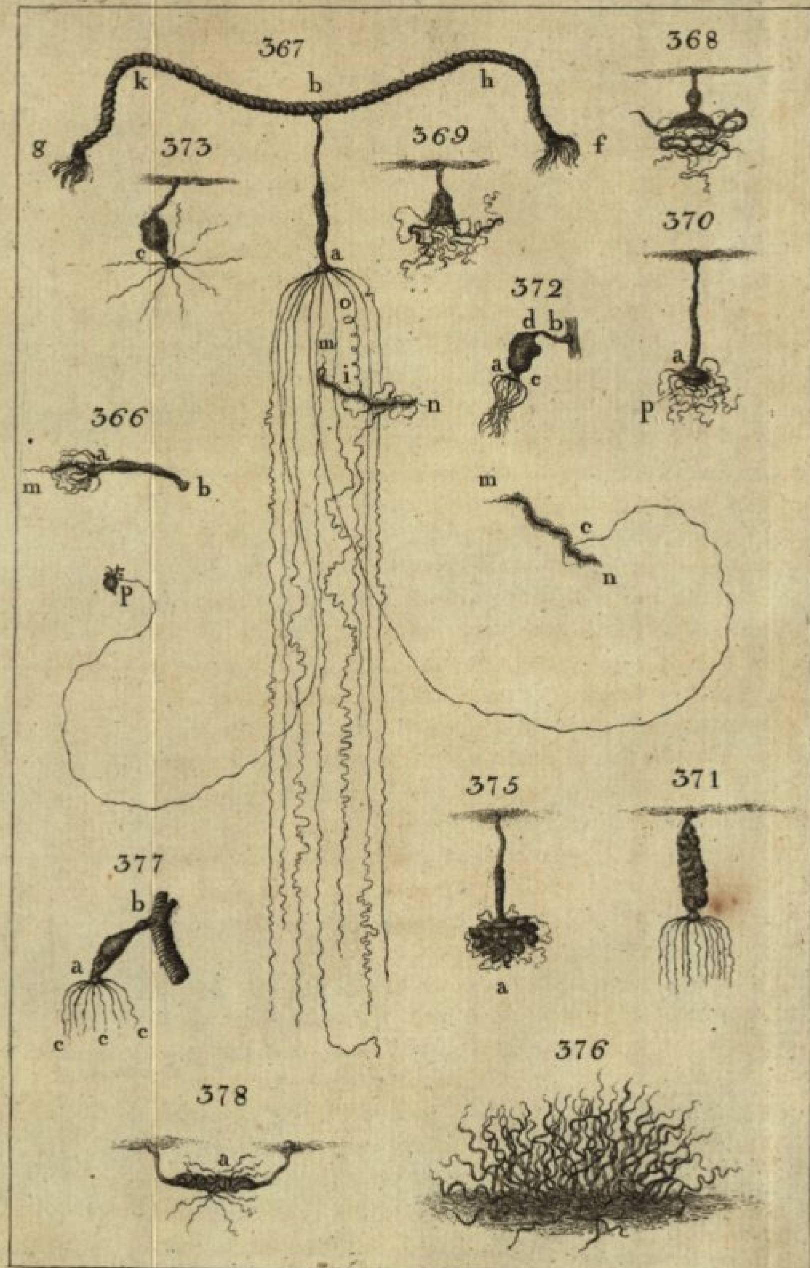
They are alſo a Proof of the Polype's Arms being tubular, and that they have an open Communication with the Stomach.

The Arms of the Polype are of the ſame Colour with its Body, and an Heap of the extravaſated Grains before ſpoken of, are of the ſame Colour alſo; it is therefore evident that the Colour of the Polype depends on the Colour of thoſe Grains which compoſe the Skin, (for when the Polype becomes white, they loſe thoſe Grains) and their Dependance is upon the nutritive Juice, drawn from the Aliments.

Theſe Grains, for Example, become red or black, if the Polype be fed with a red or black Juice; they are more or leſs tingid with theſe different Colours, in Proportion to the Strength and Quantity of the nutritive Juice. It is alſo obſervable, that they loſe their Colour, if not fed with Aliments of the ſame Colour to themſelves, and likewiſe that they will faſt a great while, but then they waſte proportionably to their faſting.

They are alſo ſubject to be infeſted with a Kind of aquatick Lice before ſpoken of, which are very common in expoſed Waters; they are of an oval Figure, and generally white; they run very ſwift upon the Polype's Body, and crowd about its Head more than any other Part, as at Fig. 385. Neverthelеſs they may be ſeen in great Numbers running over the Body a b, and Arms a c c. The preſent Figure is a Repreſentation of the Polype and Lice, as they appear in the Microſcope. If proper Care is not taken to keep them clean from theſe Animals, they will be devoured by them, their Arms will gradually diminiſh, and at laſt their Body, till there is nothing left. Fig. 386. repreſents one that had all its Head Part eat up, which after having been cleanſed, had a new Head, and new Arms, and became a very fine Polype.

Therefore the beſt Way to preſerve theſe Animals in Health, is often to change the Water, and that eſpecially after they have done eating. It is not enough to pour it off, but they muſt all be taken out, and the Bottom and Sides of the Veſſel rubb'd clean from the ſlimy Sediment adhering thereto, which is cauſed by the Fæces they diſgorge therein, which are converted into a Kind of Slime, fatal to them if not clear'd away. My Way is to looſen their Tails from the Sides or Bottom of the Glaſs, then I take them up one by one with a Quill, cut Scoop-faſhion, and place them in another Glaſs with clean Water; ſometimes they cling to the Quill in ſuch a Manner, as not eaſily to be diſengaged. The only Way then is to let the Quill remain a Minute or two in the Water, till they diſcharge themſelves,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selves, otherwise you'll be in Danger of breaking their Arms off, however when an Arm is broke, it is quickly repair'd again, but for some Days there appears a Swelling or Callosity in the Place which wears off in Time.

River, or any other very soft Water, agrees best with them, or what is taken up clear, out of some Ditch or Pond; but that which comes from a Spring or Pump, or is in its own Nature hard or sharp, prevents their thriving, and kills them in a few Days.

They are best kept in such large Glasses as hold three or four Quarts of Water, for in a Glass of this Size, the Water need not be renewed so frequently, especially if the Fæces are taken out from Time to Time, with the feather'd End of a Pen, to which it very readily adheres. Besides the Trouble is in some Measure saved of feeding each particular Polype, for here you need only throw in a Parcel of Worms, and let them take their Chance, but then all of them are not constantly fed, nor any of them so often as in the smaller Glasses.

The Worms you feed them with, must also be well cleansed from the Mud, and always remember to wash them in clean Water, every Time you feed the Polypes therewith.

Polypes are to be sought for in the By-Corners of *Ditches*, *Puddles*, and *Ponds*; for it is observable, that the Wind drives them together with the Plants, upon which they float into these Places; although we may search for them in some Places without Success, yet on coming there again, they may perhaps be found in great Abundance.

There are fewer of them in the Waters in Winter, than in the other Seasons. About the Month of *April*, *Duck-Weed* begins to rise above the Superficies of the Water, and to increase, and many other Plants also float upon the Water, the Warmth revives the Polypes, and they fix themselves to these Plants in Quest of Prey, at which Time they may be taken out of the Water with them.

SECT. III.

Of the Generation of Polypes.

WHEN a young Polype first begins to shoot, there only appears an Excrescence, which terminates in a Point e, Fig. 387. Some Time after that, when it appears cylindrical, its Arms also begin to shoot at its anterior End, c, i, Fig. 387. Its posterior End is fixed to the Body of its Mother, and gradually grows narrower, till at last it only appears to adhere thereto by a Point b, Fig. 388. at which Time it is ready to be separated; which they all perform in the same Manner. The Mother and young one fix themselves to the Glass, or other Bodies upon which they are situated, with their Arms and Head, and this is their Preparative for a Separation; sometimes the Mother gives a Twitch, at other Times the young one, and often both together.

A Polype a b, Fig. 389, with a young one c d, ready to be separated, disposes of its Body in an Arch of a Circle, a, b, d, against the Sides of the Glass. The young one being fast to the Top of the Arch at d, and its Head fix'd against the Glass; the Mother only contracts her Body, which by that Means becomes strait, as at a b, Fig. 390. which was before circular. While both its Extremities remain fixed against the Glass, the young one, which was also fastened to the Glass, does not follow the Mother when she withdraws, but remains in its Place, and its Tail d, by this Means is separated from the Body a b of its Mother.

Young Polypes shoot in Proportion to the Warmth of the Weather, and Quantity of Food the Mother eats; some have been perfectly formed in 24 Hours, and others not till the End of 15 Days. The first shot forth in the midst of *Summer*, and the other in a Season when the Water in which the Polype was contained, made * *Farenheidt*'s *Thermometer* descend to 48 Degrees.

They shoot forth from the Side of their Parent as a Branch from the Trunk of a Tree; and the Excrescence which is the Beginning of a Polype, is nothing but a Continuation of the Skin of its Mother, which is swelled and raised, nay even forms a Tube communicating with its Mother's Stomach, as appears from the following Experiment; for on choosing a large Polype of the second Sort, with a young one at its Side, which being placed upon a Slip of Paper in a little Water, the Middle of the young one's Body was cut, and the superior End of that Part which remained to the Mother was then open; next cutting the Mother on both Sides of the young Shoot, it became a very short Portion of a Cylinder open at both Ends, which being viewed through the superior and open End of the young Polype, the Light was sensibly seen in the Stomach of the Mother; but least there might yet be a Skin, which giving Passage to the Light, might nevertheless separate the two Stomachs, the remaining cylindrical Portion of the Mother was cut Lengthwise, and the two opposite Parts to that from whence the young one came out, were opened; and on observing it with a Microscope, not only the Hole t, of Communication, Fig. 391, was distinctly seen, but one might see quite through the End o, of the remaining Portion of the young one: Afterwards changing the Situation of these two Pieces of prepared Polypes, and looking through the last opening e, Fig. 392, the Day-light was seen through the Hole of Communication i.

* I must again remind the Reader, that these Thermometers are to be had at my Shop in *Fleet-Street*.

Mr.

Mr. *Trembley* not being contented with making this Experiment once, repeated it seven Times, and met with the same Success in five of them.

This Communication between the Mother and its Young may be seen on feeding them; for after the Mother a b, Fig. 393, had eaten, the Bodies of its young ones swelled, being fill'd with the Aliments as if they themselves had been eating them at their own Mouths c d e i o.

In the long armed Polypes, the young ones do not shoot out from the Tail Part b c, but only from the Part a c, Fig. 396.

It is also remarkable, that Polypes do not only produce several little ones at the same Time, all remaining fixed to their Mother, but that even some of those little ones at that very Time have two or three young ones also, of which some are perfectly formed, as at Fig. 396.

This Figure is sufficient to shew with what Promptitude the Polypes increase and multiply. The whole Groupe formed by this Mother and her 19 young ones, was but an Inch and $\frac{1}{4}$ long, and one Inch broad *Dutch* Measure; the Arms of the Mother, and the little ones, for the most part were hanging down towards the Bottom of the Vessel, whilst the Polype was suspended on the Surface of the Water. This Mother eat about a Dozen of the aquatick Fleas every Day, and the little ones, which were in a State to eat, devoured amongst them about 20 every Day.

All the fresh Water Polypes, with Arms in Form of Horns, are Mothers, for each Individual of this Sort produce young ones.

Mr. *Trembley* says, he hath nourished a thousand Polypes, and never found one which did not multiply, after it had been well fed, and always observed their Motions very attentively, in order to discover if nothing passed between them analogous to Copulation in other Animals; but could never find any Thing like it.

He then put several Polypes of the second Sort by themselves, that he might be very sure they never had since their Separation any Communication with other Polypes; and took none for these Experiments but those which he separated from their Mothers himself; or those which being separated of themselves, were taken out of the Glass in which their Mothers were, before any other young one could be separated, with which it might have been possibly coupled; yet notwithstanding all these Precautions of causing these Polypes to live in a perfect Solitude, they all *multiplied*, *eat*, and continued to produce young ones, more and more in Proportion as they were fed.

Not only these which he first put alone have multiplied, but also many of their Descendants have also been put by themselves, from Generation to Generation, even to the seventh, with the same Precautions. Whence it appears that Copulation is in no wise necessary to the Production of a Polype.

Mr. *Trembley* hath also made an Experiment to prove, that a young Polype

lype had in itself the Principles of Fecundity, before it could be thought to receive it from its Mother, or any other Polype: For on cutting off a young one which only began to shoot, and at that Time was only like a little Button, as e, Fig. 387. it is seen alone and of its natural Size after it was cut off, at Fig. 394, and as it appeared in the Microscope at Fig. 395. it was put into a Glass by itself, and gradually increased, had Arms, and at last multiplied.

It is therefore very plain, that a young Polype, after being separated from its Mother, does not want the Company of another Polype to multiply.

And that even before Separation it hath within itself the Principles of Fecundity, since from that Time it multiplies.

That if this Principle is communicated to it by the Mother while they are united, there is no Sort of Communication between the Head and Arms of either.

Neither is there any Communication after this Manner by another young one, that comes from the same Mother at the same Time with itself. And that if this Principle of Fecundity is within itself, it certainly is in an imperceptible Manner.

If we have not from hence discovered how the Polypes become fruitful, we have at least learned, that in this Point they differ from the most part of known Animals, and by Consequence have made an Exception to the general Rule, that says, *there is no Fecundity without Copulation.*

After Mr. *Trembley* had made the foregoing Observations, he was still farther desirous of finding out, whether there might not be some other natural Manner of their multiplying by Slips, as the Branches of a Tree; or if, on the contrary, this Manner of multiplying would succeed when they are cut in one or more Parts. Mr. *Trembley* hath seen Polypes which have divided themselves into two Parts, after which each Portion became a compleat Polype; whereby the same Re-production was performed as we have before remarked on cutting these Animals in two.

What hath been already said on this Head is sufficient to shew, that Polypes bear a nearer Resemblance to Plants than Animals, yet notwithstanding it is evident that they are Animals, because they eat and digest their Food.

SECT. IV.

Of cutting Polypes asunder and their Reproduction.

THE most extraordinary Part in the History of this Creature is this, that when cut into Pieces each Piece can repair itself and become a perfect Animal *.

* *Hist. de Polype. p.* 193.

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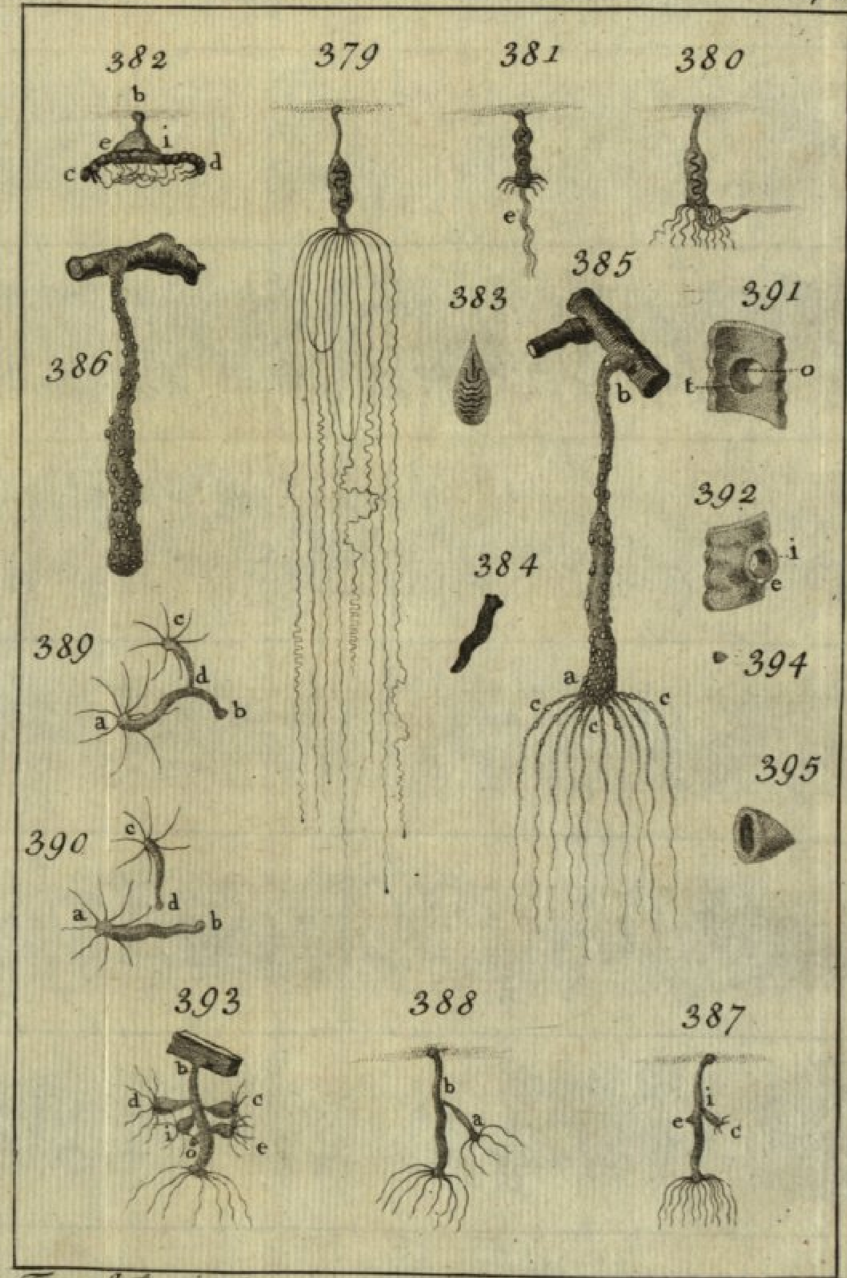

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To perform which put a little Water on a small Piece of Paper, whereon place a Polype, and wait a little while till it extends itself; then with a Pair of sharp Sciffars cut it into two Pieces, Paper and all, and examine each Piece with a magnifying Glass, to judge the Success of the Operation, putting each Portion into such a shallow Glass as is represented Fig. 26. which does not contain above 3 or 4 Tenths of an Inch in Depth of Water, by which Means they may be always observed with a *magnifying Glass*, or in the *Microscope*.

A, Fig. 397, represents the Head Part of a cut Polype, its posterior End b, being a little larger than that in a common *Polype*, and is sensibly open. In the Summer-time this first Part often walks, and eats the same Day it is cut.

The second Part, Fig. 398. hath its anterior End c more than ordinary open, and the Edges turned a little outwards, which afterwards folding inwards, closes the Aperture: The anterior End appearing then to be simply swelled, as at c, Fig. 399. This Part is never seen to change its Place before its Re-production is finished; the Arms shot out from its anterior End as those do in young Polypes, at first three or four Points begins to shoot, as at e, Fig. 400. and while these increase, others appear between them; before the Arms have done growing they can seize a Prey, and from that Time its Mouth is perfectly formed.

This *Re-production* is performed sooner or later, as the Weather is more or less warm. In the Height of Summer the Arms will sometimes begin to shoot in 24 Hours, and in two Days have been in a State to eat, but in cold Weather it will be 15 or 20 Days before the Head is formed.

If a Polype, having young ones, be cut transversly, the young ones continue to grow after the Section.

It often happens, that the second parts which have had no young ones at the Time of the Section, have had young Shoots before itself could eat, and before it had Arms.

In whatsoever Place a *Polype* was cut, whether at the Middle or near either End, the Experiment equally succeeded, and each Portion became a compleat *Polype*, which walked, eat and multiplied.

A *Polype* being cut close under the Arms, as at Fig. 401. and though small as it was, it became a compleat *Polype*, which at the Beginning was all Arms.

If a *Polype* be cut transversly into three or four Pieces; the posterior End of the first produces a Tail, the anterior End of the last a Head, and the intermediate Pieces acquire both Head and Tail.

To cut a *Polype* Lengthwise, it must be made to contract as much as possible, because the more it is contracted the larger its Body is: Therefore put the Polype upon a Slip of white Paper in a small Drop of Water, and when by touching, it is very much contracted, drain away the Water,

whereby

whereby its upper and under Sides colapse, and the Polype becoming spread in Breadth, remains fixed upon the Paper; then with a sharp Pair of Sciffars cut through both Paper and Polype, the divided Parts will adhere to the Paper like a Jelly, but may be removed therefrom to the Object carrying Glass with the Point of an Hair Pencil, first dipped in Water, upon which it may be applied to the *Universal Microscope*; or if the Papers are thrown into a Glass of Water, the divided Pieces will soon fall from them.

The Sides of a Polype cut longitudinally, roll themselves up different Ways, generally beginning from one of their Extremities, as at Fig. 402. and turns the Out-side of the Skin inwards; after some time it unrolls, and the cut Side forms itself into a Tube, whereof the Edges a b, and e i, Fig. 403. on both Sides meet each other, and re-unite themselves; sometimes they begin to join at the Tail End, at other Times they gradually approach all at once; when they begin to unite at one End, it is easy to distinguish that Portion which is joined c i b, from that which is not joined c a e, Fig. 404.

The Sides join so close, that from the first Moment no Scar can be seen; after which they become compleat Polypes, but with a less Number of Arms, and that in an Hour's Time, and in 24 Hours will seize and devour a Worm; in a few Days other Arms shoot and become as long as the rest.

Mr. *Trembley* cut a Polype into four Parts length-wise, as follows: After having cut it in two, in the Manner just shewn, he cut each of these into two also. These four Portions of the same Polype, had each of them six Arms, within six Days after the Section; and seven in four Weeks, they all eat and multiplied.

When a pregnant Polype is cut length-wise, the young ones continue to grow after the Section.

He hath also cut a Polype length-wise, and directly after cut the same transversly, and each of these four Quarters became compleat Polypes.

He likewise cut another, in Part length-wise, beginning at the Head, which became a Polype with two Bodies, two Heads, * and but one Tail. After having nourished this two headed Polype, by feeding it at both Mouths; he also split these Heads, and in a little Time it had four, and at last by cutting it after the same Manner, it had seven Heads, Fig. 405.

If a Polype be cut in Part length-wise, beginning at the Tail, it will soon have one Head and two Tails; and in this Manner the Number of Heads and Tails may be augmented by cutting, almost *ad infinitum*.

As all Sorts of these fresh Water Polypes form only a Tube or Gut, proceeding from one of its Extremities to the other, they may be turn'd Inside out as one would turn a Sack, *viz.* give a Worm to the Polype you

* *Hist. de Polype, p.* 247.

would

would perform this Experiment upon, and when it is ſwallowed, put the Polype into a concave Glaſs, or into the Hollow of the Object carrying Glaſs, with a little Water; afterwards preſs it near the Tail with an Hair Pencil, ſtroking it towards the Polype's Mouth, that the Worm within its Stomach may be forced partly out, as at c e, Fig. 412. its hinder Part a, remaining empty. As the Worm goes out, the Stomach enlarges prodigiouſly, eſpecially if it goes out double, as is expreſſed in the Figure. When the Polype is in this State, make it contract as much as poſſible, which contributes much to the Enlargement of the Stomach. It muſt be here obſerved, that as the Worm is partly out of the Stomach, it keeps it open, then taking an Hog's Briſtle in the right Hand, puſh it againſt the Extremity of the Tail b, till it enters into the Stomach, continuing gradually to advance the Hog's Briſtle, till it hath quite turn'd the Polype. When it comes to the Worm which keeps the Stomach and Mouth open, it either puſhes that out, or paſſes by on one Side thereof, and at laſt goes out of the Mouth, as at a b, Fig. 414. Sometimes the Polype is entirely turn'd at firſt, and then it covers the End of the Briſtle a b, Fig. 413. In this Caſe the exterior Superficies of the Polype is become the interior, which now touches the Hog's Briſtle, however it ſeldom happens that the Polype is entirely turned, but moſt commonly the Tail Part a b is out of the Mouth b, Fig. 414. and at the ſame Time a Part thereof is not turned; that is, its anterior End a c, which being terminated by the Arms, is folded over the turn'd End. Then to finiſh the turning, take an Hair Pencil in your right Hand, and the End of the Hog's Briſtle in the left. Always holding the other End of the Briſtle together, with the Polype in the Water, and ſtroke the End a c, which is not turn'd, very ſoftly with the Hair Pencil, that Way which is neceſſary to turn it, that is to ſay, from a to c, Fig. 414. which is preſently performed, at which Time it appears as at a b, Fig. 413. Then holding it in the Water, puſh it from a to b, with the Point of an Hair Pencil, and it will fall to the Bottom of the Glaſs without being put out of Order.

When it is firſt turn'd, the Mouth cloſes, and the Lips a, incline a little inwards; the Arms a c appear to join in a Bundle, and to come out of the Middle of the Polype's Mouth, as at a, Fig. 415.

After the Polype is turned, extend it as much as poſſible with the Hair Pencil, then taking an Hog's Briſtle with a Knot near one End thereof, run the other End through the Polype's Body, near its Lips; at that Inſtant let the other End of the Briſtle e, drop into the Water, and with the Point of the Pencil, puſh the Polype to the Middle a, of the Briſtle, Fig. 416. then take out the Briſtle and Polype, and put them into a Glaſs, f, e, g, h, taking Care that it only touches the Glaſs by its two Extremities c and d, that the Polype may be a great Way from the Bottom and Sides thereof, and the Knot End towards the Bottom; that if the Polype ſhould ſlide by its own Weight, it might not be able to diſengage itſelf. This Method is uſed to prevent the Polype from turning itſelf back into its natural State, which they ſometimes do in 24 Hours after they have ſuffer'd this Operation; and often after they have been turned, and ſpitted, to prevent them from returning, they have tore their Lips, and by that Means have formed two Heads.

Several young ones have been produced from theſe turn'd Polypes, which have alſo multiplied.

Sometimes they will eat in two Days after they have been turn'd, but generally not till 4 or 5 Days after.

Moſt of thoſe Mr. *Trembley* turn'd, endeavoured to return themſelves again, but could not entirely effect it, remaining like a Polype, partly turn'd, as at Fig. 406. the Skin of its anterior Part being applied upon the other, and forming a Kind of Pad at the anterior End a c, one Part thereof being turned, and the other not. Its Lips a, are no more at the anterior End, but are round that Part of the Body which is not turn'd back again, from whence alſo the Arms proceed, varying their Direction, ſometimes pointing towards the Tail, Fig. 406. and at others are bent over the Head, Fig. 407. their anterior Extremity c, Fig. 406. formed by the Edges of the reverſed Part c a, remain'd open, and ſome Days after began to cloſe; and on being attentively obſerved, new Arms began to ſhoot near the old ones, and ſeveral Mouths * were alſo formed near the Middle of the Bodies of theſe Polypes, that is to ſay near the Place where their Arms joined the Body at a, Fig. 406.

A Polype partly turn'd back again, remains but a little while in that Situation, as at Fig. 406. The Place a, to which this returned Portion a c, was fixed to the other Part a b of the Body, became a little ſtreighten'd, and the Portion a c formed a right Angle therewith, as is ſhewn at Fig. 408. where a c repreſents the returned Portion, and a b the other Part of the Body; the ſame Day another Head appear'd at e, and ſeveral Arms began to ſhoot, on one Side a o, of one Mouth a o n, which was formed on this Side; the other Side a n of this Mouth, being border'd by Part of the old Arms a d, a d. Next Day the Lips of the new Mouth was diſpoſed in Form of a conical Nipple, and the new Arms ſmaller than the old ones. The ſame Day the returned Portion a c, Fig. 408. which the Day before made the right Angle c a b, with the other Part a b, not returned, was drawn nearer to this laſt Part, and made an acute Angle therewith, as at Fig. 409. where a c repreſents the returned Portion, and a b that Portion not returned. The doubtful Part e, remain'd as before; a Worm being given to it, fell upon the old Arms, was ſeized, conveyed to the

* *Hiſt. de Polype, p.* 268.

new

new Mouth, and swallowed in an Hour's Time, and the Portions a c, a b, and a e, Fig. 409. were swelled with the Contents of the Worm.

Four Days after, its Form was much different, as appears by a Comparison of the Figures 410, and 411, whereof a e represents the returned Part, and a b the Part not returned. Having now but one common Mouth a, Fig. 410. the new Arms are seen between a and t, the equivocal Part e as in the Figures.

This Form was changed but little in fifteen Days, as is seen on comparing the two foregoing Figures; the old Arms which were before between a and t being vanished, and a Head at u, Fig. 411. which was at first taken for a young one, but remain'd in the same State above three Months. This Polype had two young ones, which proceeded one from g the returned Part, and the other from f, the Portion not returned.

These Observations are sufficient to shew the Nature of a Polype, that is, partly turn'd back again, and the different Revolutions made in these Animals, are seen in the Figures 406, 408, 409, 410, and 411. which represent the same Polype, and the return'd Part always a c, and that Part not returned a b.

These Changes are not exactly the same in all Polypes, but vary considerably, seldom any two of a great Number being perfectly alike.

The Polype represented by Fig. 417. was turn'd, and the following Day returned Part of its Head, as at Fig. 407. which 7 Days after was formed into three Heads, as at Fig. 417. a b shews the Tail of the Polype, which remain'd turned. a d c g e, the Portion turn'd back again so considerably changed as to form three Heads d g e.

Fig. 418. exhibits the same Polype 14 Days older, a b the Portion which remain'd turn'd, a d c n g e o, the Portion turn'd back again, a d, n g, n e, its three Heads and Necks; marked d, g, e, in the foregoing Figure.

Fig. 419. is the same Polype 13 Days after it was in the State of Fig. 418. The Portion o c of Fig. 418. is parted from o to c, and the two Portions, b a c d o, and c n g e o, Fig. 419. are only fastened to each other by a Thread o, a b is the turned Portion, a c and o c two Portions, which in the preceding Figure are re-united, and marked o c, a d, n g, n e, and are the three Heads with Necks, and are marked by the same Letters, Fig. 418.

The two Portions held by the Thread o, Fig. 419. are seen as they were separated in Fig. 420. and 421. a b, Fig. 420. is the turned Part, and a d one of the Heads, n g, n e, Fig. 421. the two other Heads.

Mr. *Trembley* imagined, that if one Polype could be put into the Stomach of another, in such a Manner, that the external Superficies of the Skin of the first, should be applied to the internal Superficies of the Skin of the second, they might stick together, and become but one Polype.

To introduce one Polype into another, first feed some of them, and when they are ſwelled by the Aliments, their Mouths will be alſo extended. Take that Polype out of the Water, you would introduce into the Stomach of another, and put it upon your left Hand, making it contract as much as poſſible by ſtroking it with an Hair Pencil, in ſuch a Manner as to force the Aliments out of its Stomach, and thereby cauſe its Mouth to open; then taking an Hog's Briſtle in the right Hand, put the biggeſt End thereof into the Polype's Mouth, and thruſt it to the Bottom of its Stomach. When this is done, place the Polype upon your Hand, into which this is to be introduced, cauſing it to open its Mouth, as in the other Polype, and thruſt that which is upon the Hog's Briſtle, into the Stomach thereof, and dip it into a Glaſs of clean Water, that you may examine it with a magnifying Glaſs; then to prevent the inner Polype from extricating itſelf, ſpit them both together upon an Hog's Briſtle.

Fig. 422. repreſents two Polypes put one into the other, a b the exterior Polype, and c a, b d, the interior one; e f in all the Figures ſhews the Hog's Briſtle which run through both the Polypes at e.

Fig. 423. is the ſame Polype, a i b the exterior one, c a i d the interior one; the Part i d by bending having ript up the Part i b of the exterior *Polype*, and by this Means got out.

Fig. 424. ſhews the ſame two Polypes, whereof i d, of the interior, tore the Part i b of the exterior one farther up, even to e; where the Briſtle at firſt ran through both the *Polypes* together: But when in the State repreſented by this Figure it pierced the interior one c a i d at e, and the exterior one a i b at i.

Fig. 425. repreſents the ſame two *Polypes* after the interior one a e b, had tore up the Lips of the exterior one c e d, and came out therefrom; they were ſeparated in a few Days, and both of them did well.

Mr. *Trembley* hath given us a curious Drawing of an aquatick Animal which he calls a *plumed Polype*; it is repreſented as they appear in the Microſcope at Fig. 426. The Plume and Length of its Body taken together are about $\frac{2}{11}$ of an Inch in Length, its Body very ſmall, almoſt cylindrical, and Skin perfectly tranſparent. The Plume is a Continuation of this tranſparent Skin, very large in Proportion to its Body, and of a very remarkable Figure.

Its Baſe e a c is in the Form of an Horſe-ſhoe, from the Edges of which proceed the Arms a d, a d, a d, whoſe Extremity is a little turned outwards, and are ſo cloſe together, that each Plume contains 50 or 60. The Baſe e a c of this Plume ſerves the Animal for a Mouth; its Inteſtines may be diſtinctly ſeen through this tranſparent Skin at e b, f g, f a, and are of a brown Colour; after the Animal hath eaten, three principal Parts of their Inteſtines are viſible, the Gullet e b, the Stomach f g, and the ſtrait Inteſtine f a.

Theſe Animals withdraw themſelves into a Caſe i, k, l, B, I, m, that ſeems

Front.^s Pag. 164.

Bowles sc.

seems to be composed of the same transparent Matter with the Skin of the Body, which is fastened by its inferior Extremity i b, I B, to the Orifice of the Case; so that whenever the Animal retires into the Case the Skin of the Body is reversed. The Plume which is upon the Base c, enters with it, and appears, when all inclosed, like A B. After it is thus inclosed, it will soon come out again if it be left quiet.

When it is out of the Case, you may see a Tendon fixed by one End g, to the inferior Extremity of the Stomach; and the other at o, the Bottom of the Case. There is also another of these Tendons fixed to the Base of the Plume at a, and the other End of the same to the Bottom of the Case at o; it is by the Help of these two Tendons that the Animal draws itself into the Cell.

These *plumed Polypes* are seldom alone, but many of them placed together one by the Side of the other; and there are several of them that come out of the same Case, but by different Orifices, which is the Way they multiply.

At first there is a little Elevation upon the Superficies of the Case of an old one, after which the Body and Plume s t begin to appear; or when a young one begins to shoot the Base of the Plume and Points of its Arms u u u, shew themselves and increase as the Body enlarges.

They can only eat very small Animals, but of these they devour great Numbers in a Day.

The quick Motion of the Plume, or rather the Feather-like Arms thereof, form a kind of Whirlpool, into which most of these little Animals that are swimming near it are precipitated.

Every Instant one or two of its Arms suddenly bend into the Plume, and immediately replace themselves into their first Situation; the same Arm seldom bends twice together, nor do they touch the Prey but by their rapid and continued Motion cause a turning in the Water, which conducts those minute Animals into the Plume, although they make several Efforts to escape, the sudden Inflection of one Arm, adds a new Degree of Rapidity to the Torrent which hurries them into the Plume, where they are immediately swallowed, by the Mouth which is in the midst thereof.

CHAP. XXXV.

Of Vegetables.

SECT. I.

THIS seemingly inferior Branch of the Creation, when carefully attended to, by the Assistance of the Microscope, exhibits to us an ample

ample Scene of the *Creator's* Wisdom, Curiosity and Art, in the wo nderfu Contrivance even of the most abject *Vegetables*, but more especially in the Anatomy of them; wherein may be seen the admirable Provision made for the Conveyance of the *lymphatick* and *essential* Juices, in communicating the *Air* as necessary to *Vegetable* as *Animal* Life, and more particularly in the Generation and Make of the *Seed*, wherein the Lineaments of the parent *Vegetable* are inclosed in Minature; and wherein also we see that *God Almighty* has by one Act of his creating Power provided for all succeeding Ages; and the future Posterity of each *Seed* does of Necessity produce its own Resemblance: For the Preservation of which, Nature hath endow'd some with light downy Wings, to be conveyed about by the Winds; others are laid up in elastick springing Cases, that upon bursting dart their Seed at convenient Distances, and others, *&c.* are planted by the Industry of the Husbandman.

The *Seeds* of *Plants* are inclosed in different *Sheaths* or *Cases*, till they are lodged in the *Earth*. Some are deposited in the very Heart of the Fruit, as the Kernels of *Apples* and *Pears*, others grow in *Cods* or *Shells*, as *Peas*, *Beans*, *Lentils*, *Poppy Seeds*, and *Cocoa Nuts*; some in wooden Shells, *&c.*

The Farina of Flowers appears to the naked Eye a kind of mealy Powder, which is found on the pendant Tops of almost every Flower; its Colour various in different Flowers, but its Structure constantly the same in Plants of the same Species. Here also the *Microscope* hath discovered surprizing Beauties, and hath shewn us, that this Powder is produced with the utmost Care in Vessels wonderfully contrived to open and discharge it, when it becomes mature, and that there is a *Pistil*, *Seed Vessel* or *Uterus*, in the Center of the *Flower*, ready to receive the minute Grains of this *Powder*, either as they fall of themselves, or are blown out of their little Cells. We are also taught by Experience, that the Fertility of the Seed entirely depends on this; for if the Farina Vessels are cut off before they open and shed their Powder, the Seed is unprolifick *.

SECT. II.

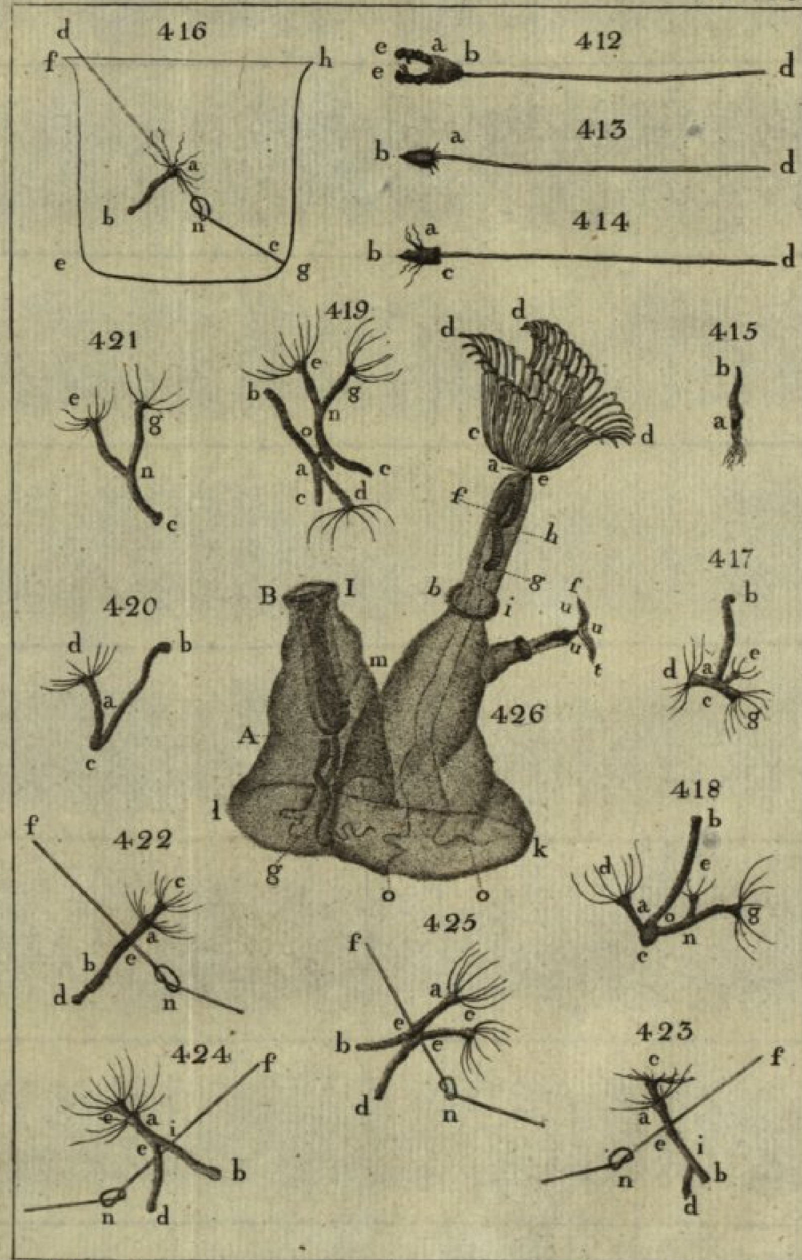
Of Seeds.

THE *Seed* is the last Product of a Plant whereby the Species are propagated; it is frequently the Fruit of the Plant, as is the Case in most Herbs: Sometimes it is only a Part inclosed in the Fruit, and that in Form either of *Grain*, *Kernel*, or *Berry*.

It is the natural Offspring of the *Flower*, and that for whose Production all

* *Phil. Transf. No.* 207.

Pl. 44.



J. Wigley. Sc.

Front.g Page. 166.

all the Parts of the Flower are intended; ſo that when this is once well formed, the ſeveral Parts of the Flower dwindle and diſappear.

It is produced from the *Farina* of the *Apices* let fall on the Head of the *Piſtil*, and thence forwarded to an *Uterus* at the Bottom thereof, divided into ſeveral Cells; where coming to receive the nutritious Juice of the Plant, it is firſt ſoftned, then ſwelled, increaſed both in Matter and Bulk, and at length comes to its State of Maturity.

By the Uſe of the *Microſcope* we diſcover in the *Seed* ſeveral Parts of the future Tree, only in Miniature; particularly a little Root call'd the *Radicle*, and the Stem call'd the *Plumule*.

I ſhall exhibit the curious and gradual Proceſs of Nature in the Vegetation of the Seed; and firſt, in that of the Garden Bean, repreſented by Fig. 427. by which a general Idea of all Seeds may be eaſily formed. It hath a ſmall Hole at a, that upon Diſſection is found to terminate againſt the Stalk of the *Plumule*; its End is apparent at a, in the tranſverſe Section of the Bean, Fig. 428. in which Figure the ſeveral Coats of the Bean appear, the innermoſt is every where twice, and in ſome Places thrice as thick as the outermoſt; and where it ſurrounds the Stalk of the Plume, it is ſix or ſeven Times as thick, as may be ſeen at b, Fig. 428.

The Hole a, Fig. 427. is not caſually made by breaking off the Stalk, but deſign'd for the Nurture of the young Plant, and may be ſeen in ſeveral other Kinds, as *Peas*, *Vetches*, *French beans*, *Lupines*, *Lentiles*, &c. in other Seeds alſo, *Medica Tornata*, *Fænugreek*, *Goats-rue*, &c. in ſeveral of theſe it is not diſcernable without the Aſſiſtance of the *Microſcope*; and in ſome not without cutting off Part of the Seed. When any of the above-named *Seeds* have been ſoaked in Water, ſeveral Bubbles will alternately break through this Hole on their being ſqueezed. All *Seeds* having thick and hard Covers, are alſo perforated in the like Manner; and thoſe lodged in Stones and Shells, though not viſibly perforated, yet the Stones and Shells themſelves always are; when the Coats of the Bean are ſtripped off, the Seed appears; its main Body is divided into two *Lobes*, joined together at the Baſe of the Bean, as at Fig. 429. In young Beans, eſpecially if boiled, theſe Lobes eaſily ſlip aſunder; but in dry Beans are very difficult to be ſeparated, unleſs they be firſt macerated for 24 Hours in Water. Some few Seeds are divided into more Lobes, as the Creſſes into ſix, and ſome not at all, as Grains of Corn, *&c.* moſt other *Seeds*, even the ſmalleſt, are divided exactly into two Lobes like the Bean; that which joins the two Lobes together is called the *Stem* or *Radicle*, out of which the *Root* is formed when the Seed vegetates. This *Stem* is found in all Seeds; in the Bean and ſeveral others, it is ſituated ſomewhat above the thick End, in *Oak Kernels*, commonly called *Acorns*, *Apple-Kernels*, *Almonds*, &c. it ſtands prominent juſt from the End.

The Plume or Bud iſſues out of this Stem, and is that which afterwards becomes

becomes the Trunk of the Plant, ſeparable in ſeveral already formed, tho' not diſplayed Leaves, which appear upon the ſprouting of the Seed, and may be ſeen in the Seed itſelf by the Aſſiſtance of the *Microſcope*.

The *Plume* is incloſed in a Cavity formed in the Lobes on purpoſe for its Reception, which may be ſeen at b, Fig. 429. it is almoſt of the ſame Colour with the Radicle, or little Root, on the Baſis whereof it is ſuſtained.

It is the firſt Part that appears out of the Earth ; as in effect it is the firſt Part that appears out of the Membrane, or Cover of the *Seed*, there being a Hole over againſt it in the Membrane, through which it makes its Eſcape.

It is the Appearance of the *Plume* without the Cavity of the Grain, that makes what we call the *Bud* or *Germ* of a Plant.

In diſſecting a *Bean*, if you hold your Knife aſlope, and very gently bear upwards, an exceeding thin and tranſparent Skin will ſhew itſelf, juſt as the Knife enters ; this Skin is not only ſpread over the Convex of the *Lobes*, but alſo upon the Flat thereof, and is extended both upon the *Radicle* and *Plume*, and ſo all over the Bean. This fine Skin vegetates imperceptibly, and the two Extremities of the Bag, which ſurround the Head of the Bud, expand and riſe with it in order to preſerve it, from all ſuch Frictions as may injure its tender and delicate Texture *. Next to this is the *Parenchyma*, conſiſting of an infinite Number of extremely ſmall Bladders, which may be ſeen in a very thin Slice of a Bean when applied to the *Microſcope*, and appears like Pith while ſappy in the *Roots* and *Trunks* of *Plants* ; on cutting the *Radicle* tranſverſly in ſeveral Parts, another Body of a quite different Subſtance from the *Parenchyma* or *Pulp*, will be found, which is alſo conſpicuous in a tranſverſe Section of the *Lobes*, and appears there like ſeveral ſmall Specks, and of a different Colour from the *Pulp*: Theſe are the ſeveral Branchings of the Tubes proceeding from the Radicle, and forming but one intire Trunk till it riſes to a b, Fig. 430, from whence it iſſues forth into three main Branches, the middlemoſt directly into the Bud c, and the other two after a little Space, paſs from e e on either Side into the *Lobes*, where they divide into ſmaller Branches, and theſe again ſpread into other more minute Ramifications, and terminating near the Verges of each *Lobe*, become a perfect Root.

This ſeminal *Root* being ſo tender, is difficult to be diſcovered, but may be come at by a careful paring off the Parenchyma in thin Slices Lengthwiſe, in new Beans, or if old Beans are ſoaked a conſiderable Time in Water, the ſame may be effected.

The Specks that appear on cutting the Radicle and Plume tranſverſly are moſt viſible in the Bean and great *Lupine*.

The ſeminal Root hath not yet been diſcovered in *Apples*, *Plumbs*, *Nuts*, &c.

* *Grew Ana. Plants, p. 4.*

&c. partly from their Colour, being the ſame with that of the Pulp, yet in the *Gourd Seed* the main Branches with their ſeveral Ramifications appear immediately on ſeparating the *Lobes*.

The *Parenchyma* of the *Lobes* is a kind of Meal intermingled with a nutritious Juice, or Sap of the Earth, forming a kind of Pap or lacteous Subſtance, which being filtered through the ſeveral Branchings of the ſeminal Root, are conveyed thro' the two ſmall Tubes a and b, Fig. 430, into the Bud, which is gradually repleniſhed therewith. When theſe ſeminal Roots have communicated all the Nouriſhment of the Lobes to the young Plant, they begin to wither, together with the Skin that covers them; the *Stem* or *Radicle* then alſo begins to take *Root* in the Ground for its future Subſiſtance.

SECT. III.

The Coats of the Seeds.

HOW it was in its State of *Vegetation* hath juſt been ſhewn; it remains then to enquire into its State of *Generation*; for what in the other State was not apparent, or intelligible, will in this occur; and here alſo we ſhall find a large Field for the Employment of the *Microſcope*.

The two general Parts of the *Seed* are its Covers and Body. The Covers in this State are uſually four; the outermoſt, which is called the *Caſe*, and is of various Forms, ſometimes a *Pouch*, as in *Naſturtium*, *Cochlearia*, &c. a *Cod*, as all Pulſe; ſometimes parted as *Sorrel*, *knotted Graſs*, &c. The two next are properly the *Coats*, in a *Bean* eſpecially, and the like; from whence the Denomination may run to the correſponding Covers of other *Seeds*; their Figures are ſometimes kidneyed as *Alcea*, *Behn*, *Poppy*; triangular, as *Polygonatum*, *Sorrel*, &c. ſpherically triangular, as *Mentha*, *Meliſſa*, &c. circular, in *Leucoium*, *Amaranthus*; globular in *Napus*, *Aſperula*; oval in *Speculum Veneris*, *Tithymalus*; ſemi-globular in *Coriander*, ſemi-oval in *Aniſe*, *Fennel*, pirimidal in *Geranium Althæafol*, with many other Differences.

Sometimes gliſtering, as in *Venus Looking-Glaſs*, rough caſt in *Catanance*, ſtuded in *Behen*, *Blataria*; favous in *Papaver*, *Antirrhinum*, *Lepidum*, *annum*, *Alcea-Veſicaria*, *Hyoſcyamus* and many more, * before the Seeds have lain long by; pounced in *Phalangium Cretæ*, *Lithoſpermum*; ramified in *Pentaphyllum fragiferum erectum majus*, reſembling the *Fibres* of the *Ears* of the *Heart*.

All *Seeds* have their outer Coats open, as in *Beans* and *Pulſe*, as before

* *Grew An. Plants*, p. 45.

 ſhewn,

ſhewn, or elſe by breaking off the *Seed* from its Peduncle or Stool, as in *Cucumber*, *Chicory*, &c. or by the Paſſage of a Branch or Branches, not only into the Concave near the Cone or Top of the Seed, but through the Cone itſelf.

The fourth or inmoſt *Cover*, is called the *Secondine*, a Sight of which may be obtained by cutting off the Coats of an Infant *Bean* in very thin Slices, at the Cone thereof, if not broke, it is tranſparent; if torn, it gathers up into the Likeneſs of a Jelly. In large old *Beans* it is not to be diſtinctly ſeen, but in moſt *Seeds* it may, even when full grown, as in *Cucumber*, *Colocynthis*, *Burdock*, *Carthamum*, *Gromwell*, *Endive*, *Mallows*, &c. though in theſe it is generally thin and difficult to be diſcovered, yet in ſome Kernels, as *Apricocks*, it is very thick, and remarkably ſo in ſome other Seeds.

The Concave of this Membrane is filled with a moſt tranſparent Liquor, out of which the Seed is formed, as appears on cutting an Infant Bean, or better in a young Walnut.

Through this Membrane, the lignous Body or Seed-Branches, in the inner Coat, ſhoot down in two ſlender Fibres, near the Baſe of the Radicle, one into each Lobe of the Bean, and there ſpread into a great many Ramifications, which convey the Juices on the Vegetation of the Seed, into the Radicle and Plume, as before deſcribed.

SECT. IV.

Of the Seed Caſes or membraneous Uterus.

THE Seed Caſe is a kind of fleſhy Uterus, growing more moiſt and pulpy as the Seed ripens, but the Caſe itſelf whether called Cod, Pod, or by any other Name, is a membraneous Uterus, which grows more dry and hard as the Fruit ripens. In ſome the Seed Caſe is originally open, in others it opens when the Seed is ripe, and in others not at all till the Seed is ſown.

Garden Radiſh-Seed breaks within as it ripens into ſeveral white dry Membranes, round about the Seed. Near the Sides of the Caſe run a Pair of vaſcular Fibres, from which branch forth ſeveral ſmaller Fibres, ſome towards the Sides of the Caſe for their Support, and others towards the Center thereof upon which the Seeds hang, Fig. 431.

Of thoſe which open as ſoon as the Seed is ripe, ſome open at the Top, as *Poppy Heads*, Fig. 432, others on the Side, as moſt Cods; and ſome at the Bottom as *Coded Arſmat*, Fig. 433. the *Poppy Head* is divided by eight or ten Partitions into as many Stalls, and on both Sides the Partitions hang a moſt numerous Brood of Seeds.

Of thoſe which open on the Side, ſome open on one Side, ſome on both, others with three Sides, ſome more, and others horizontally, or round about.

The Cod of a *Garden Bean* opens on one Side, and hath a two-fold Parenchyma; in the outermoſt ſtands all the Veſſels in ſeveral Parcels, from one of which, being larger than the reſt, and at the Back of the Cod, ſhoots forth theſe leſſer Veſſels whereon the Beans grow; the inner Pulp is wholly compoſed of Bladders, in which many of thoſe Threads whereof the Bladders are wove, are ſo looſe, as to be eaſily drawn out to a conſiderable Length, and are very viſible when applied to the *Microſcope.*

The Seed Caſe a b c d, of *yellow Henbane*, Fig. 434, opens on both Sides, from its Top at a, grows a Stem, which diminiſhes as the Caſe ſwells, and at laſt falls off. On the Sides of the Caſe run two oppoſite vaſcular Fibres, and as the Caſe gradually increaſes, it as gradually ſeparates on both Sides in the Tract of the aforeſaid Fibres as at b. The Caſe is lined with a ſmooth thin Skin, in whoſe Center is a great Parenchymous Boſs c, being the Bed of the Seeds which lie all over as in a Strawberry; throughout this Bed the Veſſels d, for the Generation and Nouriſhment of the Seed are diſtributed, as may be ſeen in the tranſverſe Section thereof at d, in which a very ſmall Fibre, ſhooting from the direct Fibres obliquely into each Seed is plainly viſible.

The *Seed Caſe* of a *Tulip*, whereof a, repreſents the Caſe intire, b is a tranſverſe Section of it, and c the Caſe ſplit down. Fig. 435, it opens on three Sides, from the midſt of each proceeds a Partition, all meeting in the Center of the Caſe, and making ſix Diviſions for the Seed. The Veſſels are curiouſly diſpoſed after they riſe above the Stalk, being at firſt divided into three principal Branches, running along the three Angles of the Caſe, from which divers leſſer Branches tend horizontally, and meet at the Middle of each Side; whence they proceed through the Breadth of each Partition to their Edges, in the Center of the Caſe, where they are again diſtributed into very fine and ſhort Threads, whereon the *Seeds* hang.

The Seed of *Anagallis* or *Pimpernel*, Fig. 436, is a little Globe opening horizontally into two Hemiſpheres, the uppermoſt falls off when the Seed is ripe, and ſo the Wind ſows them.

The Seed-Caſe of *codded Arſmat*, Fig. 433, neither opens at the Top nor on the Sides, but at the Bottom, being compoſed of four Sides, in the Center of the Caſe is a Column a, upon which the Seeds hang looſely. From this Mechaniſm that violent Ejaculation of the Seed is intelligible, which is not a Motion in the Seeds themſelves, but contrived by the Structure of the Caſe, the Seeds hanging very looſely, not on the Sides of the Caſe, but on the Stem in the Center thereof, with their thickeſt Ends downwards, ſtanding ready for a Diſcharge; the Sides of the Caſe being lined with a ſtrong Membrane, they perform the Office of ſo many little Bows remaining fast at the Top b, are let off at Bottom, and forcibly curl upwards and drive all the Seeds before them.

SECT. V.

Of the Number and Motions of Seeds.

NAture hath procured the Propagation of Plants several Ways, but chiefly by the Seed; for the Production of which the Root, Leaves, Flowers and Fruit do all officiate; and according as the Plant or the Seed it bears is more or less liable to be destroyed, Provision is made for the Propagation of either by a greater Number of Seeds, or otherwise; for Instance, the Seeds of *Strawberries* being gathered, or eaten by Vermin with the Fruit, the Plant therefore is easily propagated by Trunk Roots; the *white Poppy* being an annual Plant is highly prolifick, commonly bearing about four mature Heads, in each of which are at least ten Partitions, on both Sides whereof the Seeds grow, and on one fourth Part of one Side, about 100 Seeds, that is 800 on one Partition, which multiplied by 10 makes 8000, and this multiplied again by 4, the Number of Heads, gives 32,000 Seeds, the yearly Product of that Plant.

So also in Typha Major, the Seeds being blown off and sown with great Hazard, are prodigiously numerous, they stand altogether upon the Spike, and make a Cylinder at least six Inches long, and near $\frac{3}{4}$ of an Inch in Diameter. Nine of these Seeds set close together upon a Right Line make but the Eighth of an Inch, so that 72 make a Line of an Inch in Length; but because upon the Spike, the Hairs belonging to the Seed come between them, we will abate 10, and count but 62; to which if $\frac{3}{4}$ be added (abating the Fraction, *viz.* 46.) makes 108, for the Circumference of the Cylinder, which being six Inches long, there are 6 Times 62 for a Line the Length of the Cylinder, which is 372; which Number being multiplied by 108, produceth 40176, the Number of Seeds that stand upon one Stalk: Therefore upon three Stalks which one Plant commonly bears, there are in one Year 120,528 Seeds.

As soon as the *Seed* is ripe, Nature taketh several Methods for its being duly sown, not only in opening the *Uterus*, but also in the Make of the *Seed* itself; for first the Seed of many Plants which effect a peculiar Soil, as *Arum Poppy*, &c. are heavy and small enough without further Care to fall directly down into the Earth, and so to grow in the same Place where they had their own Birth. But if the Seeds are so large and light as to be exposed to the Wind, they are often furnished with one or more Hooks, to prevent their wandering too far from their proper Place, till by the Fall of Leaves or otherwise, they are safely lodged. The Seeds of *Avens* have one single

ſingle Hook, thoſe of *Agrimony* and *Gooſe-Graſs* many, both the former loving a warm Bank, and the laſt a Hedge for its Support; on the contrary, divers Seeds are furniſhed with Wings or Feathers, partly with the Help of the Wind to carry them when ripe from off the Plant, as thoſe of *Aſh*, *Maple*, *Orach*, &c. leaſt ſtaying thereon too long, they ſhould either be corrupted, or miſs their Seaſon, and partly to enable them to make their Flight more or leſs abroad; that by falling together, they may not come up too thick, and if one ſhould eſcape a good Soil or Bed, another may light thereon. The Kernels of *Pine* have Wings, not unlike thoſe of ſome Inſects, but very ſhort, in reſpect of the Weight of the Seed, they do not fly into the Air, but only flutter about upon the Ground; thoſe of *Typha*, *Dandelion*, and moſt of the papous Kind, with many more, have very long and numerous Feathers, by which they are wafted every where, and to any convenient Diſtance.

Some Seeds are ſcatter'd, not by flying abroad, but by being ſpurted away as *Wood Sorrel*, Fig. 437. which is effected by a white, thick and ſtrong Cover of Tendons of a ſpringy Nature, in which the Seed within its Caſe is incloſed. This Cover, as ſoon as it begins to dry, burſts open in an Inſtant on one Side, and is violently turned Inſide out, and ſo ſmartly throws off the Seed.

The Seeds of *Harts Tongue*, Fig. 439. and all that Tribe, are flung or ſhot away by a curious Contrivance in the Seed Caſe; as in *Coded Arſmart*, or other like Plants, only there the Spring moves and curls up inwards, but here it moves outwards; every Seed Caſe ſtands upon a little Pedicle, a a a, Fig. 439. being of a ſilver Colour, and of a ſpherical Figure; it is girded about with a ſtrong Tendon or Spring a, (whoſe Surface reſembles a fine Screw, of a golden Colour, which breaks the Caſe, immediately upon its becoming elaſtick enough) into two hemiſpherical Cups, as at b c, and by that Means fling off the Seeds. Theſe Caſes grow in Furrows, d e, d e, d e, on the Back of the Leaf, as at Fig. 438. in one of which of an Inch long are more than 300 of the above-mentioned Caſes; and allowing 10 Seeds to every Caſe, makes 3000 Seeds; which multiplied by the Number of Furrows in one Leaf, with Allowance of the leſſer Furrows, and that Sum by the Number of Leaves commonly growing upon one Root, amounts to above a Million of Seeds,* the annual Product of this Plant. The Seed is of a tawny Colour, flat and ſomewhat oval; of theſe ten thouſand are not ſo big as a white Pepper Corn. Fig. 439. repreſents a few of the Seed Caſes magnified; they were cut out of the Furrow at f, in the Leaf repreſented by Fig. 438.

Divers notable Means of Semination are obſerved by other Authors; Mr. *Ray* tells us, that a Quantity of Fern Seed, laid in a Lump, on a Paper,

* *Grew. Ana. Plant, p.* 119.

the

the seminal Vesiculæ are heard to crackle, burst, and, by the *Microscope*, the Seeds are seen to be projected to a considerable Distance from each other.

Dr. *Sloane* observes, that the *Gentianella flore cæruleo*, or Spirit Leaf, requiring wet Weather to be sown in, as soon as the least Drop of Rain touches the End of the Seed Vessels, with a smart Noise, and a sudden Leap, it opens itself, and with a Spring scatters the Seed.

Other Plants sow their Seeds by inviting Birds by their agreeable Taste and Smell, to feed on them, swallow them, and carry them about; thereby also fertilizing them, by passing through their Bodies. In such Manner are Nutmegs and Mizzletoe sown and propagated.

SECT. VI.

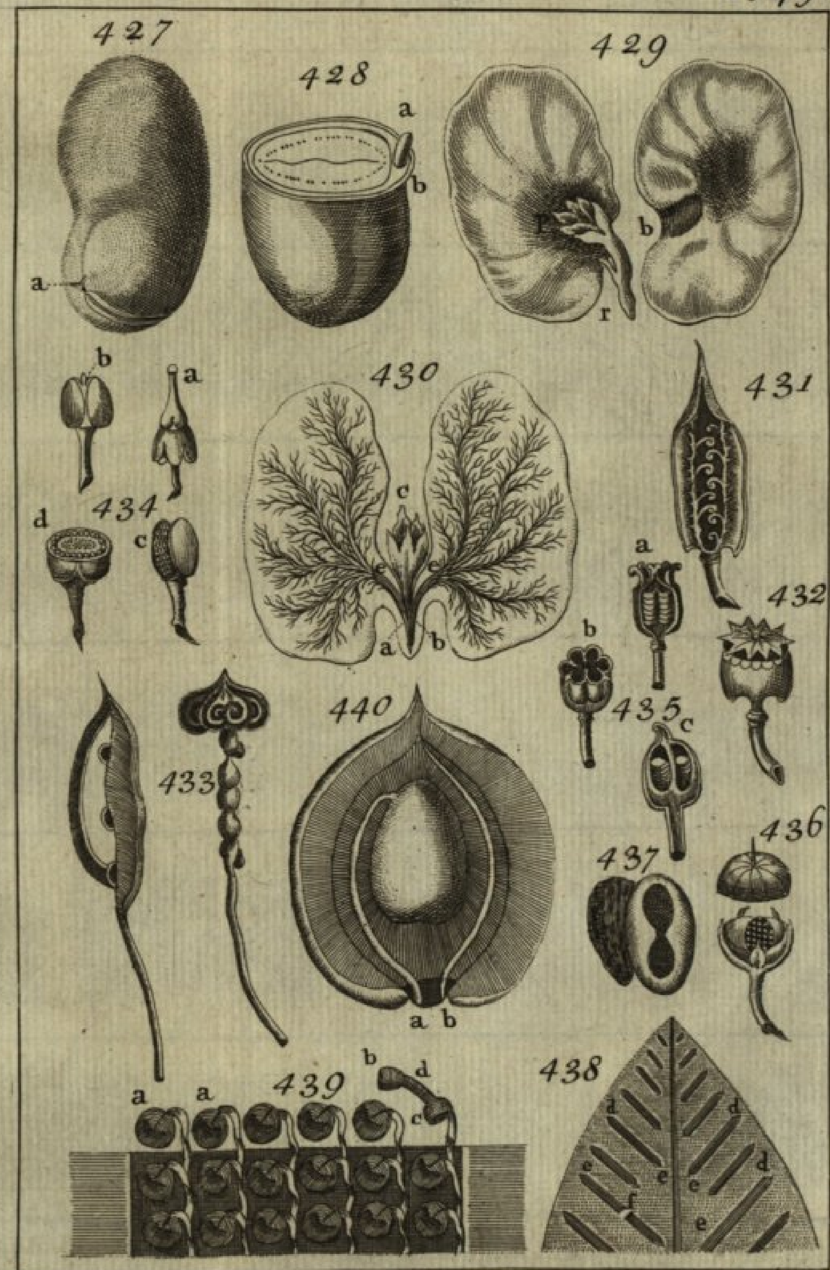
Of the Covers of the Seeds.

THE next Step which Nature takes, relates chiefly to the Growth of the *Seed*, when sown, and for this Purpose the outer Covers are somewhere furnished with Apertures, sufficient for the Reception of alimental Moisture, to be received from the Ground, and for the shooting forth of the young Root into it; as in the Seed of a *Gourd* at the Bottom, in a *Bean* on the Side, and in a *Chesnut* at the Top, in which Place the young Plant always lies, and puts forth in the said several Seeds. The Seed of *Palmi Christi* falls to the Ground, not only in the usual Covers, but also in the said Case.

If the Cover of the Seed be stony, and very hard, it is divided into several Pieces, whereby they easily cleave asunder: The Shell of a *Hazel Nut*, divides on the Edge, and the Cleft begins at the Point, where the Root stands and shoots forth; the Shells of some *Walnuts* cleave into four Parts, and the Stone of *Bellerick Myrobalan* into five: The Covers and Husks of some Sorts of Grain, as *Millet*, are folded over each other, the better to give Way to their tender Sprouts.

The Covers of all, or at least the far greater Number of Seeds, are three, and sometimes four, even those of stoned Fruits have three, besides the Stone; in *Gossipium* there are two under that lin'd with Cotton. The Seeds of *Cucumbers*, *Goat's Beard*, *Broom*, *Scabious*, *Lattice*, &c. although so small, have plainly three Coats; in some of these, and in many more, only two are distinctly visible, except in the State of Generation. In the upper Coat the Seed Vessels are disseminated; the second is at first a mere Pulp, which afterwards shrinks up, and sticks close to the upper. The third or inmost more dense; and if it be thin, for the most Part transparent; whereby the Seed seems to be sometimes naked while it lies therein, as in *Almonds*, *Cucumbers*, &c.

In



Front. I Pag. 174. Bowles sc.

In *Meliſſa*, and ſome other Seeds, it comes finely off, on being ſoaked in warm Water.

SECT. VII.

Of the Fœtus, or true Seed.

AMong Seeds of the thinner Covers are thoſe of all Sorts of *Corn* and *Graſs*, different from that of moſt other Seeds. The main Body being of one entire Piece, doubled in the Form of a Pair of Lips. In the Seeds of *Dates*, and ſome other like Plants, that which is generally called the Stone, ſeems indeed to be the main Body of the Seed, doubled or folded up in the ſame Manner as Corn, to which that Part which becomes the Plant is annexed. In Corn it is placed in the Bottom of the main Body, but here in a ſmall round Cavity in the Middle of the Back.

For the moſt Part the main Body is divided into two Lobes, plainly to be diſtinguiſhed in moſt *Kernels*, and other large Seeds, and not difficult in many leſſer ones, as in *Viola-lunaris*, *Scabious*, *Doves-Feet*, &c. if ſlipped out of their Covers before they are full ripe; in *Hounds Tongue* they are of a circular Figure; in *Cucumbers*, oblong, with ſome viſible Branches of the ſeminal Root, *&c.*

In the foregoing Seeds, the Lobes lie flat one againſt another, but in *Garden Radiſh* they are folded up, ſo as to receive the Radicle into their Boſom. In *Holy-Oak* the Lobes are plaited over each other. In Cotton Seed they are very broad and thin, and their Folds curious and very numerous.

Many of the Seeds, with bulky Covers, are not divided into two Lobes, being in a Manner of one Piece, as all the bulbous Kind: In *Flag* it is above 20 times bigger than the Seed within it, and conſiſts of Bladders radiated towards the Seat of the Seed, and theſe diſpoſed in parallel Lines running lengthwiſe.

But the greateſt Number of Seeds with bulky Covers, are divided into two Lobes. In the *purging Nut* of *Angola*, if the Shell be taken off, the upper Covers, [dried and ſhrunk up] ſeem to be but one: In theſe the ſpermatick Veſſels are branched, and under them the thick and inmoſt Cover; which being cut down the Middle thereof, ſhews the true Seed, conſiſting of two veined Leaves, as white as Milk, joined together with the Stem or Radicle at their Baſe, and ſunk into a Hollow made in the Cover. The ſame is alſo obſervable in the *Barbadoe Nuts*, *Ricinus*, *Americanus*, and ſome other *Indian* Fruits.

In the foregoing Fruits, the Bulky is very ſoft, but in *Nux Vomica Officinarum*, it is nearly as hard as a *Date Stone*; in this, and the foregoing, the

Seeds

Seeds are large, but in others are ſo ſmall, that they are ſcarce diſcernable without a *Microſcope*, as in *Staphiſagria*. The thick or inmoſt Cover is conical towards the Baſe, at whoſe Point is a little Cavity where the Seed is lodged; the Root thereof pointed, and Lobes rounded at the Top. In *Peony* the ſame Cover is ſoft, white, and of an oval Figure, the Part uſed for Medicine, is thought to be the Seed itſelf, but is near 200 times bigger than the true Seed; which lies in a little Cavity near the Bottom of the Cover, with a blunt Root, and two pointed Lobes.

In *Coffee-Berries*, the Seed lies in the inner Cover, near the Top; the Back of the Lobes are veined like two minute Leaves, and joined to a long Root.

The Seed of *Stramonium* is incloſed in a bulky Cover, which being ſoaked in Water, and carefully cut about the Edges with a ſharp Razor or Penknife, its Seed may be taken out entire, and examined by the *Microſcope*.

SECT. VIII.

Of the Buds of Seeds.

THE Stalk of the Plant riſes up from between the Lobes, which may always be ſeen, in ſome by the naked Eye, and in others by the *Microſcope*; in many Plants Nature ſees fit only to lay the Foundation thereof in a round Node, as in *Viola luniaria*, &c.

But in moſt Seeds is formed a true Bud, conſiſting of perfect Leaves, in ſome two, others four, *&c*. In *Bay-berry* only two, very ſmall, but thick, and finely veined; in the Seed of *Carduus Benedictus*, they are alſo two, pointed at Top, and ſituate a little Diſtance from each other, for the two next to riſe up between them.

In ſome Herbs, although the Bud conſiſts but of two perfect Leaves, yet they are very conſpicuous, not only in the larger Seeds, as *Phæſcolus*, or *French Beans*, but in ſmall ones two, if examined by the *Microſcope*, as in the Seed of *Hemp*. A B, Fig. 441. in which the two Leaves are plaited, and ſet Edge to Edge, c ſhews the other Part of the Seed which was ſeparated to lay the Bud fair to View. In the Seed of *Senæ*, the Bud hath four Leaves: In the Seed-Bud of an Almond C, D, Fig. 442. there are ſix or eight, and ſometimes more diſtinct Leaves viſible, if by a dextrous Separation of the Outer, the Innermoſt are laid open, they are folded inward one over the other, as appears at D, which repreſents them open, and at C the ſame Seed-Bud is ſeen ſhut.

The Lobes of the Seed, and ſo likewiſe the Stalk and Bud, conſiſt of a Skin, Parenchyma and branched Veſſels, as before deſcribed; all which are apparent to an Eye armed with a *Microſcope*.

The

The firſt Skin, as in *French-Beans*, may be eaſily ſeparated from the Parenchyma, eſpecially if the Bean be ſoaked in Water for ſome Days, it will ſlip eaſily off, and will be found to conſiſt of Bladders, ſmaller than thoſe of the Parenchyma, and intermix'd with a kind of lignous Fibres which give a Toughneſs to the Skin. The branched Veſſels run through the Parenchyma, and compoſe the ſeminal Root in the Lobes, being no where extended to the Circumference of the Lobes, but are all inoſculated together at a conſiderable Diſtance from it; all meeting therein in one ſolid Nerve, but in the Stalk are dilated into an hollow Trunk, filled with a Pith compoſed of Bladders, which in the Stalks of *French Beans* is very conſpicuous; they conſiſt of Sap and Air Veſſels as the other Parts of a Plant, not running collateral, the latter being ſheathed in the former, and are plainly viſible in the *Microſcope*.

Sect. IX.

Of the Generation of the Seed.

As a *Garden Bean* was choſe to ſhew the Manner of the Seeds Vegetation, ſo an Apricock is very fit to obſerve and repreſent the Method Nature takes in its *Generation*.

A proper Uterus is firſt prepared, both to keep the Membranes of the Fœtus warm and ſucculent, and to preſerve and ſecure it afterwards till it takes Root in the Ground. For this Purpoſe both the Pulp and Stone of the Fruit are neceſſary; but firſt the Stone, the Pulp being only neceſſary to form the Stone, the petrifying of that Parenchyma which is the Ground of the Stone, being effected by the ſinking of the Tartar * thereinto; for

It is evident on cutting a young *Apricock*, and then with a ſharp Razor ſhaving off a thin Slice, and viewing it through the Microſcope, that at firſt the Ground of the Stone is a diſtinct and ſoft Parenchyma, compoſed of Bladders, as the Pulp itſelf is, which Bladders, as it hardens into a Stone, fill up and diſappear.

This Parenchyma takes its Riſe from the Pith, as the Pulp does from the Bark, and compoſes the greateſt Part of the Stone; its Inſide is lined all over with a thin Skin, covering the Seed Branch on its firſt Entrance into the Hollow of the Stone; which Skin is alſo compoſed of exquiſitely ſmall Bladders, by which Means it ſoon becomes a very hard and dry Body.

The Stone being made hard and dry, could never be ſufficiently ſoftned (to give Paſſage for the Vegetation of the Seed) by lying under Ground, did it not eaſily cleave in two; for which Purpoſe the Skin of the Fruit is

* *Grew. An. of Plants, p.* 209.

immediately concerned; for in a tranſverſe Slice of a young *Apricock*, if it be cut with a ſharp Knife, this Skin may be ſeen (when applied to the Microſcope) fairly doubled inwards from the two Lips a b, a b, of the Fruit, Fig. 443 and 444, and from thence continued through the Pulp and Stone itſelf into the Hollow thereof, where it meets and is united with the Lining before-mentioned; and as it conduces towards the drying of the Stone, ſo alſo it renders it cleaveable in that Part where it runs through it.

Nature having thus provided a convenient Uterus, her next Care is about the Membranes of the Fœtus, theſe are three apparently diſtinct, and in many Reſpects different from each other.

The firſt of theſe, Fig. 443. repreſents a tranſverſe Slice of a young Apricock near the lower End, ſhewing the Duplicature of the Skin half Way through the Stone. Fig. 444. a tranſverſe Slice cut through the upper End, ſhewing the Duplicature of the Skin quite through the Stone; and at a b, Fig. 446. is ſhewn the Branches which run through the Stone to the Flower and Seed, in a well grown Apricock cut Lengthwiſe.

The outermoſt of theſe Membranes takes its Riſe from the Parenchyma, and ſurrounds the Seed Branch, and upon its Entrance into the hollow of the Stone is expanded into two Bladders, one within the other; whereof one becomes the Lining of the Stone, the other the outer Membrane, and is beſt ſeen on cutting a young Apricock when it is about half an Inch long through the Middle, or from the Seat of the Flower to the Stalk, between the two Lips a b, Fig. 443. At this Age the outer Membrane hath a full and firm Body, and is compoſed of Bladders, as may be plainly ſeen on its Application to the *Microſcope*.

The Veſſels contained in the Seed Branch, are diſtributed throughout this Membrane, beginning a little below its ſmaller End, and running round both Ways, meet in the Middle of the greater, where they are all inoſculated and form a kind of umbelical Node, as at a, Fig. 445. from whence they ſtrike deeper into it till they arrive at the middle Membrane, where they become inviſible; theſe Veſſels convey the Sap to the middle Membrane, whoſe Bladders are more angular and amplified towards the Center, being at leaſt two hundred * Times bigger than thoſe of the outer Membrane.

This middle Membrane is ſo called from the State and Condition it hath upon the Augmentation of the Seed, at which Time it obtains the Name of an Involucrum †, but originally is every where entire without any Hollow, filling up the Cavity of the outer Membrane like a ſoft and delicate Pulp. After a ſhort Time a ſmall Channel appears therein, running from the Bottom to the Top; at firſt no wider than to receive a human Hair, and then only viſible in a tranſverſe Slice, and that not without a *Microſcope*;

* *Grew. An. Plan. p.* 210. † *Ibid.*

ſcope; but when grown a little wider, may be ſeen if the Membrane be carefully cut Lengthwiſe, at which Time it is dilated into two oval Cavities, e f, Fig. 446. one at each End, into which a moſt pure Lympha continually owzeth, and is therein reſerved for the Nouriſhment of the Seed, and alſo paſſes freely from one to the other.

A few Days after this, the inmoſt Membrane begins to appear like a ſoft Bud growing out of the upper Cavity, being joined to its lower End by a ſhort and tender Stalk; from whence it is produced into a conical oval Figure, anſwerable to that marked g in the Cavity, Fig. 447. This Membrane, though ſoft and full of Sap, is compoſed of Bladders, three hundred Times ſmaller than thoſe of the middlemoſt, by which Means the Seed is ſo well guarded, as not to be ſupplied with any other Part of the Lympha but the pureſt, and that only but by ſlow Degrees.

If with a ſteady Hand this Membrane be pulled very gently upwards, it will draw a ſmall tranſparent String after it to the Bottom of the middle Membrane: This ſaid String, though for the greater Part parenchymous, is neverthleſs ſtrengthned with ſome lignous Fibres, which ſeem to be a Portion of thoſe that are inoſculated at the Bottom of the outer Membrane, and thence produced through the middlemoſt under the Channel which joins the two oval Cavities, till at laſt they break forth into the upper Cavity, where they form this inner Membrane, which is originally as entire as the middlemoſt; but as it increaſes, becomes a little hollow near the Cone, and the aforeſaid lignous Fibres fetching their Compaſs from the Baſe, ſhoot forth into the Cone, and make a very ſmall Node therein, for the firſt Eſſay towards the Generation of the Seed, as at h, Fig. 448. which are ſpun out to the utmoſt Degree of Fineneſs for that Purpoſe. In this Figure the inmoſt Cover is laid open to ſhew the Seed itſelf.

When this Node is grown to about the Size of the fifth Part of a Cheeſe-Mite, it begins to be divided by a little Indenture towards the Top, as at k, Fig. 449. which gradually grows deeper till the Node is diſtinguiſhed into Lobes or thick Leaves; and as theſe increaſe, their Baſe is contracted into the Radicle, or that Part of the *Seed* which becomes the Root; at this Time the *Seed* is ſo extremely ſmall, that the Lobes cannot be ſeparated; but it is probable, that as ſoon as the Radicle is finiſhed, the next Step is the puſhing forth another Node between the Lobes, in order to the Formation of the Bud, and ſo the Perfection of the Seed.

This being done, or in doing, the Stalk of the Seed is more and more contracted at Bottom, and hangs at the inner Membrane only by an extremely ſmall and ſhort Ligament m, Fig. 450. which at laſt breaks; and then the Seed, as Fruits when ripe, falls off and lies looſe in the inner Membrane, which gradually ſhrinks up and becomes more hollow to make more Room for the farther Growth of the Seed.

In *Malpighi*'s Life was a Debate between him and Seignior *Triumphetti*, Provoſt of the Phyſick Garden at *Rome*, whether the whole Plant be actually contain'd in the *Seed?* The Affirmative is maintain'd by *Malpighi* with cogent Arguments; among which this is one, that in a *Kidney Bean*, ere ſown, the Eye, aſſiſted with a *Microſcope*, eaſily diſcovers *Leaves*, a *Bud*, and even the Knots or Implantation of the Leaves on the Stem. The Stem itſelf is very conſpicuous, and plainly conſiſts of woody Fibres, and Series's of little Utricles. Whereas Seignior *Triumphetti* had objected, that by Poverty, Tranſplantation, *&c.* ſeveral Plants degenerate into others, particularly Wheat into Tares, and Tares again into Wheat; in Anſwer to this, which is one of the ſtrongeſt Objections againſt that Opinion, *Malpighi* replies, that he is not fully ſatisfied as to the Truth of the Objection; for that both himſelf and his Friends making the Experiment, no Metamorphoſis of the Wheat ſucceeded: But granting the Metamorphoſis, it is the Soil, or the Air, or the Culture is in Fault. Now, therefore, from a morbid, and monſtruous Condition of Nature, there is no inferring her genuine and permanent State.

That Experiment related in the following Section, of the Orange Kernel, which Mr. *Leeuwenhoek* made to germinate in his Pocket, is a plain Demonſtration, that the Plant and all that belongs to it, was actually in the Seed itſelf.

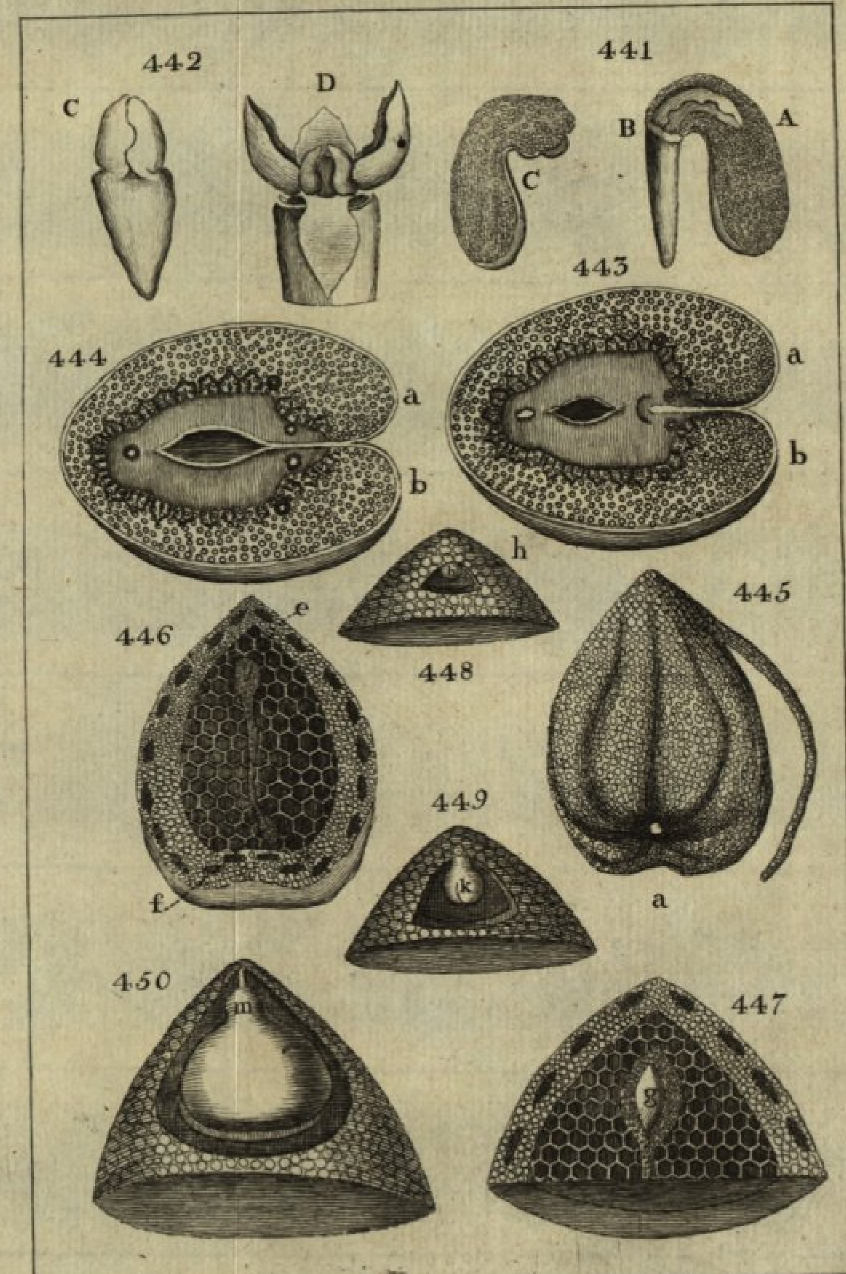
SECT. X.

Of the Seed of Oranges.

THE Proceſs of Nature in the *Vegetation* of *Plants*, is very accurately deliver'd by Mr. *Leeuwenhoek*, to the Effect following, by an *Orange Kernel* which he made to germinate in his Pocket, *viz.*

The *Kernels* of *Oranges* being diveſted of their outer Membrane, will appear as Fig. 451. on one Side of which lies a String a, which cauſes a little Protuberance in the firſt Skin; from this String, not only the Seed, but alſo the Plant within it, receive their Increaſe and Nouriſhment, and to which through the ſecond Membrane, it extends its ſmall Veſſels to the Seat of the *Plant*. Mr. *Leeuwenhoek* was of Opinion, that this String does actually comprehend in itſelf, as many diſtinct Veſſels as are to be found in the *Orange-Tree* when arrived at its full Maturity *. For, ſays he, if all theſe Veſſels were not in the young Plant, whilſt it lies involved in the Kernels *Matrix*, whence could they afterwards proceed? Fig. 452. repreſents Part of the ſame String, cut a-croſs, and greatly magnified, which at K L M N, has Abundance of exceeding ſmall Veſſels, but very difficult to be

* *Phil. Tranſ.* No. 287.



J. Wigley. Sc.

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perceived. About I H N M, they grow larger, and conſequently are more viſible. B, Fig. 453. repreſents a Seed diveſted of its Membranes, which ſeemed to have but one Plant within it, tho' often there is two, and ſometimes three diſtinct Seeds with their Plants contain'd under the Membrane of an *Orange Kernel*; theſe Seeds, with their incloſed Plants, are eaſily divided into two Lobes; which are framed by Nature, to nouriſh the tender Plant within, till it is able to ſtand alone, and draw its Subſiſtence from the Earth about it; having ſplit the Seed into two Parts, they are repreſented by C and D, Fig. 453. in the firſt, is Part of the Plant, which would have become a Tree, and is no bigger than a Grain of Sand to the naked Eye. The Counterpart of the ſaid Kernel is repreſented at D, with the Concave, in which Part of the Plant lay. Fig. 454. repreſents the laſt mention'd Plant, as it appear'd in the Microſcope, whereof Q L M is partly that which Nature intends for the Body and Root of the Tree; M N O P the Leaves with which the young Plant is already provided, O P that Part of the Leaves which is ſomewhat protuberant, by Reaſon of the ſmall incloſed Leaves, M N, and P Q ſhews the two Sides of the Plant torn off from the Kernel, to which it was united, and from which it received its Nouriſhment. Fig. 455. S T V, ſhews the ſame Plant a little turned about before the *Microſcope*, in order to repreſent the two largeſt Leaves, between which, according to all Appearance, a great many ſmall ones are ſhut up. If the Leaves be cut a-croſs, ſome of the included ones may ſometimes be diſcerned, and on cutting that Part of the Plant which is to be the Body and Root of the Tree, that which was deſigned for the Pith, and even the Wood itſelf may be diſcover'd.

Fig. 456. ſhews the Root when the Plant vegetates, T V and W X the two Halves of the Kernel, and Y that Part which is to become the Body of the Tree.

Fig. 457. repreſents the young Plant of 12 Days Growth, whereof A C D ſhews the Root, and F G that Part which is to be the Tree, D E the Seed or Kernel, which being ſurrounded with its Membrane, which was taken off the better to expoſe thoſe Parts to view, that ſerve for the Nouriſhment not only of the Root, but of the upper Parts of the Plant likewiſe, as alſo the ſhort String D. Thus we may ſee how ſmall a Particle, that is no bigger than a Grain of Sand, * as the Plant was at firſt, is increaſed in Bulk! and all this is brought about by Heat and Moiſture, it being rais'd to this Degree of Perfection, in ſome Sand firſt moiſtened, and then incloſed together with the Seed, in a Glaſs Tube, wore all Day in the Pocket, cloſe to the Body, and at Night, placed within a large Tin Bottle, filled with hot Water, which is a plain Demonſtration that the Plant, and all that belonged to it, was actually in the Seed; that is to ſay, not only the young *Plant*, its

* *Phil. Tranſ.* No. 287.

Body,

Body, *Root*, and *Fruit*, but even its *Seed* alſo, to perpetuate the Species; as hath been before obſerved.

Mr. *Leeuwenhoek* comparing the Animalcula in *Semine Maſculino*; and theſe Plants, computes them to be 1,000,000 times ſmaller than a Plant in an Orange-Kernel; and tho' we cannot make our Obſervations of the Growth and Increaſe of the ſaid Animalcula from Time to Time in their Mother's Matrix; yet we may certainly conclude, that the Laws which the *wiſe Creator* of all Things hath preſcribed to *himſelf*, in the *Production* both of *animate* and *inanimate* Creatures, are homogeneous and uniform; and that as the Earth is the common Matrix of Plants, ſo is the Fallopian Tube in moſt of thoſe Animals that are formed *Ex Semine Maſculino*; for as theſe receive their Nouriſhment, and increaſe by a String, till they are brought into the World; ſo are all Seeds (at leaſt as far as we know) ſupported and nouriſhed by a like String; and the Seeds thrown into the Ground, do again, by the ſame String, whereby they received their Increaſe, convey Nouriſhment to the Seed or Kernel.

SECT. XI.

Of the Seeds of Venus *Looking-Glaſs, or Corn Violets.*

FIG. 458. repreſents one of the Seeds of *Corn-violets*; the Seed is very ſmall, black, and ſhining, and to the naked Eye looks almoſt like a very ſmall Flea, but through the *Microſcope* appears to be covered with a tough, thick, and bright, reflecting Skin, very irregularly ſhrunk, and pitted, that it is almoſt impoſſible to find out two of them wrinkled alike, ſo great a Variety there is even in this little Seed.

SECT. XII.

Of the Seeds of Thyme.

THESE little Seeds, although they differ ſomewhat in Figure and Bulk, yet when looked at through the *Microſcope*, all of them exactly reſemble a dried Lemon, one of which is repreſented at Fig. 459. ſome of them are a little rounder, and of the Shape of an Orange. They have each of them a conſpicuous Part, by which they are joined to their little Stalks, they are a little creaſed or wrinkled, as is expreſſed in the Figure.

Sect. XIII.

Of the Seeds of Poppy.

POppy *Seeds*, one of which is repreſented in Fig. 460. deſerve to be taken Notice of among the other *microſcopick* Seeds of *Vegetables*; both for their Smallneſs, Multiplicity, and Prettineſs, and alſo for their admirable ſoporifick Quality, although they grow in a very large Caſe, yet are they ſo ſmall, as not to exceed the Bulk of a very ſmall Nitt, being not above $\frac{1}{51}$ Part of an Inch in Diameter; whereas the Seed Caſe oftentimes exceeds two Inches, and is therefore capable of containing near two hundred thouſand of them. They are of a browniſh colour'd Red, curiouſly Honeycomb'd all over with a pretty Variety of Net-work, or a ſmall Kind of Emboſsment of very orderly raiſed Ridges.

Sect. XIV.

Of Purſlane Seed, &c.

THE Seeds of *Purſlane* ſeems of very notable Shapes, and appear through the *Microſcope* like *Porcelane* Shells, as at Fig. 461. It is coyled round in the Manner of a Spirial; at the greater End, which repreſents the Mouth or Orifice of the Shell, is a white, ſkinny, tranſparent Subſtance B, which ſeems to be the Place where the Stem was joined. Its whole Surface is cover'd with little Prominencies, orderly ranged in ſpiral Rows; one of theſe being cut aſunder with a ſharp Penknife, diſcovered the Shell to be of a browniſh Red, but ſomewhat tranſparent, and manifeſted the Inſide to be filled with a whitiſh green Pulp, the Bed wherein the ſeminal Principle lies *inveloped*.

Fig. 465. repreſents the Seed of *Ben*, it is ſomething like a Kidney, but hath its Circumference rais'd up into double Ridges, towards which ſeveral ſmall Ridges do in ſome Sort radiate from one Center.

Fig. 464. repreſents the Seed of *Chickweed*, this alſo is partly like a Kidney, and partly like a Retort, being rough caſt with ſmall Pieces, as if they were Inſects with little Feet.

Fig. 463. repreſents the Seed of *Bellis Tanaceti Folio*. It hath two triangular Sides, and the third conical; the two firſt have ſeveral Ridges running to the Baſe, the Head triangular with one Side convex, the other two ſtreight with a little Pinnacle in the Center.

Fig. 462. repreſents the Seed of *Wartworth*, or *Sun Spurge*, it is of a very complex

complex Figure, its Belly consisting of two *Planiconick* Sides, and back Sphericonick. The Base and Head are both flat, in the Middle of the former is a Peg, by which the Seed is fastened, and of the latter a pointed Knob. The Belly-Sides is hollowed, so as to make a flat Rim of equal Breadth; and the Hollows filled up with Bladders, like those of the parenchymous Parts of a Plant.

There are Multitudes of other *Seeds*, which imitate the Forms of divers Sorts of *Shells*; as Seed of *Scurvy-Grass*, a Kind of *Purcelane Shell*; others represent several Sorts of larger Fruits, *Sweet* and *Pot Marjoram* represent *Olives*, *Carrot-Seeds* are like a Cleft of a *Cocoa Nut Husk*. Others are like artificial Things, as *Succory Seeds* are like a Quiver of *Arrows*, the Seeds of *Aramanthus* are somewhat like an *Eye*, the Skin of the black and shrivell'd Seeds of *Onion*, are all over knobbed like a Seal Skin, and *Sorrel* has a black shining three-square Seed. It is almost endless to reckon up the several Shapes of Seeds, they being so many and so various in their Forms. I shall therefore leave them to the further Examination of the curious Observer.

The Seed or Powder of the *Fungus Purverulentus*, or *Puff-Ball*, when crushed, appears like Smoak to the naked Eye, but when examined by one of the greatest Magnifiers, is found to be infinite Numbers of little Orange colour'd Globules, somewhat transparent; in another Sort the Globules are of a darker Colour, each of them having a little Stalk or Tail, which are evidently so many minute *Puff-Balls*, * furnished with Stalks, to penetrate easily into the Ground, and the Mischiefs they do the Eyes, is probably owing to the Sharpness of these Stalks,† which prick and wound that tender Organ.

CHAP. XXXVI.
Of the Roots of Plants.
SECT. I.

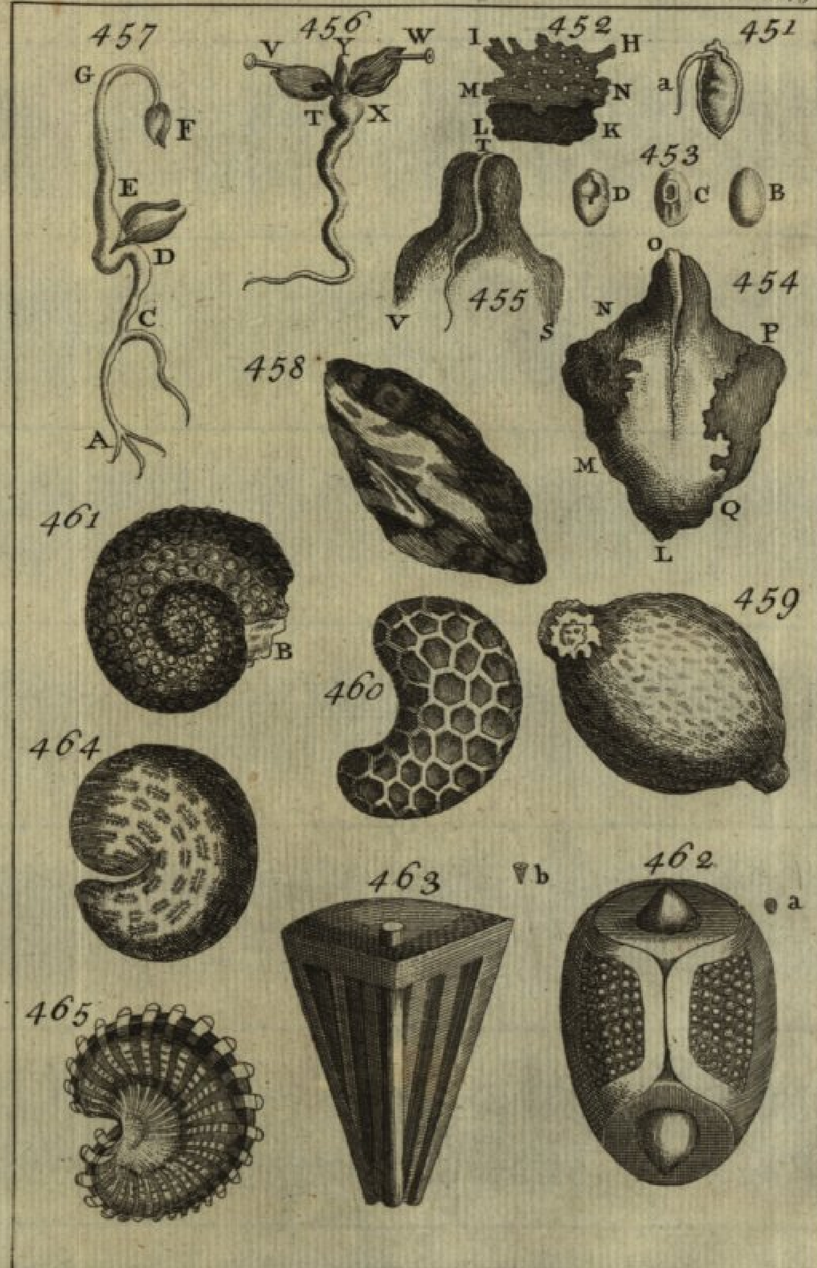
THE *Root* is that Part of a *Plant* which immediately imbibes the Juices of the Earth, and transmits them to the other Parts for Nutrition. It consists of woody Fibres, cover'd with Bark, more or less thick, and arises from a little Point in the Seed called the Radicle.

We learn by the Assistance of the *Microscope*, that Plants consist of different Parts, Vessels, &c. each of which is supposed to be the Vehicle of a different Humour, or Juice, secreted from the Mass of Sap, which is consider'd as the common Fund of them all.

* *Phil. Trans.* No. 284. † *Derham's Phys. Theo. p.* 418.

I must

Pl. 47.



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I muſt not here omit a curious Phenomenon in the Natural Hiſtory of Plants, and that is, when the *Radicle* in ſowing happens to light loweſt, it is no wonder the Root ſhould ſpread itſelf under Ground, and the Stem of the Plant riſe up perpendicularly: But when the *Radicle* falls uppermoſt, by what Means it is that it changes its Poſition, to favour the Aſcent of the Stem, is one of the Wonders of Vegetation.

M. Dodart firſt obſerved this Perpendicularity of Plants, and publiſhed it in an expreſs Eſſay of the Affectation of Perpendicularity, obſervable in the Stems or Stalks of Plants, *&c.*

The Matter of Fact is, that though almoſt all Plants riſe a little crooked; yet the Stems ſhoot up *perpendicularly*, and the Roots ſink down *perpendicularly*; even ſuch as by the Declivity of the Soil come out inclined, or are diverted out of the Perpendicular by any violent Means; again redreſs or ſtrengthen themſelves, and recover their Perpendicularity, by making a ſecond or contrary Bend, or Elbow, without rectifying the firſt.

A common Eye looks on this Affectation, without any Surprize; but a Man, who knows what a Plant is, and how formed, finds it a Subject of Aſtoniſhment.

It has been before ſhewn, that each Seed contains a little Plant, already formed, needing nothing but to be unfolded; the little Plant has its little Root and Pulp, which is generally ſeparable into two Lobes, and is the Foundation of the firſt Food the Plantule draws by its Root, when it begins to *germinate.*

If a Seed in the Earth be ſo diſpoſed, as that the Root of the little Plant be turned downwards, and Stem upwards, and even *perpendicularly* upwards; it is eaſy to conceive, that the little Plant coming to unfold itſelf, its Stalk and Root need only follow the Direction they have to grow perpendicularly. But,

It is very well known, the Seeds of all Plants, whether ſown of themſelves, or by the Help of Man, fall into the Ground at random; and among an infinite Number of Situations, with reſpect to the Stalk of their Plant, the *perpendicular* Direction upwards is but one.

It is therefore neceſſary that the Stalk redreſs or rectify itſelf in all the other Situations, in order to find its Way out of the Ground: But what Force is it that effects this Change, which is certainly a violent Action? Is it, that the Stalk finding a leſs Load of Earth above it, goes naturally that Way where it finds the leaſt Obſtacle; were it ſo, the little Root when it happens to be uppermoſt, muſt for the ſame Reaſon follow the ſame Direction, and mount on high.

Therefore *M. Dodart*, ſuppoſes the Fibres of the Stalks are of ſuch a Nature, as to contract and ſhorten by the Sun's Heat, and lengthen out by the Moiſture of the Earth; and on the contrary, that the Fibres of the

Roots contract by the Moisture of the Earth, and lengthen by the Heat of the Sun.

Then when the Root of the Plantule is uppermost, the Fibres which compose one of the Branches of the Root, are not equally exposed to the Moisture of the Earth; the lower Part is more exposed than the uppe, which must therefore contract the most; this Contraction is again promoted by the lengthening of the upper, whereon the Sun acts with the greatest Force; consequently this Branch of the Root must recoil towards the Earth, and insinuating thro' the Pores thereof, get under the Bulb, *&c.*

By inverting this reasoning, it will appear, how the Stalk comes to get uppermost.

In a Word, we may imagine, that the Earth attracts the Root to itself, and that the Sun contributes to its Descent; and, on the contrary, that the Sun attracts the Stem, and the Earth in some Measure sends it towards the same. Again,

M. *de la Hire* imagines, that the Root draws a coarser and heavier Juice, and the Stem and its Branches a more volatile one; which Difference of Juices, supposes larger Pores in the Roots than in the Stalks; therefore in the Plantule we may conceive a Point of Separation; such, that all one Side of the Root shall be unfolded by the grosser Juices, and all the other Side by the more subtle ones.

If now the *Plantule* be inverted when its Parts begin to unfold, the Juices which enter the Root being coarsest, when they have enlarged the Pores to admit Juices of a determinate Weight, those Juices pressing the Root more and more, will drive it downwards, and this the more as the Root is more extended or enlarged; for the Point of Separation, being conceived as the fix'd Point of a Lever, they will act by the longer Arm. At the same Time the volatile Juices having penetrated the Stalk, will tend to give a Direction from below upwards, and by Reason of the Lever, will give it more and more every Day till it be perfectly erect.

Mr. *Astruc* accounts for Perpendicularity of the Stems, and their redressing themselves on these two Principals.

First, that the nutritious Juice arises from the Circumference of the Plant, and terminates in the Pith. Second, That Fluids contain'd in Tubes, either parallel or oblique to the Horizon, gravitate on the lower Part of the Tubes, and not at all on the upper.

Whence it easily follows, that in a Plant posited either obliquely or parallel to the Horizon; the nutritious Juice will act more on the lower Part of the Canals than on the upper; and by this Means insinuate more into the Canals communicating therewith, and be collected more copiously therein; thus the Parts on the lower Side will receive more Accretion, and be more nourished than those on the upper; the Consequences whereof must be, that the Extremity of the Plant will be obliged to bend upwards.

The

The ſame Principle brings the Seed into its due Situation at firſt; in a *Bean* planted upſide down, the Plume and Radicle are eaſily perceived with the naked Eye, to ſhoot at firſt directly for about an Inch; but thenceforward they begin to bend, the one downwards, and the other upwards, as in the Example of the Orange Seed, Fig. 457; the like is ſeen in a Heap of *Barley* to be made *Malt*, in a Quantity of *Acorns* laid to ſprout in a moiſt Place, *&c.* each Grain of *Barley* in the firſt Caſe, and each *Acorn* in the ſecond hath a different Situation, and yet all the Sprouts tend directly upwards, and the Roots downwards, and the Curvity or Bend they make, is greater or leſs as their Situation approaches more or leſs, to the Direction wherein no Curviture at all would be neceſſary. Now two ſuch oppoſite Motions cannot ariſe without ſuppoſing ſome conſiderable Difference between the two Parts; the only one we know of, is, that the *Plume* is fed by a Juice, imported to it by Tubes parallel to its Sides; whereas the Radicle imbibes its Nouriſhment at all the Pores in its Surface. As oft therefore as the Plume is either parallel or inclined to the Horizon, the nutritious Juice feeding the lower Parts more than the upper, will determine its Extremes to turn upwards, for the Reaſon already aſſigned. On the contrary, when the Radicle is in the like Situation, the nutritious Juice penetrating more copiouſly through the upper Part than the under; there will be a greater Accretion of the former than the latter; and conſequently the Radicle will be bent downwards: And this mutual Curvity of the Plume and Radicle muſt continue, till ſuch Time as their Sides are nouriſhed alike, which cannot be till they are perpendicular *.

Roots are generally diſtinguiſhed by their Figures, ſome being entire, as *Liquorice*; parted, as *St. Johnwort*; ſome parted at Bottom, as moſt Roots; others at Top, as *Dandelion*, &c. ſome parted and ramified, as *Comfrey*; others having divers Strings iſſuing from one Head, as *Crowfoot*; ſome ſtrait as *Radiſh*, crooked as *Biſtort*, ſmooth as *Bugloſs*, ſtringy all round as *Columbine*; ſome thick as *Rhubarb*, ſlender as the *Vine*, long as *Fennel*, ſhort as *Turnep*, &c. &c.

The Motions of Roots are ſometimes perpendicular, as *Parſnip*, level as *Hops*, *Ammi*, *Cinquefoil*, &c.

There is a kind of wreathing or twiſting in the Veſſels of ſome when the Bark is ſtripped off, in *Carduus*, *Sonchus*, &c. in which may be ſometimes ſeen two or three Circumvolutions.

But the moſt remarkable of all *Roots* are ſuch as are annually renewed or repaired out of the Trunk or Stalk itſelf, as *Arum*, *Rape-Crowfoot*, *Valerian*, *Brownwort*, *Bearsfoot*, *Tanſy*, *Lychnis*, *Sapier*, *Primroſe*, *Ammi*, *Avens*, *Wood-Sorrel*, *Iris*, and others; that is to ſay, the Baſis of the Stalk continually and by inſenſible Degrees, deſcending below the Surface of the Earth, and hiding itſelf therein, is both in Nature, Place and Office changed into

* *Men. d. l. Acad. Roy. des Science*, *n.* 1708.

a Root. So in *Brownwort* the Basis of the Stalk sinking down by Degrees till it lies under Ground, becomes the upper Part of the Root; and continuing still to sink, the next Year becomes the lower Part, and the next after that rots away, * a new Addition being yearly made out of the Stalk, as the older Parts annually rot away.

In a Dissection of the *Root* we shall first find the *Skin*, next the *Cortical*, which when thin is commonly called the Bark; next within this are the woody Fibres, which together with all its Parts, are visible in a Circle; its Pores being nothing near so numerous as that of the Cortical, but in some more open than in others, as may be seen on cutting a very thin transverse Slice of the Branch of a Tree, and holding it against the Light, or placing it before the *Microscope*. In *Currant* and *Goosberry-Trees* it is less conspicuous than in *Oak* or *Plumbs*, in *Damsins* it is more, and in Elder and Vines more; the cortical Body doth not only surround the Wood, but is as it were wedged into it in many Places, and is even inserted therein as far as the Pith, and appears in a transverse Section of a Root like Lines drawn from the Center to the Circumference.

Fig. 466. represents a transverse Slice of the Root of *Asparagus*, and Fig. 467, exhibits a *microscopic* Picture of a Piece thereof cut out at a b, in which

A B shews the Skin.
A B C D the Bark, or all that Part analogous to it.
C D E F the Lympheducts on the inner Edge of the Bark.
E F G H the Wood in which the black Spots shew the Air Vessels.
G H I the Pith.

Fig. 468. is a transverse Slice of the *Root* of *Mallows*. Fig. 469. represents a Piece thereof, which was cut out at c d, as it appeared before the *Microscope*; in which

A B C D shews the Skin.
C D E F the Bark, or all that Part of the Root which answers to it, in which the round Spots are the Mucids.
E F G H the common Lympheducts.
G H I K the pithy Part of the Root.
I K L more Lympheducts, in both which the black Holes are the Air the Air Vessels.

Fig. 470. represents a Slice of a *Vine Root* cut transversly, out of which at e f was cut a small Piece, which when placed before the *Microscope* appeared as represented by Fig. 471. wherein

A B shews the Skin.
A B C D the Bark.
L S Parcels of Sap Vessels.
L I Parcels of Wood in which the darker shaded Circles great and small are the Air Vessels.
E F parenchymous Insertions between the Parcels of Wood.
G G others within them.

* *Grew. Anat. of Plants, p.* 59.

At Fig. 472. is seen a transverse Slice of a *Horse Radish* Root, and at a b the Place from whence a Gore was cut, which is represented as it appeared in the *Microscope* by Fig. 473. whereof

AB is the Skin.
ABCD the Bark.
CDEFGHI the Sap Vessels in Form of a Glory.
CDKL the Wood in which the darker Circles are the Air Vessels.
KLMN a Ring of more Sap Vessels.
MNO the Pith.

Fig. 474. exhibits a transverse Section of *Buglose Root*, from which at c d was taken a small Piece, that when magnified appeared as Fig. 475. in which

AB is the Skin.
ABCD the Bark.
ABEF the Bladders in the outer Part of the Bark; they are figured somewhat oblong, and are ranged in Circles.
EFCD the inner Part of the Bark in which the Bladders are ranged in curved Arches.
CDGH a Ring of Sap Vessels,
II a parenchymous Insertion, of which there are several in the whole Section.
LKKL the Wood in which the dark Spots are the Air Vessels.
KKM the Pith.

SECT. II.

Of the Skin of Roots.

THE outer Part of all *Roots* is the *Skin*, which in *Skerrits* is white, yellow in *Dock*, red in *Potatoes*, brown in *Lovage*, black in *Buglos*, &c. their Surface is sometimes smooth, as in *Horse radish*, rough, as in *Scorzonera*. The Skins of the several Shells of a *Tulip-Root* fresh taken up, appear to be perforated with a Number of small Holes. This Skin is very thin in *Parsnip*, thicker in *Buglos*, very thick in *Iris*, opake in some as the *Thistle*, and transparent in others, as the *Madder*.

Every *Root* hath two kinds of Skin, one of the same Age with the other Parts, and the other succeeding in the Place of the former; as in *Dandelion*, the old Skin seems to be that Part which composed the cortical Body the Year before, which by the Generation of a new Ring next the Wood, is now thrust outward, and shrunk up into a Skin as at AB; in an *Horse-radish* Root, Fig. 473. or at AB in a *Buglos Root*, Fig. 475. as far as the Bladders in the former, and Vessels in the latter, are radiated; the cortical Body seems to shrivel up into a new Skin, as the old ones fall off, and probably the whole Body of the perpendicular Roots, except the woody Fibre in the Center, becomes the second Skin, as in *Asparagus*, Fig. 467.

This

This Skin is made up of two Kinds of Bodies, one parenchymous, generally composed of exceeding small Cells or Bladders, which are plainly visible, if viewed through a *Microscope*, and appear as in Fig. 467. which represents a transverse Piece of the Root of *Asparagus* magnified; these Bladders are of different Sizes, being larger in *Bugloss* than in *Asparagus*, &c.

The other Part of this Skin is composed of tubular Wood-Vessels, intermix'd with the Bladders before-mention'd.

If a *Root* be cut transversly, and laid by for some Time, all the Parts where there are no Vessels will shrink below the Surface of the cut End; but the Vessels will all retain the same Length, at which Time they may be examined by the *Microscope*.

Of the Bark of Roots.

THE *Bark* is situate just within the Skin, in some Roots it is yellow, as in *Dock*, red in *Bistort*, but in most white, in some it is very thin, and in others it makes the greatest Part of the Root, the thinnest and thickest being all analogus.

It is exceeding porous both in Length and Breadth, as appears from its shrinking up equally both Ways, and dilating to its former Size on being soaked in Water. All this is apparent to the naked Eye; but the *Microscope* confirms the Truth thereof, by shewing that these Pores are an infinite Number of little Cells or Bladders, sometimes running in Ranks both the Length and Cross-ways of the Root, as at A B C D in *Bugloss*. Fig. 475. it may be seen both in a transverse and upright Section, and always best after the Pieces so cut hath lain by some Time to dry.

This parenchymous Part is of an uniform Texture in many Roots, and diversified in as many others; the Bladders, though very regular, yet differ in Shape, Size and Situation; in some Places like white Rays, streaming from the inner Edge thereof outwards to the Circumference of the Bark, as is apparent in a transverse Section of *Lovage*, *Melilot*, *Parsnip*, &c. continuing in direct Lines the whole Length of the Root.

The *Bark*, as before observed, is intermixed with a few lignous Vessels, which are apparent in most Roots in the Resemblance of Threads. These tubular Threads do not run in direct Lines, but are frequently braced together in the Form of Network, as is apparent if the Bark be stripped off, and a Piece of it examined by the *Microscope*.

In *Parsnips* these Vessels yield a thin Lympha. It is certain that this clear Sap ascends only in these Vessels, because no Liquor will do the like from any parenchymous Part; sometimes they yield a thick mucilaginous Lympha as *Comfrey*; oftentimes these succiferous Vessels yield a milky or white Sap, and sometimes yellow, as in *Sonchus*, and most cichoraceous Plants; in *Angelica*,

gelica, and moſt umbelliferous; in *Burdock* and divers Thiſtles; in *Scorzonera*, *common Bells*, and many other Plants, not commonly taken Notice of to be milky. Theſe milky Saps, although of different Colours, Thickneſs, and other Qualities, agree in being more oily than any of the lymphous Saps; for the Mixture of the oily Parts, with ſome other limpid Liquor, cauſes them to be of a milky *, or other opake Colour. In the ſame Manner as common Oil, and a ſtrong Liquament of Tartar, ſhook in a Bottle, become white.

Sometimes the Oil will ſeparate, as is obſervable on cutting a *Fennel Root* tranſverſly, after it hath lain ſome Days out of the Ground. The ſame Veſſels, which before yielded Milk, will now yeild Oil.

All *Gums* and *Balſams* are likewiſe the Contents of theſe Veſſels, for theſe and Milks are nearly a-kin. The Milk of *Fennel* ſtanding ſome time, turns to a clear Balſam, of *Scorzonera*; *Dandelion*, and others, to a Gum. In the dried Root of *Angelica*, when ſplit, the Milk † is ſeen in Clods, in the Continuation of theſe Veſſels, condenſed into an hard ſhining Roſin. The Root *Helenium* cut tranſverſly, preſently yields a Balſam of a Citron Colour, ſo called becauſe it will not diſſolve in Water. The Root of common *Wormwood* yields a true Balſam, with all the defining Properties of a Terebinth; the Roots of *Trachelium* and *Enula*, yield both a Lympha and a Citron Balſam; and *Wormwood* both a Lympha and a Terebinth § at the ſame Time. It is doubtful whether all *Roots* have Lympha Ducts, but probably they have, and for the moſt Part ſtanding in a Ring, at the inner Verge of the *Bark*.

The Situation of theſe Veſſels are very curious, if viewed in a tranſverſe Section of the Root; ſometimes they only form a Ring at the inner Edge of the *Bark*, as at E F, in *Aſparagus*, Fig. 467. in which Poſition they are in moſt, if not all Roots; in ſome they ſtand in Rays, as *Borage*, or *Peripherial*, as in *Celandine*. Theſe vaſcular Rays are extended in ſome towards the Circumference of the Bark, about half Way, as between C D E F, in Bugloſs, Fig. 475. in all *Docks* and *Sorrels*, about $\frac{3}{4}$ ths of the Thickneſs of the *Bark* toward the Circumference, ſeveral of them are alſo arched thereabout. In all, or many *Trefoils*, and of the leguminous Kind, only one Third of the Bark. In the umbelliferous, they are ſituate between the diametrical Portions of the Parenchyma. In the *Microſcope* they all of them appear to be real Circles; and in a tranſverſe Section, when the Milk has been licked off with the Tongue, till no more will riſe. They may alſo be ſoaked in Water, after which the Poſition of the Milk Veſſels will be viſible; in ſome *Roots* they run more parallel, and keep aſunder, as in *Monks-hood*, and join towards the Circumference of the *Bark*, in *Eryngo*. They terminate more circular, in *Briony* angular, or in the Form of a

* *Grew. An. Plant. p.* 67. † *Ibid. p.* 67. § *Ibid. p.* 68.

Glory,

Glory, as will appear alſo on viewing an *Horſe Radiſh Root*, C D E F G H I, Fig. 473. in the *Microſcope*. In ſome almoſt entire Circles, as in *Dandelion*; in others compoſed of ſhort Chords; in ſome theſe Specks are ſo exceeding ſmall, that to the naked Eye they ſeem continued Rings, but when viewed in the *Microſcope*, are diſtinct Veſſels, as in *Marſh-Mallows*, and *Liquorice*. In *Marſh-Mallows* the Lymphæducts appear in Rays, and the Lacteals in Rings, Fig. 469. In *Dandelion* they appear to the naked Eye like numerous Rings, but when viewed through the *Microſcope*, are found to conſiſt of very many ſmall Rays, ſtreaming from the inner Verge of the *Bark*, a-croſs three or four of the ſmaller Rings.

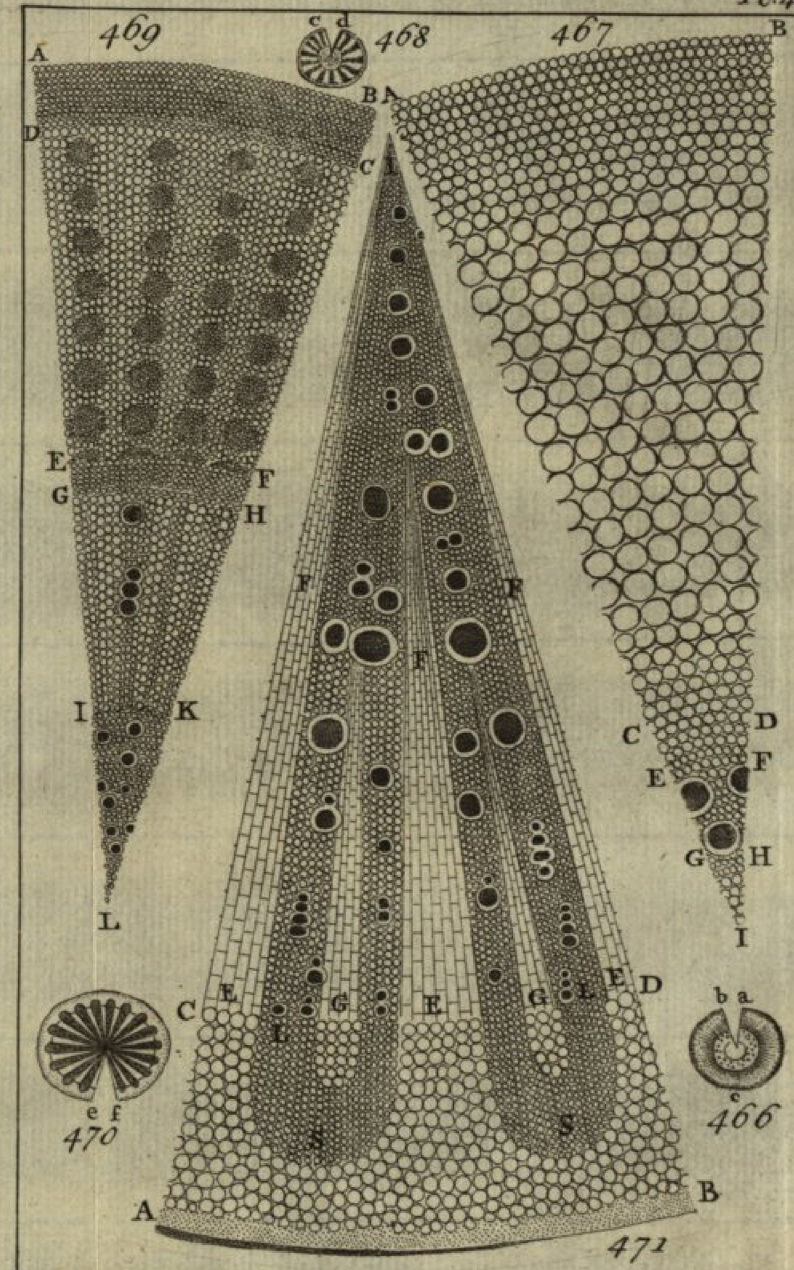
SECT. III.
Of the Wood of Roots.

THAT Portion of the *Root*, which is contiguous to, and within the Bark; in Trees, and ſhrubby Plants, is the Wood, which conſiſts of the Parenchyma and lignous Subſtance. The firſt of which is of the ſame Nature with that of the Bark. The Poſition of its ſeveral Parts are moſtly diametrical, running between the *lignous Parts*, from the Circumference towards the Center of the *Root*, and all together conſtitute that which is before called the Inſertment. Theſe Inſertments are moſt obſervable in the *Roots* of many Herbs, as *Comfrey*, which exhibits a good Notion of all other, as well Trees as Herbs; ſometimes this parenchymous Body is diſpoſed into Rings, as in *Fennel*. In moſt woody Roots, they ſtream between the Pith and Bark, like ſo many ſmall Rays. In ſome Roots they continue to the Center, as *Columbine*, in others not, as *Parſnip*; and ſometimes different in the ſame Root, as E F in the *Vine*, Fig. 471. They are compoſed of many ſmall Bladders, as in the Bark, but generally ſmaller. Their Shape uſually round, but ſometimes oblong and oval, as in *Borage*, or oblong and ſquare, as in the *Vine*.

The lignous Part alſo conſiſts of two Kinds of Bodies, ſucciferous, or lignous, and Air Veſſels. The lignous are of the Nature with thoſe of the Bark, and in a tranſverſe Section of the Root, emit a Liquor as thoſe do. Theſe Veſſels are no where interwove or braced together, but continue from one End of the Root to the other.

The Poſition of both theſe Kind of Veſſels is various, the ſucciferous or lignous are ſometimes ſituate in diametrical Lines, as in the *Vine*, Fig. 471. and moſt Trees, ſometimes oppoſite to the Areal, as in *Beet*, &c.

SECT.



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Sect. IV.

Of the Pith of Roots.

WIthin the woody Part, is the *Pith* which is not common to all Roots, for ſome have none, as *Nicotian*, *Stramoniam*, and others. The *Pith*, for the moſt Part, eſpecially in Trees, is a ſimple Body, yet like the Bark it is compounded, ſome ſucciferous Veſſels being mixed with it, as in *Jeruſalem Articboke*, *Horſe Radiſh*, &c. many Roots that have no Pith at their lower Part, have one at the Top, as *Columbine*, *Lovage*, &c. Their Contexture by the *Microſcope*, appears to be of the ſame general Kind in all Plants, both in the Parenchyma of the Bark, in the Inſertment or diametrical Portions, and in the Pith, all being compoſed of *Bladders*, which are of very different Sizes, ſeldom leſs than thoſe of the Bark, as in *Aſparagus*, Fig. 467. but generally much bigger, as in *Horſe Radiſh*, Fig. 473. their Poſition ſeldom varies, but is uniform in a tranſverſe Section of all Parts of the Root piled up evenly one over another. In an upright Section they ſeem to run in direct Trains, length-ways; they are for the moſt Part orbicular, though in the larger Roots ſomewhat angular. On obſerving theſe Bladders with the *Microſcope*, their Sides will be found to conſiſt of ſeveral Ranks of exceeding ſmall Fibres, lying for the moſt Part evenly one over another, from the Bottom to the Top of every Bladder, and running a-croſs alſo from one Bladder to another. If the *Pith* be cut with a ſharp Razor, or Penknife, and ſo applied to the *Microſcope*, they will be ſeen diſtinctly.

All Plants exhibit this Spectacle, but thoſe beſt with the largeſt Bladders; nor the ſame *Pith* ſo well in any other Condition, as when dry; becauſe then the Sap being voided, the Spaces between the Fibres, and the Fibres themſelves are more diſtinctly ſeen. Yet it muſt not be dried after cutting, becauſe its ſeveral Parts will thereupon coincide and become deformed, but to be choſen while the Plant is growing, at which Time it may be often found dry and not deformed; as in the Trunks of *common Thiſtle*, *Jeruſalem Artichoke*, &c. cut off the white Bottoms of the Bladders of a *Bulruſh* tranſverſly, and they will appear like a curious Piece of Needle-work. The whole Body of a *Root* therefore conſiſts of Veſſels and Fibres, and probably theſe Fibres themſelves are tubular.

If you take the Roots of *Vine*, *Fennel*, *Dandelion*, *Plumb-tree*, *Elder*, *Willow*, &c. and lay them for ſome Time to dry, then cut off a thin Slice of each tranſverſly, and place it before the Microſcope, by pinching one Edge thereof between the Nippers, the Light will then be trajected through the Perforations of all the Veſſels both great and ſmall, they are ſcarce ever viſible in the freſh Slices of theſe Roots.

A clear and elegant Sight of the Fibres which compose the Air Veſſels, may be obtained by ſplitting a *Vine Root*, or a Piece of *Oak*, and may be ſeen in the Side of the greater Air Veſſels, in the Reſemblance of Needle-Work; the Spiration of the Fibres may be better obſerved in the *Trunk* than in the *Root*, and beſt in *young Plants*, but not ſo well by cutting as ſplitting, or by tearing off ſome ſmall Piece, through which they run; their Confirmation being by this Means not ſpoiled.

But in the Leaves or tender Stalks of all ſuch Plants as ſhew upon breaking, a kind of Down or Wool; they may be ſeen drawn out, and that ſometimes to the naked Eye. This Wool being nothing elſe but a certain Number of Fibres drawn out of their ſpiral Poſition, appearing more or leſs in the Leaves and other Parts of moſt Plants, as in the *Vine*, *Scabious*, &c. in the *Scales* of a *Squil* they are ſo eaſily ſeparable, as to ſhew the Plate or Zone into which the *Air Veſſels* are uſually reſolved, which is not one ſingle Piece, but made up of ſeveral round Fibres, running parallel, and knit together by other ſmaller ones tranſverſly in the Form of a Zone.

CHAP. XXXVII.

Of the Trunks of Trees.

SECT. I.

THE *Trunk* comes next under Conſideration, which conſiſts of the *Bark*, *the Wood*, the *Inſertions* or *Veins*, and the *Pith*.

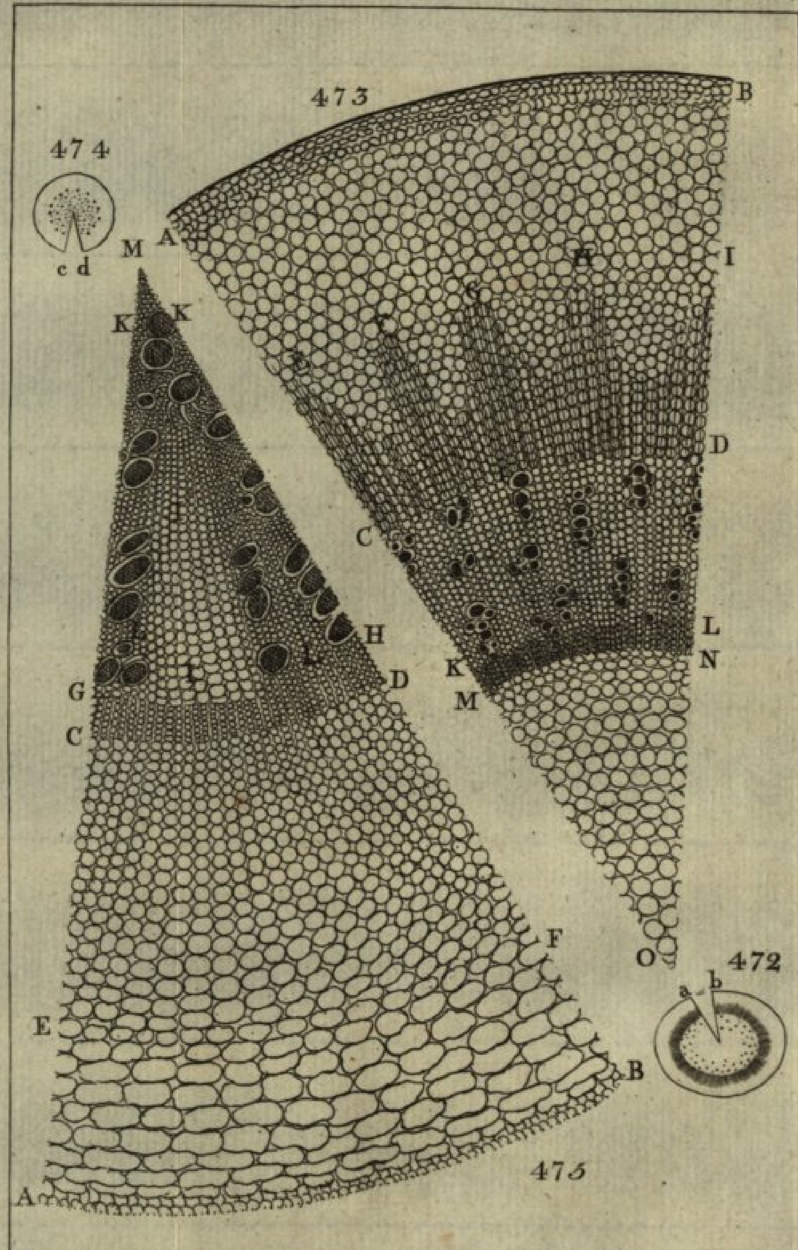
The croſs Shootings of the Wood in Trunks of ſeveral Years Growth appear in Rings, ſo that we may judge by the Number of Rings of how many Years * Growth the Tree is; in each of theſe Rings is one Circle of large open Pipes, but the fewer of theſe the ſtronger the Timber.

The Pores of the Wood in well-grown Timber are very conſpicuous both in an upright and tranſverſe Section thereof.

The lignous Body in the Trunks of Herbs are extremely viſible in the *Microſcope*, each Fibre thereof being perforated with 30, 50, 100, &c. Pores, as may be ſeen in a magnified Piece of Burdock, Fig. 477. and although each Fibre appears to the naked Eye to be but one, yet when magnified we plainly find them to be compoſed of a Number of Fibres, or rather hollow Tubes joined together, ſo that what we call the woody Part of a Tree, notwithſtanding all its Solidity, is nothing elſe but a Cluſter of innumerable and extraordinary ſmall vaſcular Fibres; ſome of which riſe from the Root upwards, and are diſpoſed in Form of a Circle, and the others which Dr. *Grew* calls *Inſertions*, tend horizontally from the Surface to the

* *Phi. Tranſ. No.* 213.

Center,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472
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C
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a b
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E

Center, in ſuch a Manner as to croſs each other, and are interwove like the Threads of a Weaver's Web.

Theſe *Inſertions* are viſible on ſawing Trees Lengthwiſe, and ſhaving from thence very thin Slices. They are alſo diſcernable at their Entrance into the Wood on ſtripping off the *Bark*.

As the Pores or Veſſels are greater or leſs, ſo are alſo the Inſertions, to the naked Eye, the largeſt only are diſcernable; but by the Help of the *Microſcope* they appear very numerous.

The Inſertions in the Trunk are viſible in a tranſverſe Section, and are diſpoſed in even Lines or Rows throughout its whole Breadth; they are repreſented as they appear in the Root of a *Vine*, when viewed through a *Microſcope*, by E F, Fig. 471.

The Pores of the Pith are moſtly obſervable in the *Trunk*, being larger than in the Root; and through a *Microſcope* appear like ſo many Bubbles or Bladders, as in a Piece of Burdock, Fig. 477.

In the Piths of many Roots and Plants, ſome of the larger Pores or Bladders have ſmaller ones within them, ſome of which are divided with croſs Membranes, and between their ſeveral Sides other ſmaller Bladders are inſerted, in orderly Ranks Length-wiſe.

What Dr. *Grew* calls *Fibres* and *Inſertments*, or the lignous Body interwoven with that which he takes to be the cortical, that is the ſeveral Diſtinctions of the Grain, are called by Mr. *Liſter* Veins, * that is, ſuch Ducts as ſeem to contain and carry in them their nobleſt Juices, analagous to human Veins. Mr. *Liſter* makes it appear, that theſe Veſſels are not the Pores of the lignous Body, from a tranſverſe Section of *Angelica Sylveſtris magna vulgatior*; the Veins there clearly diſcovering themſelves to be diſtinct from the Fibres, obſervable in the Parenchyma of the ſame cortical Body, the milky Juices always riſing on the Side, and not in any Fibre. Alſo in a like Inciſion of *Burdock*, in *June* the Juice ſprings on each Side the Radii of the woody Circle, that is, in the cortical Body and Pith only; again where there is no Pith none of this Juice is obſerved.

In a tranſverſe Cut of a Leaf it is obſervable, 1. That theſe Veins accompany the Ribs and Nerves. 2. That the middle Fibre or Nerve ſeems to yield one big Drop of a milky Juice ſpringing as it were from one Vein, yet by the *Microſcope* it is plain there are many Veins, to the making up of that Drop. 3. That if a Fibre or Nerve be carefully taken out of the Leaf, the Veins will appear therein like ſo many Pipes running along the Nerve, and yet theſe numerous Veins are all of an equal Bigneſs.

It is obſervable in the Motion of theſe Juices, that the milky Juice always moves and ſprings briſkly upon the opening of a Vein, † the limpid Sap only at certain Seaſons.

* *Phil. Tranſ.* No. 79. † *Ibid.* No. 90.

Dr. *Grew* assigns the Offices of the several Vessels, *viz.* those placed on the inner Verge of the Bark, he calls *Lymphæducts*, and supposes them destined for the Conveyance of the most watry Liquor; these Mr. *Bradley* calls the *new forming Vessels*, which are annually produced, and help to increase the Bulk of the Tree.

Those in the Middle of the Bark Dr. *Grew* calls *lactiferous* or *resiniferous* Vessels: Their Use, according to *Bradley*, is to return the superfluous Sap: These Vessels *Grew* observes, are the principal Viscera of Plants; and adds, that as the Viscera of Animals are but Vessels conglomerated; so the Vessels of a Plant are Viscera drawn out at length, all which will be easily understood by an Inspection of the following Figures.

Fig. 476. represents a small Piece cut out of a *walking Cane*, as it appeared in the Microscope. A B E F shews a transverse Section thereof, wherein are seen Clusters of Air Vessels surrounded with Rings of sap Vessels, and at A B C D the Pores in the outside Skin or Bark of the Cane are plainly visible.

Fig. 477. represents a magnified Piece of the Stalk of Burdock cut transversly and down the Side.

Fig. 478. exhibits a Piece cut out of a Branch of *Pine*, wherein at ABCD is seen the Bark Side-ways, and at A B E E a transverse Section thereof, through which the Turpentine Vessels run Lengthwise. G H represents one of them cut down the Middle to shew the Inside of it, and another is seen intire at I K.

Fig. 479. represents the Milk Vessels in the Bark of *Sumach*, in the same Manner as the Turpentine Vessels are represented in the foregoing Figure, and are expressed by the same Letters also.

Fig. 480. represents Part of a *Vine Branch* cut transversly; and Fig. 481. a Piece cut out of the same at a b, as it appeared in the *Microscope*; whereof A B C D shews the Skin Length-ways. At A B E F is seen a transverse Section of the Wood and Air Vessels, and between G H and I K part of the Wood and Bark is taken away to shew the same Lengthwise.

Fig. 482. a, is a transverse Section of an *Apple Branch*, in which the several Circles of Wood that shew of how many Years Growth the Tree is, are visible to the naked Eye. Fig. 482. b, represents a Gore cut out of the aforesaid Slice at a b, as it appeared in the Microscope; in which

A B represents the Skin.
A B C D the Bark.
H I spiral sap Vessels in arched Parcels.
O O the common sap Vessels which begin to turn into Wood.
C D E F the Wood of three Years Growth.
K L M N one Year's Growth, in which the dark Spots represent the Air Vessels.
g g g the true Wood.
P P the Insertions.
E F other sap Vessels.
E F G the Pith.

Fig.

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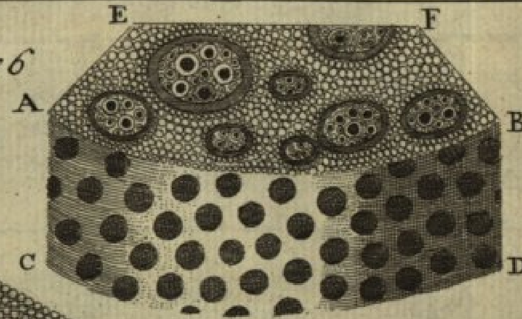

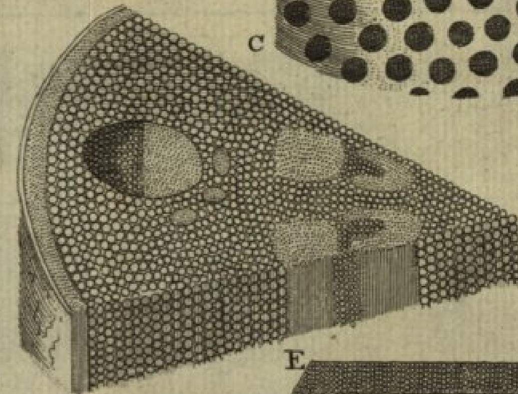

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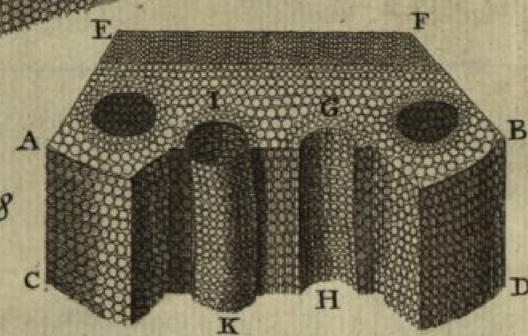

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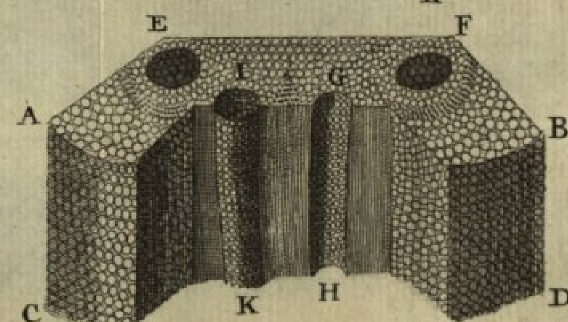

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Fig. 483. ſhews a tranſverſe Slice of a Hazel Branch, and Fig. 484 repreſents a Piece thereof, which was cut out at c d, as it appeared when placed in the *Microſcope*.

AB the Skin.
ABCD the Bark.
QQQ the ſimple Parenchyma.
HI a Ring of ſpecial Veſſels.
PP common ſap Veſſels.
CDEF the Wood of three Years Growth.
KLMN one Years Growth.
XXX great Inſertions.
PO leſſer between them, the black Parcels between theſe Inſertions are the Wood, which is compoſed of minute Tubes (although it is here repreſented in a Shade) in which the dark Spots are the Air Veſſels.
EFG the Pith.

Fig. 485. exhibits a tranſverſe Slice of a *Walnut Branch*, and Fig. 486. a *microſcopick* Picture of a Gore thereof cut out from e f, in which

AB is the Skin.
ABCD the Bark.
RR the Parenchyma.
HRI two Rings of ſpecial ſap Veſſels.
DC common Lympheducts.
DCEF the Wood of four Years Growth.
ddd the true Wood.
KLMN one Year's Growth.
Qd, Qd, part thereof whiter than the reſt, by the Mixture of ſap Veſſels, which are repreſented by the tranſverſe Lines.
MN the great Air Veſſels.
ce, ce Parcels of leſſer ones.
EF a Ring of other ſap Veſſels.
EFG the Pith.

At Fig. 487. is ſeen a Slice of a Branch of *Pine* cut tranſverſly, and at Fig. 488. a magnified Piece of the ſame cut out from g h.

ABCD the Bark.
MMM the Parenchyma.
DLC the Lympheducts.
HH Turpentine Veſſels.
DCEF the Wood in which the white Spaces tending to the Center ſhew the Inſertions.
EFG the Pith, the larger Holes both in the Wood and Pith are more Turpentine Veſſels.

Fig. 489. repreſents a tranſverſe Section of a *Wormwood-Stalk*, from whence a Piece i k was cut, which is exhibited as it appeared in the *Microſcope*, by Fig. 490. whereof

ABCD is the Bark.
AMB the Parenchyma.
HMI Balſamic Veſſels.
KL another Sort of ſap Veſſels in Parcels.
KLCD Lympheducts.
DCEF the Wood in which the dark Spots are the Air Veſſels.
MM the Inſertions.
R another balſamic Veſſel.
EFG the Pith.

Fig. 491. is a tranſverſe Section of a *Thiſtle-Stalk*, out of which at l m was cut a Piece, which is ſeen as it appeared in the *Microſcope* at Fig. 492.

ABCD the Bark.
HI the Parenchyma.
ee a Sort of ſap Veſſels.
aa another Sort.
cc Milk Veſſels.
DCEF the Wood.
VV the Air Veſſels.
tt more Lymphæducts.
ſſ mere Milk Veſſels.
at Inſertions.
EFG the Pith compoſed of angular Bladders, Bladders of Threads, and Threads of ſingle Fibres.

Fig. 493. ſhews a tranſverſe Section of *Sumach Stalk*, and Fig. 494 a magnified Gore thereof, which was cut out at n o.

AB aa the hairy Skin.
ABCD the Bark.
HWI the Parenchyma.
DMC the common Lymphæducts.
KML three Milk Veſſels.
HI another Sort of Lymphæducts, arched over the Milk Veſſels.
XX ſeems to be a third Sort of Lymphæducts.
DC EF the Wood.
the white Rays tending from M to M are the Inſertions.
YY the true Wood in which the dark Spots are Air Veſſels.
EF a Ring of Lymphæducts.
EFG the Pith.

Fig. 495. repreſents part of a *Vine Branch* cut tranſverſly at ABG, and at ABC, and alſo ſplit half way down the Middle at GGBB, whereof

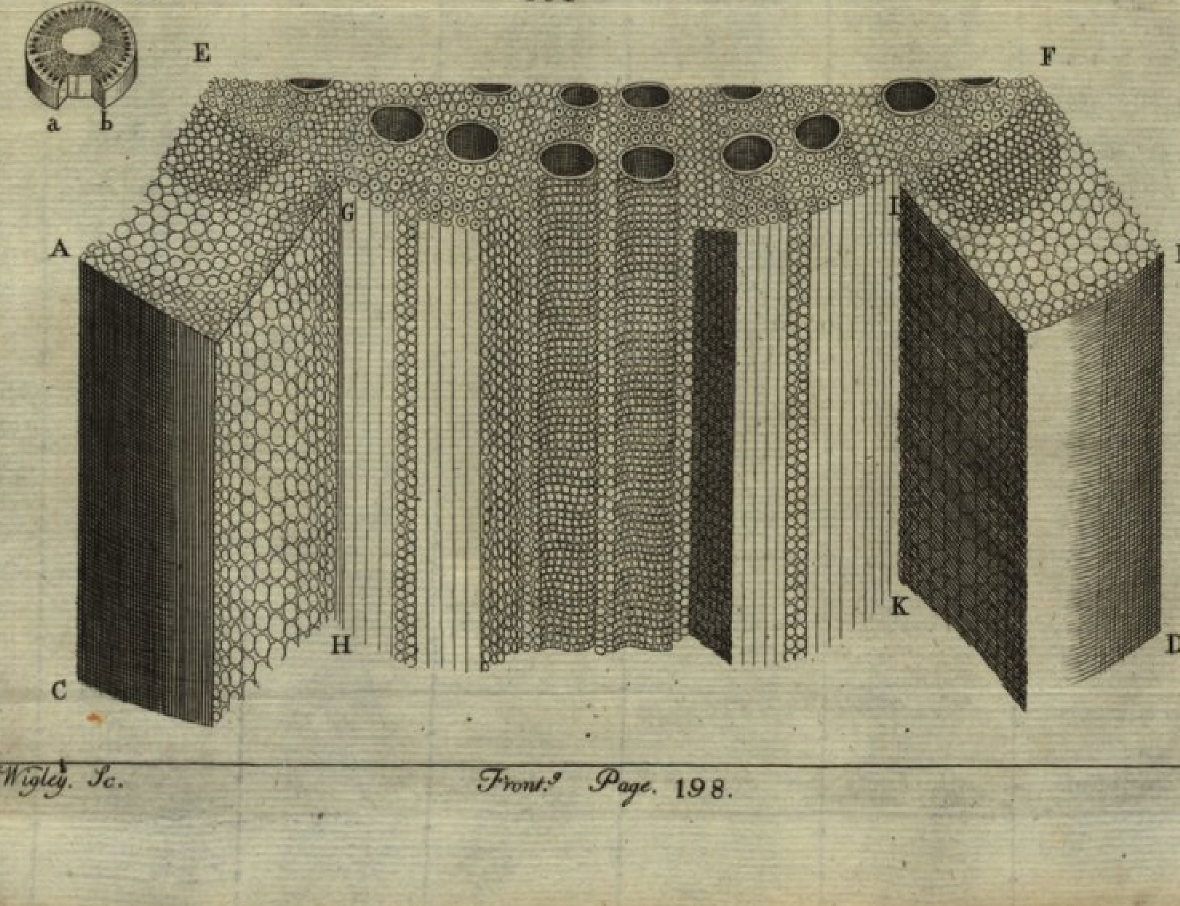
ABAB is the Skin.
ABCD, ABCD the Bark.
HHH ſap Veſſels in arched Parcels.
I the Parenchyma.
CDEF the Wood.
ddd the true Wood, in which the dark Spots are the Air Veſſels.
KK the Inſertions.
EF a Ring of other ſap Veſſels.
EFG the Pith.
Between GG, FF, is ſhewn the Poſition of the Bladders in perpendicular Rows.
Between DD and BB is ſeen the ſame of the Bark; and
Between FFDD is ſeen an upright Section of the Wood and Air Veſſels.

SECT. II.

Of the Bark of Trees.

THE exterior Part of Trees is the *Bark*, and ſerves them for a Skin or Covering; in general it is of a ſpongy Texture, and by many little Fibres, which paſs through the capillary Tubes whereof the Wood conſiſts, communicates with the Pith; ſo that the proper Nutriment of the Tree being imbibed by the Roots, and carried up through the fine arterial Veſſels of the Tree by the Warmth of the Soil, *&c.* to the Top of the Plant, is uſually ſuppoſed to be there condenſed by the cold Air; and returns by its own Gravity down the Veſſels, which do the Office of Veins, lying between the Wood and inner *Bark*, leaving, as it paſſes by, ſuch Parts of its Juice as the

480 481



J. Wigley. Sc. Front.e Page. 198.

Pl. 51.

the Texture of the Bark will receive and requires for its Support. That ſoft whitiſh Rind or Subſtance, between the inner Bark and the Wood, which, Mr. *Bradley* thinks, does the Office of Veins; ſome account a third Bark, differing only from the others in the Cloſeneſs of its Fibres; 'tis this contains the liquid Sap, Gums, *&c.* found in Plants in the Spring and Summer Months. It hardens by little and little, by means of the Sap it tranſmits, and is imperceptibly converted into the woody Part of the Tree. There are few Trees but what have it; yet it is ſtill found in leſs Quantity as the Tree is more expoſed to the Heat of the Sun. It is here the Corruption of Trees generally begin; whence thoſe who fell and cut Trees ought always to take Care to leave as little of it on as poſſible.

The *Bark* conſiſts of two Parts, the outmoſt Skin and the main Body; the Skin is generally compoſed of very ſmall Veſicles or Bladders; but as the Plant grows, the Skin dries, and the Bladders ſhrink up and diſappear. Amongſt theſe ſkinny Bladders are intermixt a Sort of woody Fibres, as in *Mallow*, *Nettle*, *Borage*, *Thiſtle*, and moſt Herbs.

The Skin of the Trunk is ſometimes viſibly porous, as in the better Sort of *Walking Canes*, Fig. 476. ABCD.

The main Body of the Bark alſo conſiſts of two Parts, the Parenchyma and Veſſels; the Parenchyma is compoſed of an infinite Number of ſmall Bladders, and the Veſſels are very numerous ſtanding in or near the inner Margin of the Bark, and are always ſap Veſſels *.

The Properties of the ſaid Veſſels are diſtinguiſhed from one another in the ſame Plant, and in the ſeveral Species of Plants; which Properties are not accidental, but ſuch as ſhew the conſtant and univerſal Deſign of Nature.

For in the Figures 482, 484, 486, 488, the Veſſels of the *Bark* are only of two Kinds, which in the firſt two ſeem to be roriferous † and Lymphæducts (yet in all the four their Number and Poſition is very different.) In Hazel, Fig. 484, they are but few; in Apples, Fig. 482, they are more, and alſo in *Pear*, *Plumb*, *Elm*, &c. ſtill more numerous. As to their Poſition in *Hazel*, the Lymphæducts or Veſſels next the Wood, ſtand in ſemicircular Parcels; and in *Holly* they ſtand in Rays, yet ſo numerous and cloſe together as to make one intire Ring. In the Apple Branch, Fig. 482. the Lymphæducts OO are radiated, they are alſo radiated in the Pear and Plumb, *&c.* In *Hazel*, Fig. 484. the roriferous Veſſels HI, as Dr. *Grew* calls them, make an intire Ring. In *Apple*, Fig. 482, they are neither radiated nor make an intire Ring, but ſtand in peripherical Parcels, much after the ſame Manner they ſtand in *Elm*. In Aſh the Veſſels make two Rings, the inmoſt or Lymphæducts conſiſt in arched Parcels, and the outmoſt or roriferous of round ones; whereas in the foregoing the Lymphæducts are contiguous to the Wood, and the roriferous more or leſs diſtant

* *Grew. Ana. Plant, p.* 108. † *Ibid.* 109.

from

from the Skin; here, on the contrary, the first are distant from the Wood, and the latter contiguous to the Skin.

In the two next Branches, Fig. 486 and 488, the Vessels of the *Bark* are also different in Number, Position, Size and Kind. In *Pine* they are less, and in *Walnut* more numerous; as to their Position, the inmost D C in *Pine*, Fig. 488, compose a radiated Ring, the utmost are stragling up and down without any certain Order. In *Walnut*, Fig. 486, the inmost D C make also a radiated Ring, and the utmost a double Ring H R I, not radiated but of round Parcels: As to their Kind, they differ most apparently from the Diversity of Saps those different Vessels contain; which in the Bark of Pine, Fig. 488. are also of two Sorts, the inmost are Lymphæducts, as in the two former; the outmost are not Milk, but Gum Vessels, or resiniferous, and stand straggling or singly about the Bark; all the clear Turpentine that drops from the Tree issues from these Vessels, which are apparent even to the naked Eye; whereas those of the Lymphæduct are not to be discerned without the Assistance of a *Microscope*.

The two next Pieces of Branches are common Sumach, Fig. 494. and *common Wormwood*, Fig. 490, which are remarkable for their having three kind of Vessels in the *Bark*, whereas the former have only two. First then in *common Sumach* is a thick radiated Ring D M C of Lymphæducts, standing on the inner Margin of the Bark contiguous to the Wood; these Vessels exhibit their Lympha very apparently. The second Kind of Vessels XX compose a Ring, and are situate near the outward Margin of the *Bark*. Between these two Kinds stand the Milk Vessels K M L, each of which being empaled or hem'd in by an Arch of roriferous Vessels.

The next is a Branch of common *Wormwood*, Fig. 490, in the *Bark* of which are also three kinds of Vessels; first there is a thin radiated Ring, C D L K of Lymphæducts, contiguous to the Wood, yet this Ring is not entire, but made up of several Parcels; which are intercepted by as many parenchymous ones, inserted from the *Bark* into the Pith. The second Sort of Vessels K L, which seem to be roriferous, are situate near the Middle of the Bark, and stand in arched Parcels; these also compose a Ring.

Beyond these Arches, and towards the outer Margin of the *Bark*, stand a third Sort of Vessels H M I, their Content is a kind of a *liquid*, *oleous* and *viscid Gum*, which for its pleasant Flavour may be called an *aromatick Balsam* *, because it perfectly affordeth whatever is in the Smell or Taste of Wormwood, being the Essence of the whole Plant, so that they are in all Respects analogous to the Turpentine Vessels in Pine.

The Structure of the Milk and Gum Vessels when viewed with the *Microscope*, seem to be made by the Constipation of the Bladders in the Bark, that is to say, they are so many Chanels, not bounded by any Sides proper to

* *Grew An. Plants, p.* 111.

them-

themſelves, as a Quill thruſt into a Cork, or as the Air Veſſels in the Wood, but by the Bladders of the Parenchyma * which are ſo crowded up together, as to leave certain tubular Spaces throughout the whole Length of the Bark.

One Difference between thoſe Veſſels juſt deſcrib'd, and theſe hollow Tubes, *&c.* in the Pith, is this, that they are not originally formed with the Pith, but are formed partly by the ſtretching it undergoes from the Dilatation of the Wood, and partly from the drying and ſhrinking up of its Bladders, and of their component Fibres; whereas the Veſſels in the Bark are many of them originally formed † therewith; and thoſe which ſucceed them are not cauſed by any Rupture as thoſe in the Pith are, but from a regular Diſpoſition of the parenchymous Fibres, and Conſtipation of the Bladders thereof; all which will appear very plain upon viewing the three Figures 477, 478, and 479.

It has been before obſerved, that the lignous or towy Parts of all Plants are tubular, and that the Juices are conveyed the whole Length of the Plant through an infinite Company of ſmall Tubes.

Theſe very Tubes or Lymphæducts are likewiſe made up of other yet much ſmaller Tubes, ſet round together in a cylindrical Figure; by which alſo appears the admirable Smallneſs of theſe Fibres; for there are ſome Lymphæducts that may be reckoned 50 Times ſmaller § than an Horſe-hair, and that thoſe minute Fibres are alſo compoſed of other ſuch Fibres, but much ſmaller, is not altogether improbable; allowing therefore but 20 of theſe to compoſe a Thread no bigger than one of theſe Lymphæducts; then one of theſe Fibres muſt be 1000 Times ſmaller than an Horſe-hair.

They may be obſerved in a very white and clear Piece of Aſh torn carefully lengthways, and ſometimes alſo in a very white Piece of Fir.

In the *Eaſt Indies* they manufacture the *Bark* of a certain Tree into a kind of Stuff or Cloth; it is ſpun and dreſs'd much after the Manner of *Hemp:* The long Filaments which are ſeparated from it, upon beating and ſteeping it in Water, compoſe a Thread, of a middle Kind between Silk and common Thread, neither ſo ſoft or bright as Silk, nor ſo hard or flat as Hemp. Some of theſe Stuffs are pure *Bark*, and are called Pinaſſes, Biambonnes, *&c.* In others they mix Silk with the Bark, and call them Ginghams and Nillas; the Fontalungees too, are part Silk, part Bark, and are only diſtinguiſhed by being ſtripped.

* *Grew Ana. Plants, p.* 113. † *Ibid.* § *Ibid. p.* 112.

Sect. IV.
Of the Wood.

THE next general Part of a Branch is the Wood which lies between the Bark and Pith, it is compoſed of parenchymous and lignous Parts; the parenchymous Part of the Wood in all Trees, though much diverſified, is diſpoſed into many Rays or Inſertions running between as many woody Portions, from the Bark to the Pith. Theſe Inſertions are various according to the ſeveral Sorts of Trees or Plants, in Pine, Fig. 488, and Wormwood, Fig. 490. they are not ſo numerous as in Sumach, Fig. 494. in the Apple, Fig. 482, or in the Hazel, Fig. 484.

Theſe Inſertions do not run only through the Wood, but alſo ſhoot out beyond it into ſome Part of the Bark, as in *Elm*, *Sumach*, *Wormwood*, &c.

The Texture likewiſe of theſe Inſertions is alſo various in Wormwood and moſt Herbs, they are manifeſtly compoſed of ſmall Bladders, yet larger in theſe than in Trees.

The *Wood* is likewiſe compoſed of two Sorts of Bodies, that which is ſtrictly woody, and the Air Veſſels. The true *Wood* is nothing elſe but a Maſs of antiquated Lymphæducts, *viz.* thoſe which are originally placed on the inner Margin of the Bark; for in that Place there annually grows a new Ring of Lymphæducts, which by degrees loſing its firſt Softneſs, is at the latter End of the Year turned into a dry and hard Ring of perfect *Wood.* Whence it is evident that the Bark of a Tree is divided into two Parts, and diſtributed two contrary Ways; the outer Part falleth off towards the Skin, and at length becomes the Skin itſelf. The outward Skin of a Tree is not originally made a Skin, but was once ſome of the middle Part of the Bark itſelf, which is annually caſt off and dried into a Skin; the inmoſt Portion of the Bark is yearly diſtributed and added to the Wood, the parenchymous Part thereof makes a new Addition to the Inſertions within the *Wood*, and the Lymphæducts a new Addition to the woody Pieces between which the Inſertions ſtand; ſo that a Ring of Lymphæducts in the Bark this Year will be a Ring of Wood the next, and another Ring of Lymphæducts and of Wood ſucceſſively from Year to Year; ſo in Fig. 482, of part of an *Apple Branch* cut tranſverſly, three Years Growth, are repreſented in that of Sumach, Fig. 484. one Year only is exhibited, and in that of *Walnut*, Fig. 486. are ſhewn four Years Growth of Wood between the Letters DCEF.

Here alſo may be obſerved, that certain Parcels of Wood make either ſeveral ſmall white Rings, as in *Oak*, or ſeveral white and crooked Parcels tranſverſe to the Inſertions, as at DC, KL, *&c.* in *Walnut*, Fig. 486.

In the Branches of *Fir*, *Pine*, &c. are a few Turpentine Veſſels diſperſed

up

up and down the *Wood*. The Air Veſſels with the Inſertions, and true Wood altogether, make up that which is commonly called the Wood of a Tree.

The Variety of the Air Veſſels are many, with reſpect both as to their Number, Size, and Poſition, and are not to be found alike in any two Sorts of Plants whatſoever: As to their Number it is very great, in *Apple*, *Pear*, *Hazel*, &c. but in different Degrees, they are repreſented by all the black Spots in the Wood, in all the Figures before referred to.

Their Sizes are as different as the Trees to which they belong, being at leaſt twenty Times bigger in *Elm* or *Oak*, than in *Holly* or *Pear*, &c.

Their Situation is alſo different: In *Apple*, Fig. 482. and in *Walnut*, *Fig*, &c. they are ſpread abroad in every annual Ring; in others they keep more in the Compaſs of ſome Line or Lines, either diametrical or peripherical. In *Holly*, &c. they are radiated or run in even diametrical Lines between the Pith and Bark.

Whether the Air Veſſels are irregular or radiated, Nature hath ſo diſpoſed them, as that many of them ſtand always near the Inſertions.

In *Aſh* the Air Veſſels ſtand in Circles on the inner Margin of every annual Ring. Theſe Circles are in ſome very thick, as in *Aſh* and *Barberry*, in ſome thin, as *Elm*, &c.

Their Form is ſuch that they are never ramified, but continued from one End of a Plant ſmall or great, quite through to the other End thereof.

As to their Texture they oftentimes appear to be unwreathed in Form of a very ſmall Plate, which alſo is not only of different Breadths in different Plants, and uſually broader in the Root than in the Trunk; but alſo the ſaid Veſſels are oftentimes unwreathed, not in the Form of a Plate but of a round Thread. The Cauſes of which Diverſity are principally three, the Weſtage of the Fibres of which the Air Veſſels conſiſt: The Difference between the ſaid Fibres, or between the Warp and Woof, and the different Kinds of Woof.

By the Weſtage of the Fibres it is, that the Veſſels oftentimes untwiſt in the Form of a Plate; as if a fine narrow Ribband be wound ſpirally, and Edge to Edge, about a Stick, and then the Stick being drawn out, will leave the Ribband in the Form of a Tube * and of one of theſe Air Veſſels, for that which upon the unwreathing of the Veſſel ſeems to be a Plate, is as it were a natural Ribband, conſiſting of a certain Number of Threads or round Fibres, ſtanding parallel as the Threads do in a Ribband; and as in a Ribband ſo here, the Fibres which make the Warp and run ſpirally, do not grow together, but are held in that Poſition by other tranſverſe Fibres which embrace them, and are in the Place of the Woof.

And as the ſaid Fibres are tranſverſly continued thereby making a Warp

* *Grew. An. Plan. p.* 117.

and Woof, ſo are they (as in divers Woollen Manufactures) of different Bulk; thoſe of the former being ſtronger and bigger than thoſe of the latter; by which Means, as Cloth and Silk will uſually tear ſooner one Way than another; ſo here while the Warp or thoſe Fibres which run ſpirally are unwreathed, without breaking the ſmaller ones which hold them together, eaſily tear all the Way.

In the following Figures are ſhewn the Poſition of the Veſſels in ſeveral Sorts of Timber cut Length-wiſe and Croſs-wiſe as follows:

Fig. 507. repreſents a ſmall Piece of the Wood of an *Oak-Tree*, cut tranſverſly, and of its natural Size; and Fig. 508. A B C D, ſhews the ſame Piece as it appeared before the *Microſcope* when greatly magnified, whereof the Parts F F ſeemed to be brown dark Streaks, the Wood included between the Spaces H I and K L, is the Breadth of that Circle which the Tree had increaſed in one Year. E E are the Cavities of very large Air Veſſels, which run the Lengthway of the Tree. Theſe large Veſſels are compoſed of ſeveral ſmaller Membranes, as may be ſeen at Fig. 512. which repreſents part of one of the aforeſaid Air Veſſels ſeen length-wiſe, and as it appeared before the Magnifier.

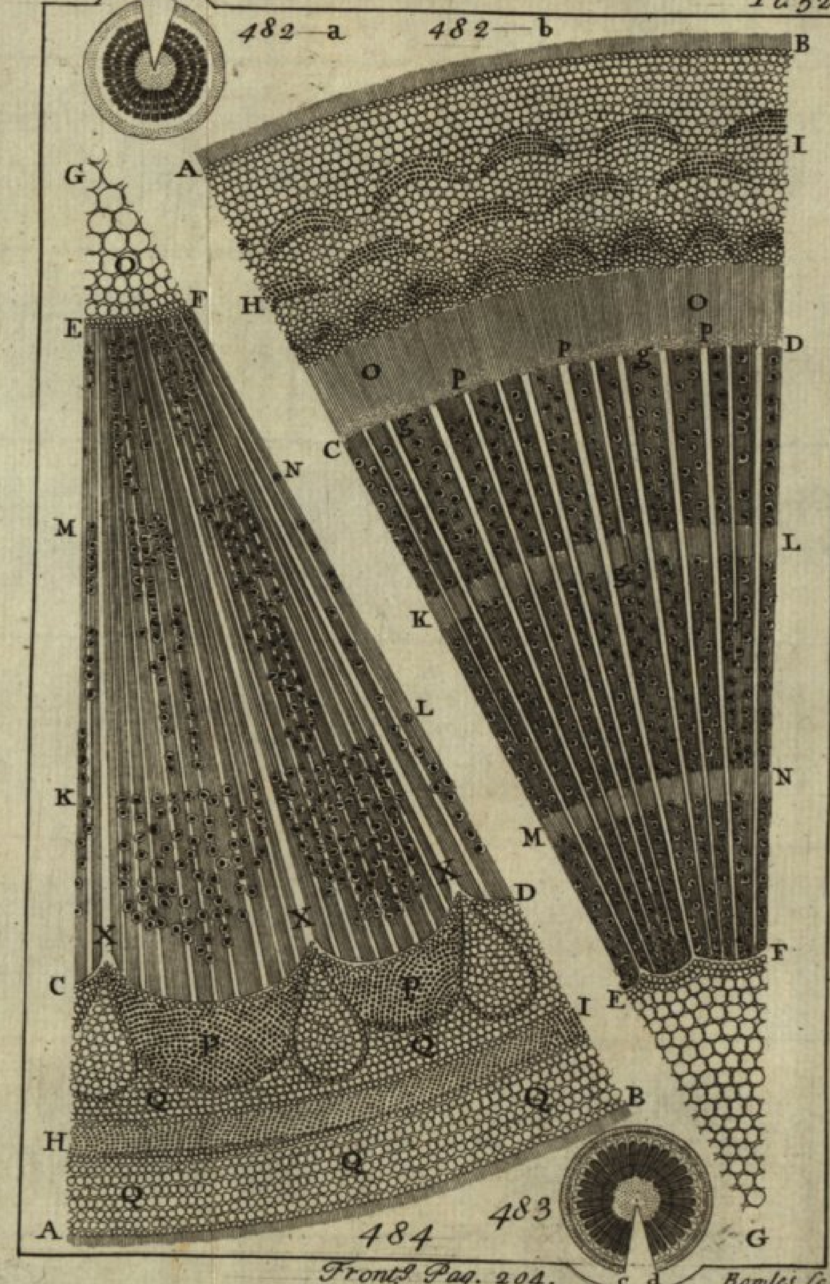
The ſecond Sort of perpendicular Veſſels which tend upwards, are ſeen at e e, Fig. 508. and are alſo compoſed of exceeding fine Skins, * in which are ſeen ſome Spots that in the Microſcope appear like Globules, as at O N, Fig. 511. which ſhews one of theſe ſecond Sort of Veſſels cut lengthwiſe.

The third Sort of theſe Veſſels which run upwards, are extremely ſmall and in great Abundance, as appears throughout the whole Space H I K L, Fig. 508. Theſe alſo are compoſed of extremely fine Skins; they are ſeen length-ways between P Q, Fig. 511.

G G G, Fig. 508. are another Sort of Veſſels, which run horizontally from the Bark to the Pith: Theſe ſeemed to extend themſelves in Furrows, and were crooked or bowed round the Knots. When the *Wood* is cut length-wiſe, theſe horizontal Veſſels are cut acroſs, as at G G G, Fig. 511. The ſecond Sort of horizontal Veſſels are greatly numerous, which when the Oak is cut length-wiſe, are alſo cut acroſs, and appear to the naked Eye as Fig. 513.

Fig. 496. ſhew a Piece of *Elm* cut tranſverſly as it appeared to the naked Eye; and Fig. 497, a *microſcopick* Picture of the ſame. A B, C D is the Breadth of the Ring the Tree had increaſed in one Year. The ſmaller perpendicular Veſſels are ſituate between and joined to the larger, having ſmaller ones between them, as in Oak; the Tubes here alſo are compoſed of ſkinny Membranes. A C and B D, Fig. 497, are horizontal Veſſels ſeen lengthwiſe. Fig. 498, is an upright Section of the Wood of *Elm* magnified, in which G G ſhews the exceeding ſmall Veſſels length-ways,

* *Leeuwen. Anat. & Contemp. Vol.* 1. *p.* 3.



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H H is the Cavity of one of the great Veſſels, being full of Turpentine Threads, or little Tubes, with black Spots curiouſly wove together; as at Fig. 499.

Fig. 500. is a ſmall and thin Piece of *Beach*, cut tranſverſly, and Fig. 501. repreſents the ſame as it appear'd in the *Microſcope*. Its Length between A B and D C is the Breadth of a Circle, of one Year's Growth. The perpendicular Veſſels in this Wood are of two, and the horizontal Ones of three Sizes; of which thoſe expreſſed by E E, Fig. 501. are exceeding ſmall; in the upright Section, Fig. 502. theſe horizontal Veſſels are cut tranſverſly, and ſhewn by H H, the ſecond Sort of horizontal Veſſels are ſeen lengthwiſe, from D to A, Fig. 501. and a tranſverſe Section of the ſame Veſſels are ſeen in the upright Section of the Timber, Fig. 502. at I, I, I, and at K K are ſeen the great perpendicular Veſſels.

Fig. 509. repreſents a tranſverſe Section of a ſmall Bit of *Black Ebony*, greatly magnified, of which G, G, G, are the large upright Veſſels. K K, in Fig. 510. ſhews one of theſe large Veſſels cut lengthwiſe, and at Fig. 511. is ſeen another of a larger Sort, in which are many Streaks and Spots. The ſecond Sort of perpendicular Veſſels are ſeen between A B, A B, and the third Sort between C D, C D; a fourth Sort are ſquariſh, and included between the ſecond and third in the upright Section, Fig. 510. L L ſhews the ſmalleſt Veſſels, and I, I, the tranſverſe Sections of the horizontal Ones.

Fig. 503. A B C D is a ſmall Piece of *Box*, cut tranſverſly, and of the ſame Size to the naked Eye as the Piece of *Ebony*. This Wood alſo conſiſts of large and ſmall perpendicular Veſſels intermix'd; the large ones are compos'd of Skins, and are full of extremely minute Particles, as may be ſeen in the upright Section thereof at E E, Fig. 504. the Cavities of the leſſer Veſſels are ſhewn lengthways at F E. A B and C D, Fig. 503. are horizontal Veſſels, running lengthways, and at G G, Fig. 504. is ſeen a tranſverſe Section of the ſame.

A B C D E F, Fig. 505. repreſents a tranſverſe Section of a ſmall Piece of *Straw*. A B E F is the ſhining Bark, compoſed of an incredible Number of exceeding ſmall Veſicles. G G G G are Veſſels, or rather Bladders, having four, five, or ſix Sides, and compoſe the greateſt Part of the Inſide of the *Straw*. H H H are ſome of the before-mentioned Veſſels, intermixed with, or ſurrounded by a great Number of exceeding ſmall Veſſels. At Fig. 506. the ſame Veſſels are ſeen lengthways in a perpendicular Section of the *Straw*.

Sect. V.

Of the Pith.

THE third general Part of a Branch is the *Pith*, being in Subſtance nearly allied to the Parenchyma in the *Bark*, and the *Inſertions* in the Wood.

Its Size is various, not being the ſame in any two Branches here repreſented. In Wormwood, Fig. 490. and Sumach, Fig. 494. it is very large. In Pine, Fig. 488. and Walnut, Fig. 486. not ſo large. In Apple, Fig. 482. and Hazel, Fig. 484. it is ſmaller.

It is alſo remarkable, that the *Bark* and *Wood* in moſt Plants increaſe yearly; and the *Pith*, on the contrary, grows ſmaller.

The *Pith*, for the moſt Part, is furniſhed with a certain Number of Sap Veſſels, which form a Ring round the Margin thereof. They are numerous and conſpicuous in *Walnut*, Fig. 486. and in *Fig*, *Pine*, &c. and are of divers Kinds, being Lymphæducts in *Walnuts*, Lacteals in *Fig*, and Reſiniferous in *Pine*.

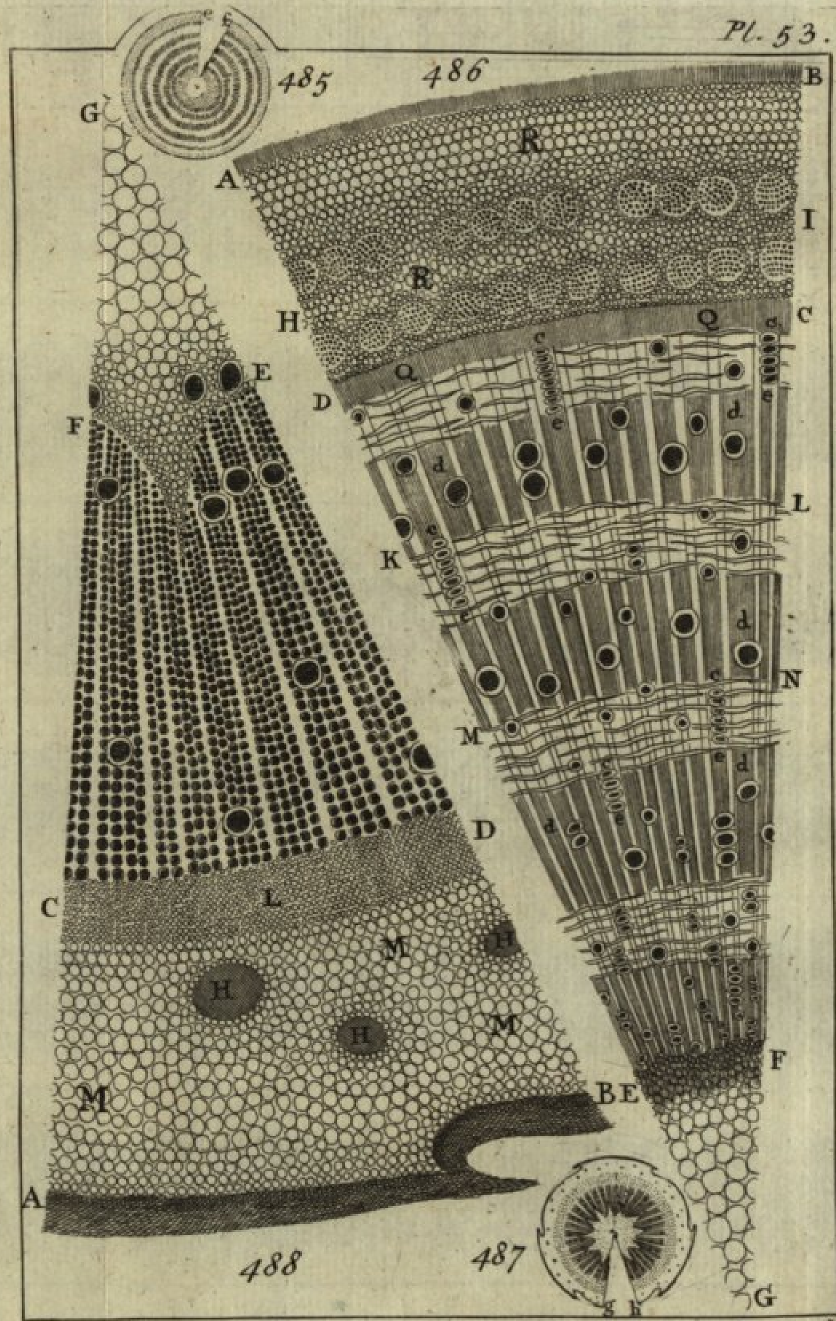
The Parenchyma of the *Pith* is compoſed of Bladders the very ſame with thoſe in the *Bark*, and oftentimes in the Inſertions within the Wood, only theſe of the *Pith* are largeſt, thoſe in the Bark leſs, and theſe in the Inſertions leaſt of all.

The Bladders of the *Pith*, tho' always comparatively great, are of very different Sizes. Thoſe of *Thiſtle*, *Borage*, &c. appear in the *Microſcope* like the Cells of an Honey-Comb; the Bladders in *common Thiſtle* and *Borage*, are ſo large as to contain within their horizontal Area, about twenty Bladders of the *Pith* of *Oak*. Wherefore one Bladder in *Thiſtle* is at leaſt an hundred times bigger than another in *Oak*.

The Shape of the *Pith* Bladders admit of ſome Variety, they are for the moſt Part round, yet oftentimes angular, as in *Reed Graſs*, a Water Plant; where they are alſo cubical; in *Borage*, *Thiſtle*, and many others they are pentangular, ſexangular, and ſeptangular.

As to the Texture of theſe *pithy* Bladders, they are oftentimes compoſed of ſmaller ones, as in *Borage*, *Bulruſh*, and many other Plants.

Whence it appears, that as the Veſſels of Plants, *viz.* the Air Veſſels and Lymphæducts are made up of Fibres, ſo the *Pith*, or the Bladders of which the *Pith* conſiſts, are likewiſe compoſed of Fibres, which is alſo true of the Parenchyma of the Bark, and of the Inſertions in the Wood, and even of the Fruit, and all other parenchymous Parts of a Plant, and that the very Pulp of an *Apple*, *Pear*, *Cucumber*, *Plumb*, or any other Fruit, is nothing elſe but a Ball, of moſt extreamly ſmall tranſparent Threads or Fibres, joined



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together in a different, but curious Manner, even all thoſe Parts of a Plant, which are neither formed into viſible Tubes, nor Bladders, are made up of Fibres; and though it be difficult to diſcover them in thoſe Parts which are the moſt compact and cloſe, yet in the *Pith* which conſiſts of more open Work, they are viſible; and that in the *Pith* of a *Bulruſh*, *common Thiſtle*, &c. not only the Threads of which the *Bladders*, but alſo the ſingle Fibres of which the Threads are compos'd, may be diſtinctly ſeen, when placed before the *Microſcope*.

The Fibroſity of the Parenchyma is alſo viſible in ſome Woods, being interwove with the lignous Parts, and with every Fibre of every Veſſel, as in very white *Aſh* or *Fir* may be diſcover'd.

Whence it follows, that all the Parts of a Plant conſiſt of Fibres, of which thoſe of the Lymphæducts run lengthwiſe, thoſe of the Pith, Inſertions, and Parenchyma of the Bark horizontally, thoſe of the Air Veſſels begin their Circuit horizontally, and continue it in Height or lengthwiſe.

From what has been ſaid, there appears to be a great Similitude between the Mechaniſm of *Plants* and *Animals*, the Parts of the former ſeem to bear a conſtant Analogy to thoſe of the latter; and the *Vegetable* and *Animal* Œconomy ſeem to be both formed on the ſame Model; for from the foregoing Obſervations, and the Aſſiſtance of the *Microſcope*,

Firſt, the *Root* is found to be a ſpongy Body, whoſe Pores are diſpoſed to admit certain humid Particles, prepared in the Ground.

Second, the *Wood* which conſiſts of capillary Tubes running parallel from the Root throughout the Stalk, (the Apertures of thoſe Tubes are too minute to come under the Cognizance of the naked Eye) theſe Mr. *Bradley* calls *arterial Veſſels*; it being through theſe that the Sap riſes from the Root.

Third, beſides theſe there are other larger Veſſels, diſpoſed on the Outſide of the arterial Veſſels between the Wood and the inner Bark, and leading down to the Covering of the Root, which he alſo calls *venal Veſſels*, and ſuppoſes them to contain the liquid Sap found in *Plants* in the Spring.

Fourth, the *Bark* being of a ſpongy Texture, which by many little Strings communicates with the *Pith*.

Fifth, the *Pith*, or Pecten, which conſiſts of little tranſparent Globules, chained together ſomewhat like the Bubbles that compoſe the Froth of Liquor.

Malpighi was the firſt who obſerved, that Vegetables conſiſts of two Sorts of Veſſels. 1. Thoſe abovementioned, which receive and convey the alimental Juices. 2. *Tracheæ*, or *Air Veſſels*, which are long hollow Pipes, wherein Air is continually received and expelled, *i. e.* within which *Tracheæ* he ſhews all the former Series's of Veſſels are contained.

Hence

Hence it follows, that the Heat of a Year, nay of a Day, of a single Hour, or Minute, must have an Effect on the Air, included in these *Trachea*, i. e. it must rarify it, and consequently dilate the *Trachea*; whence also must arise a perpetual Spring or Force of Action to promote the Circulation in *Plants*.

For by the Expansion of the *Trachea*, the Vessels containing the Juices are pressed; and by that Means the contained Juice is continually propelled, and so accellerated; by which same Propulsion the Juice is continually comminuted and rendered more and more subtle, and so enabled to enter Vessels still finer and finer; the thickest Part of it being at the same Time secreted and deposited into the lateral Cells, or Loculi of the *Bark*, to defend the Plant from Cold and other external Injuries.

The *Juice* being thus conveyed from the *Root*, to the remote Branches, and even to the Flower; and having in every Part of its Progress deposited something both for Aliment and Defence; what is redundant passes out into the *Bark*, the Vessels whereof are inosculated with those wherein the Sap is mounted; and through these it descends to the Root, and thence to the Earth again, and thus is Circulation effected.

Thus is every Vegetable acted on by Heat during the Day-time, and the Sap Vessels thus are squeezed and press'd, and the Sap protruded and raised, and at length evacuated, and the Vessels exhausted in the Night again; the same *Trachea* being contracted by the Coldness of the Air, the other Vessels are eased and relaxed, and so disposed to receive fresh Food for the next Day's Digestion and Excretion.

The Juice being carried on to the *Germs* or *Bud*, is more concreted; and here having unfolded the *Leaves*, which being exposed to the alternate Action of Heat and Cold, moist Nights, and hot scorching Days, are alternately expanded and contracted; and the more on account of their reticular Texture.

By such Means the *Juice* is farther altered and digested, as it is further yet in the *Petala*, or Leaves of the Flowers, which transmit the *Juice*, now brought to a further Subtility to the *Stamina*; these communicate it to the *Farina*, or Dust in the *Apices*, where having undergone a farther Maturation, it is shed into the *Pistil*, and here having acquired its last Perfection, gives Rise to a new Fruit or Plant.

Fig 514, and the four following Figures, represent the Structure of the woody Fibres and Lymphæducts both in the Bark and Wood.

Fig. 514, shews a single Vessel in the *Bark* of *Flax*; and Fig. 515. represents the same Vessel as seen in the *Microscope*, and greatly magnified; whence it appears to be composed of a great Number of other lignous Fibres, with which also the Parenchymous are intermixt.

Fig. 516, exhibits a Parcel of the same Vessels in the Wood of Fir, greatly magnified; and at a, is seen the same Piece of its natural Size.

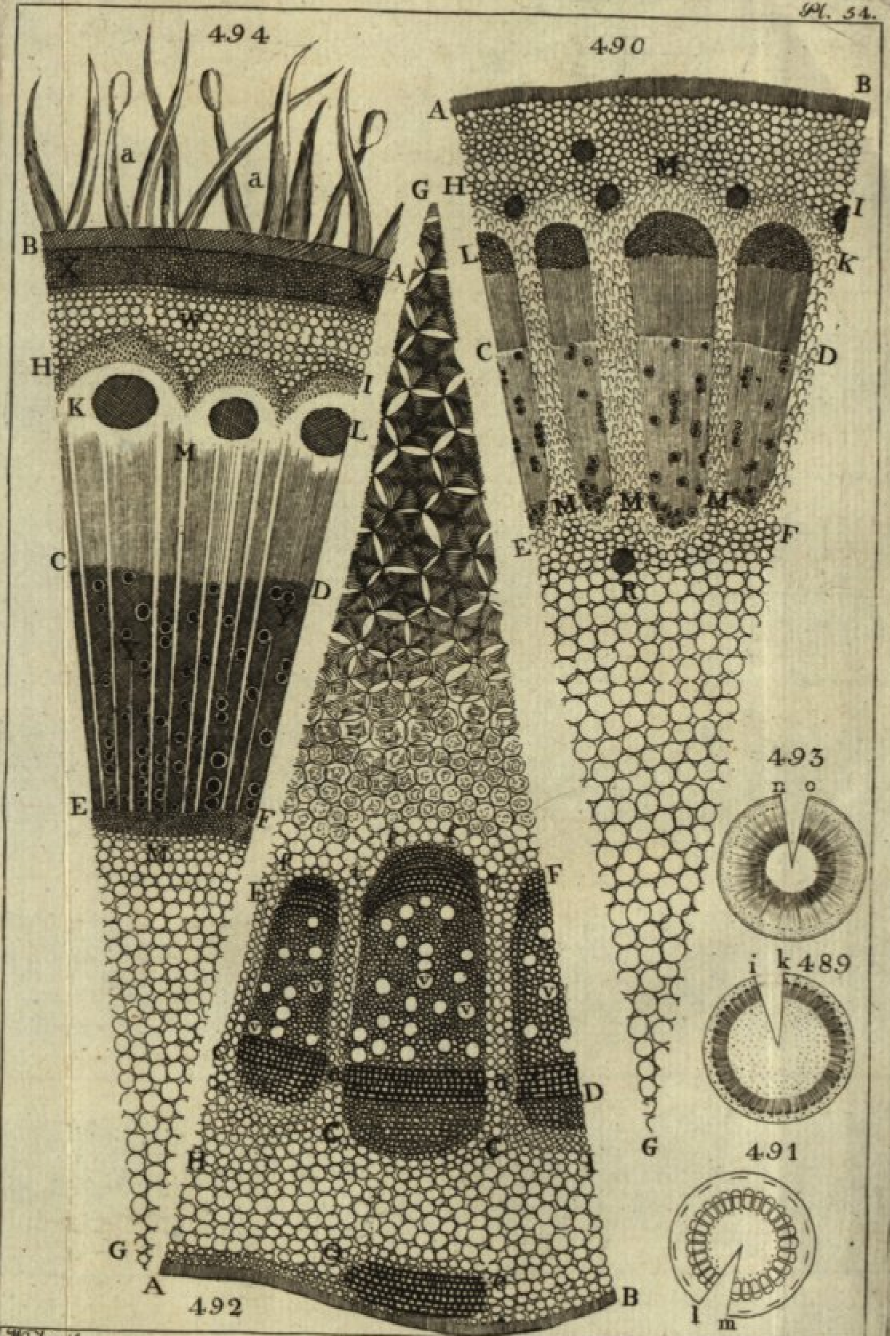

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Fig. 517, AB, ſhews a Lymphæduct, and Fig. 518, C, repreſents a lactiferous Veſſel, both of which are ſurrounded with parenchymous Bladders, and are greatly magnified.

Fig. 519, repreſents part of the Stalk of Sumach, ſomewhat larger (and more magnified) than that of Fig. 494, with ſeveral Breaks in it, to ſhew the Contexture both of the perpendicular and horizontal Fibres; in which, as before,

AB aa ſhews the hairy Skin.
ABCD the Bark in which the Fibres b b, c c, and d d, that hang down therefrom are Lymphæducts, one of which d d d, is compoſed of a great many other ſmaller Fibres.
HWI the Parenchyma.
DMC the common Lymphæducts.
KML the Milk Veſſels compoſed of Bladders.
HI another Sort of Lymphæducts arched over the Milk Veſſels.
DCEF the Wood, from which the Fibres e f, that hang down, are ſome of them the old Lymphæducts turned into Wood; g h g h are two Air Veſſels in which the wreathing thereof is plainly ſeen, and from h to i is alſo ſeen Part of the ſame Veſſels unwreathed.
OP is part of one of the Inſertions compoſed of Bladders, and thoſe Bladders of Threads.
EFG is part of the Pith compoſed of thready or fibrous Bladders.

CHAP. XXXVIII.

Of Leaves.

SECT. I.

THE *Leaves* of Trees or Plants are full of innumerable Ramifications, that convey the perſpirable Juices to the Pores for their Diſcharge. The Fibres of the Leaf do not ſtand in even Lines from the Stalk, but always in an angular or circular Poſture, and their vaſcular Fibres or Threads are 3, 5 or 7; the Reaſon of their being in this Poſition, is for the more erect Growth and greater Strength of the Leaf, as alſo for the Security of its Sap. Another Obſervable in the Fibres of the *Leaf*, is their orderly Poſition, ſo as to take in an eighth Part of a Circle, as in *Mallows*, in ſome a *Tenth*, but in moſt a *Twelfth*, as in *Holy-Oak*, or a *Sixth*, as in *Syringa*.

The Art of folding up the *Leaves* before their Eruption out of their Gems, *&c.* is incomparable both for its Elegancy and Security, *viz.* in taking up (ſo as their Forms will bear) the leaſt Room; and in being ſo conveniently couched, as to be capable of receiving Protection from the other Parts, or of giving it to one another, *e. gr.* firſt there is the *Bow-lap*, where the Leaves are all laid ſomewhat convexly, one over another, but not plaited, but where the Leaves are not ſo thick ſet as to ſtand in the *Bow-*

lap; there we have the *Plicature*, or the *flat Lap*, as in *Rose-tree*, &c. To these Dr. *Grew* adds their various Foldings, which he calls by the Names of the *Duplicature*, *Multiplicature*, the *fore Rowl*, *back Rowl*, and *tre Rowl* or *treble Rowl*.

To these curious Foldings may be added another noble Guard by the Interposition of Films, *&c.* of which Dr. *Grew* saith there are about six Ways, viz. *Leaves*, *Surfoyls*, *Interfoyls*, *Staks*, *Heads*, and *Mantlings*.

The various Methods which Nature takes to preserve the Leaves from the Injuries both of the Ground and Weather are, *viz.* the young Buds of *Ammi*, at their first Eruption from the Ground, are couched, as *Fern* is rowled inward; each Bud, against the Brace of the Stalk of the foregoing Leaves, and most exactly inclosed in the Membranes thence produced. Nature hath generally provided them with another Protection, where the Stalks of the Leaves are so long that they cannot lap over each other, the Bottoms of the Stalks are expanded into broad Membranes, as in *Crows-foot*, *Doves-foot*, *Clover*, *Cransbill*, *Strawberry*, *Harrow*, &c. and sometimes instead of two Skins lapped over each other, one entire Skin is produced from the Stalk, in which, as within a Secundine, the Bud is safely lodged, which it gradually breaks open in its Growth.

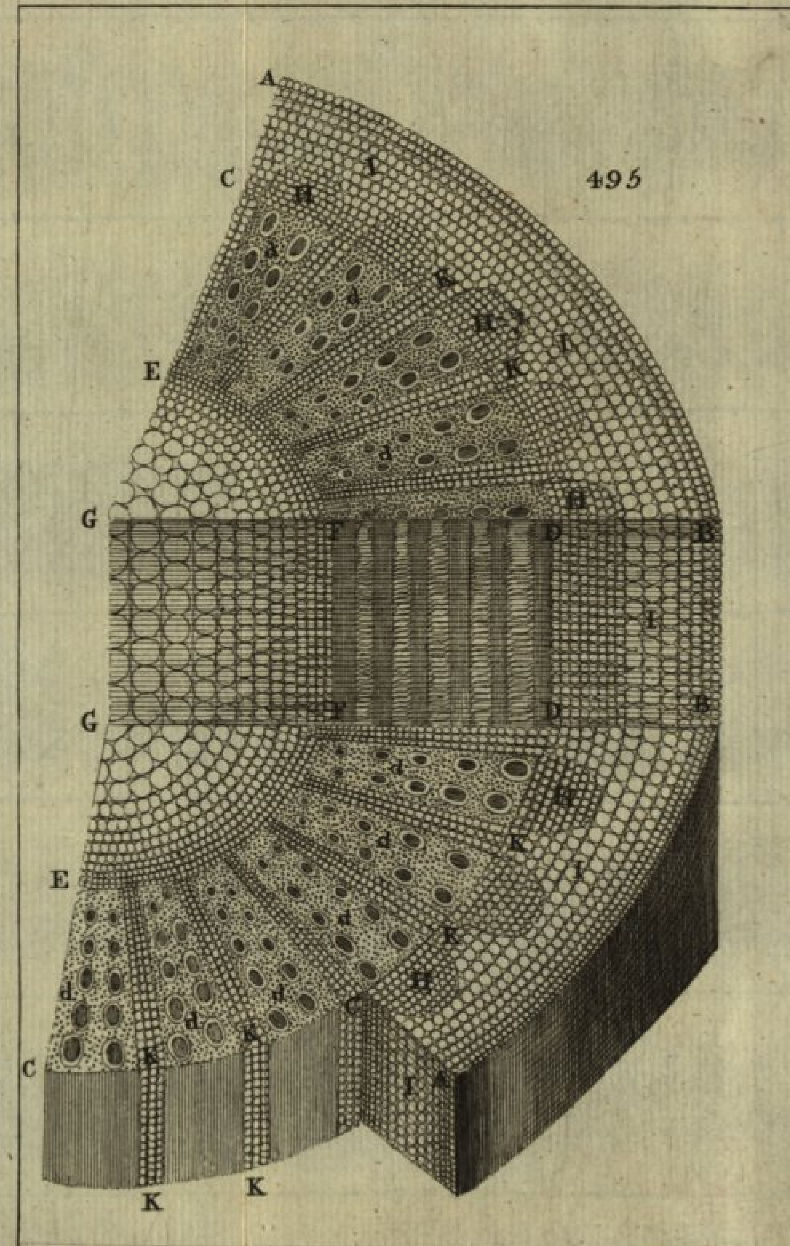
It is also observable in *Dock*, *Sorrel*, *Bistort*, and all other Plants of this Sort, with this Difference, that every Veil or Secundine is not here produced from the Stalk of the *Leaf*; whereas in the former every Bud hath one to itself in these Plants, every lesser *Leaf*, together with its own proper Veil, is always inclosed with the next greater *Leaf* in another common to them both, and both these with the next in another, and so on to the greatest. The *Orchis*, and other Plants of this Sort, have a double Sheath over all. The Buds of some Herbs as *Plantain*, having no Hairs growing over them, are covered with hairy Thrums, and the *Nettle* hath Bastard-leaves or Interfoyls between *Leaf* and *Leaf*, for the Preservation of its Stings.

Another Sort of Protection is seen, in white *Archangel*, and other Plants of a like Shape. In which the greater *Leaves* do also inclose the lesser, by a double fore Curl at the Bottom of every two great *Leaves*, which embraces the little under Bud, and so keeps it clean and warm.

The *Leaves* of *Onions* are all Pipes one within another, having a small Aperture about the Middle common to all of them, even the most minute ones in the Center.

As the Buds of *common Sumach* are exceeding tender, Nature appears in a peculiar Manner solicitous for their Preservation, being lodged within the Body of the Stalk, as entirely as a Kernel is within an Apple; from whence it is that the Basis of every Stalk is extremely swelled.

There are also *globular Excrescencies*, *Spots*, *Hairs*, *Thorns*, and *Prickles*. Globulets are seen upon *Orach*, but more plainly upon *Bonus Henricus*, in



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in these growing almost upon the whole Plant, and being very large, are by most People taken Notice of; but the *Microscope* hath discovered to us that they are the natural and constant Offspring of very many other Plants, they are of two Kinds transparent as upon the Leaves of *Hysop*, *Mint*, *Baume*, &c. white on *Germander*, *Sage*, &c. Sometimes they appear like a fine Powder upon the Leaf, these were first white and transparent as in *Bears Ear*. If this be licked of, it will afford the Taste of the essential Content of the Plant. They frequently grow on both Sides the *Leaf*, yet sometimes, as in *Ground Ivy*, chiefly on the Back side thereof, and in many Plants where the Elder-leaves have none, on the young Buds they are very numerous, as in *Corin tree*, *Sorrel*, and others.

Spots are observable in *St. Johns-wort*, *Rue*, *Ground-Ivy*, *Pimpernel* or *Anagallis*, &c. when held up against the Light.

Thorns are lignous and cortical, the first are such as those of *Hawthorn*, somewhat like these are the Spinets or thorny Prickles, upon the Edges and Tops of divers *Leaves*, as *Biberry*, *Holly*, *Thistle*, *Furz*, &c.

Cortical Thorns are such as those of the *Rasberry-Bush*, being not, unless in an invisible Proportion propagated from the lignous Body. They are of Use not only for the Protection of the Bud, but also for the Support of the Plant.

The Use of Hairs on Leaves are to preserve young Buds, not only from the cold Air, but also from too much wet, which if it were contiguous would often rot and dry them. But being made to stand off in Drops, at the Ends of the Hair, does not hurt but refresh them. Thus we see by the Assistance of the *Microscope*, that Nature oftentimes makes the meanest Things subservient to the best Ends.

SECT. II.

Of the Parts and Texture of the Leaf.

THE first Part which here presents itself is the Skin, a small Bit of which being stripped off the *Leaf*, and laid upon the Object carrying Glass R, of Fig. 2. or held between the Nippers, and then placed before the Microscope, will appear to consist of parenchymous and lignous Fibres, all very curiously and admirably interwoven, as in Flag, Tulip, &c.

From hence it is easy to conceive, that the Skins of all Plants (as well as those of Animals) are perspirable between the several Fibres of which they consist, formed into several Orifices, either for the better Avolation of superfluous Sap, or the Admission of Air, these Orifices are not in all Leaves alike, but varied in Bigness, Number, Shape and Position, and are the Cause of the Gloss on the Upper-side of the Leaves, the Backside having none of them.

 Next

Next the Skin lies the pulpy Part of the *Leaf*, called the Parenchyma, being composed of an incomparable Number of little cylindrical Fibres, which are in most Leaves wound up into minute Bladders, but generally more visible in the Stalk than in the Body of the Leaf. In some Leaves, as in Borage, Fig. 520 the greater Bladders are made up of lesser ones, and in some others these parenchymous Fibres are all drawn up close together.

The pithy Part in the Stalk, and almost up to the Top of the chief Fibre, in many *Leaves* is tubular, even whilst they are yet young and sappy, as in *Sweet Cervil*, *Hemlock*, *Endive*, *Cichory*, *Lampsana*, *Dandelion*, *Burdock*, *Daize*, *Scorzonera* and others, and sometimes the said pithy Part is opened into several pithy Pipes; the Fibres also of the Leaf, which is visible to the naked Eye, are composed of Sap and Air Vessels. Their Position is various and regular, not only in the Body of the Leaf, but likewise in the Stalk, as in the Stalk of a Mallow-leaf, Fig. 521. they stand in six oblong Parcels of equal Size, and in a Circle near the Circumference. In *Dandelion*, *wild Clary*, and in *Borage*, Fig. 522. they stand in five Parcels.

In the Body of the Leaf, besides the Positions of the fibrous Strings, there is one in particular which runs round the Edge of the Leaf in all Plants; but can hardly be well discover'd without stripping off the Skin of the Leaf. The Continuation of the Vessels seem to be ramified, and seems also to be inosculated.

These *Tracheæ* or Air Vessels are visible, and appear very pretty in the Leaf of Scabious, or the Vine, by pulling asunder some of its principal Ribs or great Fibres; between which may be seen the spiral Air Vessels (like Threads of a Cob-web) a little uncoyled, as represented by Fig. 523. which shews a Piece of a *Vine-leaf*, wherein these Vessels were drawn out and a little magnified, and at a, the spiral Circumvolutions are represented as they appear'd in the *Microscope* when greatly magnified, and as they stand intire within the Wood; and at b, is seen one a little stretched.

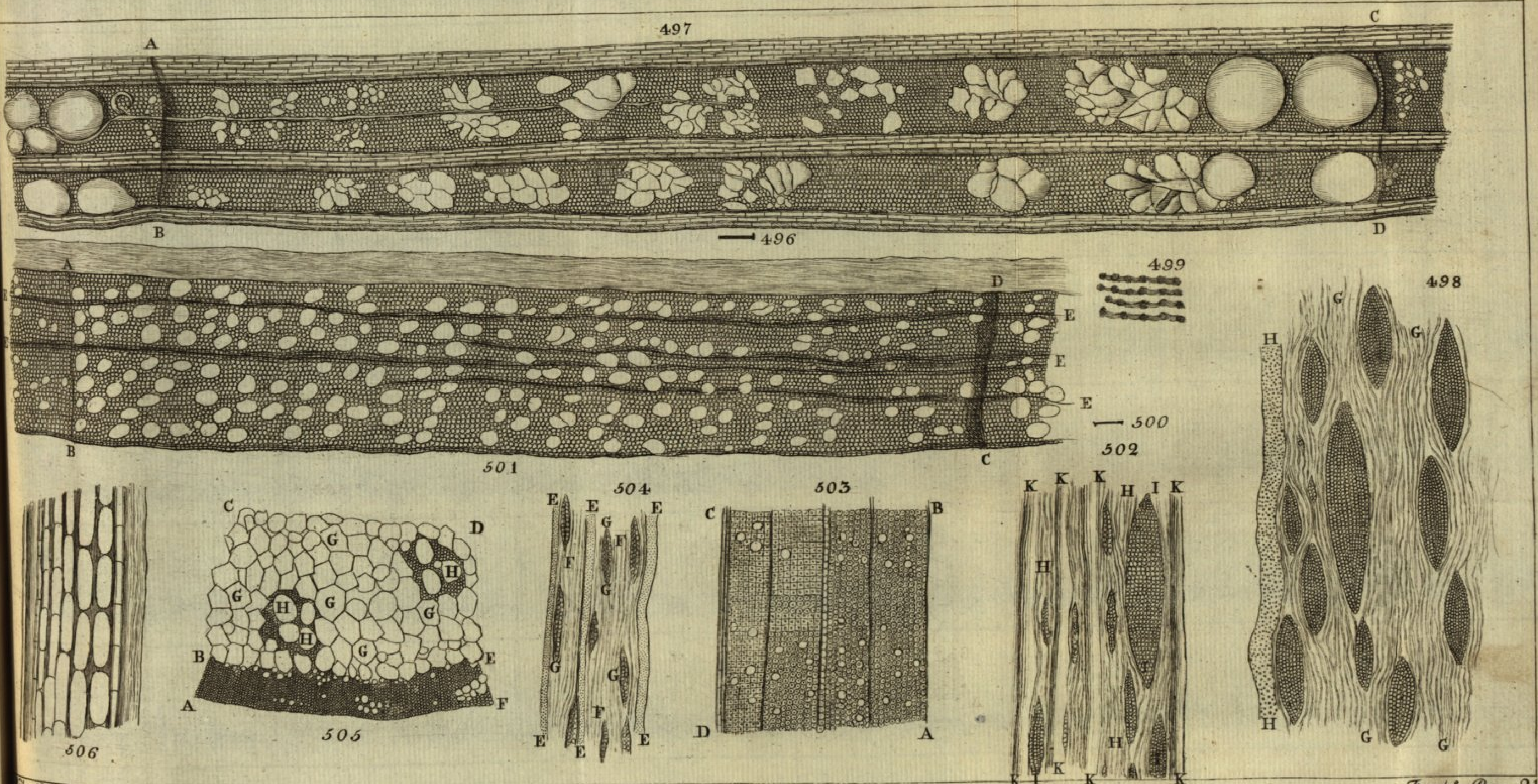
Mr. *Leeuwenhoek* tore a Leaf of *Box* to Pieces, called *Palma Cereris*, that he might the better examine it, and computed one Side thereof to contain 172090 Pores, and as the other Side must consequently have the same Number, the whole Pores in a Box-leaf will be 344180.

Sect. III.

Of Rosemary-Leaves.

FIG. 524. represents a small Part of the Underside of a *Rosemary-leaf*,* whereof A B shews Part of the Upper-side which was doubled over, and consisted of a smooth shining Substance, but its Under-side appeared

* *Ho. Mi. p.* 142.



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in the *Microscope* like a Thicket of Bushes, amongst which were a great Number of round Balls, exactly globular, and afford a very agreeable Prospect.

The Back-side of a Rose-tree Leaf, but especially of a Sweet Briar-leaf, looks diapered with Silver.

The Back of the Leaf of *English* Mercury * looks as if rough cast with Silver, and all the Ribs set round with white transparent Balls.

A Leaf of Rue looks full of Holes like an Honey-Comb.

A Sage-leaf is tasseled with white Silver Thrums, and one or two Crystal Beads, or Pendants, fastned to every Knot.

SECT. IV.
Of Stinging-Nettles.

A Nettle is a Plant known almost to every body, there being very few but what have felt as well as seen it; but how the Pain is so suddenly created, and by what Means continued, we must have recourse to the Microscope for our Information, and that will if almost any Part of the Plant be looked on, shew us the whole Surface thereof to be very thick set with sharp Points, that penetrate the Skin when touched, and occasion Pain, Heat, and Swelling; they are represented in a small Part of the Leaf as they appear in the Microscope, by Fig. 525. at A B, consisting of a rigid hollow Body tapering from B, till it terminate in the most acute Point imaginable, being exceedingly clear and transparent. At the Bottom of this Cavity lies a minute Bag B, containing a limpid Liquor, † which, upon the least Touch of the Prickle, is squirted through the little Orifice, and if it enters the Skin, produces the before-mentioned Mischiefs by the Pungency of its Salts. C D shews one of the chief Fibres of the Leaf, from whence the Stings proceed.

The other Parts of the Leaf or Surface of the Nettle have very little considerable, but what is common to most Plants, as the Ruggedness, Indenting, and Hairiness, and other Roughnesses of the Surface, on the Outside of the Plant.

SECT. V.
Of Cowage, or Cowitch.

THERE is a certain Down of a Plant, brought from the *East-Indies*, which grows on a Kind of hairy Kidney Bean §. The Pods about three Inches long, resemble a *French* Bean, and are cover'd with this Down

* *Pow. Mi. Ob. p.* 50. † *Hook*'s *Mi. p.* 143. § *Ibid. p.* 146.

or Hair, which is very ſtiff for its Bigneſs, and cauſes Pain, and Inflammations, if rubbed on any Part; and when viewed by the Microſcope, this Down appears to be a Multitude of pointed Thorns exquiſitely ſharp.

SECT. VI.

Of the Texture of the Leaves of Sea-Weeds.

IT is a Plant which grows upon the Rocks under Water, increaſing and ſpreading itſelf into a great Tuft, which is not only handſomely branched into ſeveral Leaves; but its whole Surface is cover'd over with a curious Kind of carved Work, * conſiſting of a Multitude of very ſmall Holes, ranged in the neateſt and moſt delicate Order; a ſmall Piece thereof is repreſented as it appear'd in the Microſcope, at Fig. 526.

CHAP. XXXIX.

Of Flowers.

A *Flower* is that Part of a Plant which contains the Organs of Generation, or the Parts neceſſary for the Propagation of the Kind.

It is a natural Production, which precedes the Fruit, and yields the Grain or Seed.

Their Structure is ſomewhat various, though the Generality, according to Dr. *Grew*, have theſe three Parts entire, the *Empalement*, the *Foliation*, and the *Attire*.

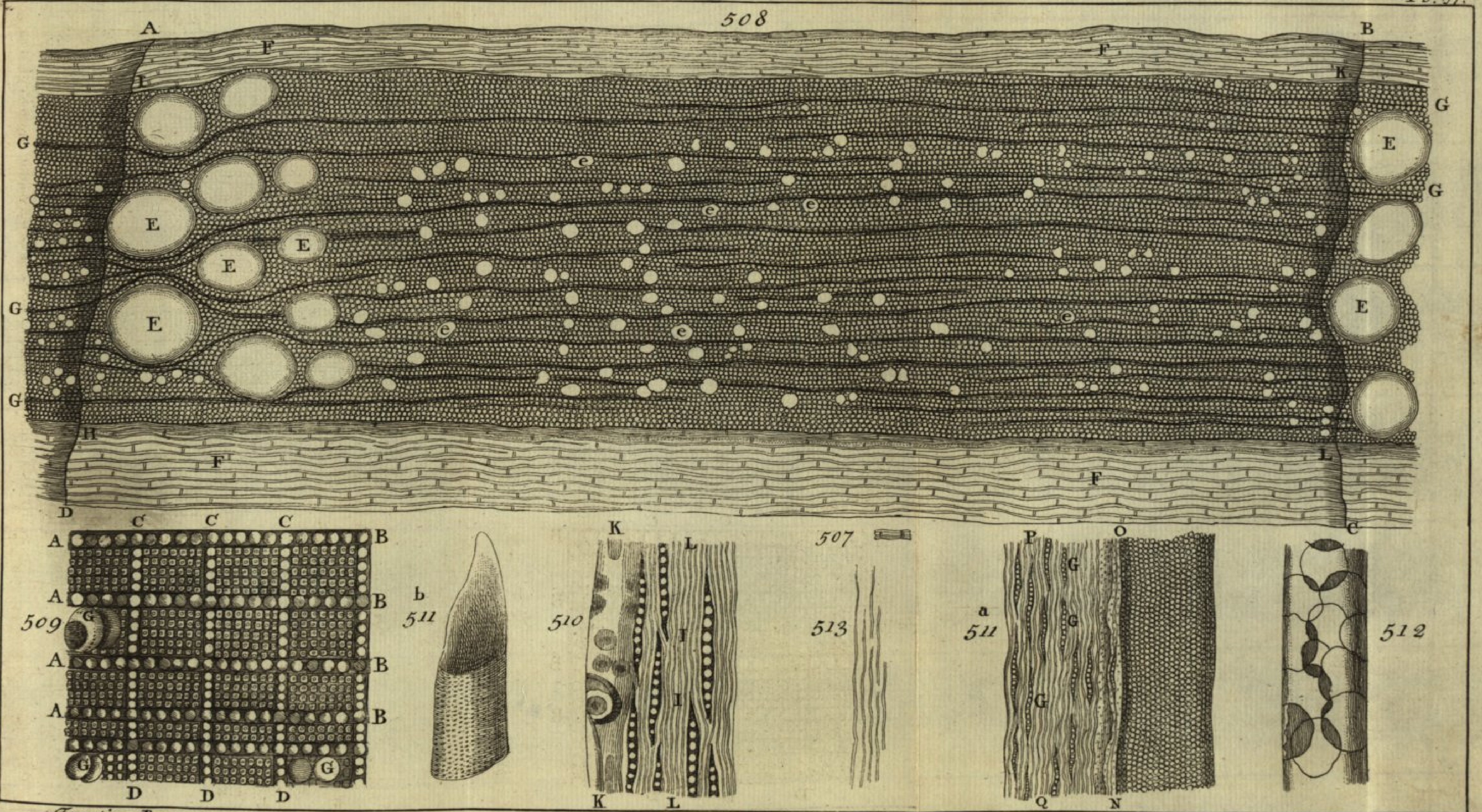
Mr. *Ray* reckons, that every perfect *Flower* has the *Petala*, *Stamina*, *Apices*, and *Stylus*, or *Piſtil*; ſuch as want any of theſe he deems imperfect Flowers.

In moſt Plants there is a Perianthium, Calyx, or Flower Cup, of a ſtronger Conſiſtence than the Flower itſelf, and deſigned to ſtrengthen and preſerve it.

Flowers, whoſe *Petala* are ſtrong (as *Tulips*) have no *Calyx*; Carnations, whoſe *Petala* are long and ſlender, have an *Empalement* of one Piece; and others as *Knap-Weeds*, have it conſiſting in ſeveral Pieces, and in divers Rounds, and all with a counterchangeable Reſpect to each other, for the greater Strength and Security of themſelves and the *Petala*, &c. they include.

The next is the Foliation, as Dr. *Grew*, the Petala, or Folia, as Mr. *Ray*, and others; in theſe, not only the admirable Beauty, and luxuriant Colours are obſervable, but alſo their curious Foldings, in the Calx before their Ex-

* *Hook's Mi. p.* 140.



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pansion, of which Dr. *Grew* hath these Varieties, *viz.* the Close Couch, as in *Roses*, and several other double Flowers; the Concave-Couch, as in *Blataria*; *Flora albo*, the single Plait, as in Pease-Blossoms; the double Plait, as in Blew-bottles, *&c.* the Couch and Plait together, as in *Marigolds*, *Daizes*, &c. The Rowl, as in *Lady Bower*; the Spire, as in *Mallows*; and lastly, the Plait and Spire together, as in *Convolvulus Doronici Folio.*

As to the Stamina with their Apices and Stylus (called the Attire by Dr. *Grew*) they are admirable, whether we consider their Colours, or their Make, but especially their Use, if it be as Dr. *Grew*, Mr. *Ray*, and others imagine, namely, as a *Male Sperm*, to impregnate and fructify the Seed; which Opinion is corroborated by the ingenious Observations of Mr. *Samuel Moreland*, viz.

All *Flowers*, in general, or at least the greatest Part of them, are furnished with Chives, Tops, and Pistils.

The Farina, or fine mealy Powder, which is at its proper Season, shed out of those Thecæ or Apices; Seminiformes, which grow at the Top of the Stamina, does in some Measure perform the Office of a *Semen Masculinum*, by dropping upon the Outside of the *Uterus* or *Vasculum Seminale*, and impregnate the included Seed, &c. But Dr. *Moreland* was of Opinion, that the Seeds which come up in their proper Involucra, are at first, like the unimpregnated Ova of Animals; * that this Farina is a Congeries of seminal Plants *, one of which must be conveyed into every Ovum, before it can become prolifick. That the Stylus, as Mr. *Ray*, or the upper Part of the Pistulum, as Mr. *Tournefort* calls it, is a Tube designed to convey these seminal Plants into their Nest in the Ova; and that there is such a vast Provision made thereof, because of the Odds there are, whether one of so many shall ever find its Way into, and thro' so narrow a Conveyance.

For in the *Corona imperialis*, where the *Uterus* or *Vasculum Seminale* of the Plant stands upon the Centre of the Flower, from the Top of which stands the *Stylus*; the *Vasculum Seminale*, and *Stylus* together, representing a Pistillum; round this are planted six Stamina; upon the Extremities of each of these are Apices, so artfully fixed, that they turn every Way with the least Blast of Wind, being in Height almost exactly equal to the *Stylus*, about which they play, and which in this Plant is manifestly open at Top; it is hollow all the Way, and upon the Top of the Stylus there is a Sort of Tuft, consisting of pinguid *Villi*, supposed to be placed there to catch and detain the Farina, as it flies out of its Theæ; and that the Rain either washes it, or the Wind shakes it down the Tube, till it reaches the *Vasculum Seminale.*

In the *Caprifolium* or Honey Suckle, there rises a *Stylus*, from the Rudiments of a Berry, into which it is inserted, to the Top of the monopetalous Flower; from the Middle of which Flower are sent forth several Stamina,

* *Phi. Trans. No.* 287.

mina, that ſhed their Farina off the Caſes, upon the Orifice of the Stylus, which in this Plant is villous or tufted, upon the ſame Account as the former is.

In *Allium* or *common Garlick*, there ariſes a tri-coccous Uterus, or Seed-Veſſel, in the Center of which is inſerted a ſhort *Stylus*, not reaching ſo high as the Apices, which thus overtopping it, have the Opportunity of ſhedding their Globules the more eaſily into its Orifice; for which Reaſon there is no Tuft on this as on the former, to inſure its Entrance, that being provided for by its Situation juſt under them.

From whence we conclude, that where a fine Powder is curiouſly prepared, carefully repoſited, and ſhed abroad at a peculiar Seaſon, where there is a Tube planted in ſuch a Manner, as to be fit to receive it, and ſuch Care in diſpoſing this Tube, that where it does not lie directly under the Caſes that ſhed the Powder, it hath a peculiar Apparatus at the Extremity to inſure its Entrance, ſo that nothing can be more genuinely deduced from any Premiſes; than it may from theſe, that this Powder, or ſome of it, was deſigned to enter this Tube; if theſe *Stamina* had been only excretory Ducts, to ſeparate the groſſer Parts, and leave the Juice deſigned for the Nouriſhment of the Seed the more reſerved, what Need was there to lodge theſe *Fæces* in ſuch curious Repoſitories? They would have been convey'd any where, rather than where there was ſo much Danger of their dropping into the Seed-Veſſel again, as they are here. Again the Tube over the Mouth of which they are ſhed, and into which they enter, leads always directly into the Seed-Veſſel; to which may be added, that the Tube always begins to die, when theſe *Thecæ* are emptied of their Contents; if they laſt any longer, it is only whilſt the Globules which enter at their Orifice, may be ſuppoſed to have finiſhed their Paſſage; nor can we expect a more convincing Proof of theſe Tubes being deſigned to convey theſe Globules, than that they wither when there are no more Globules to be conveyed.

In leguminous Plants, if the Petala of the Flower be carefully taken off, the Pod or Siliqua may be diſcovered, cloſely cover'd with an involving Membrane, which about the Top, ſeparates into ſeveral *Stamina*, each being fraught with its Quantity of *Farina*; and theſe *Stamina* bound cloſe upon the Bruſh, which is obſervable at the Extremity of that Tube, which here alſo leads to the Pod; it does not indeed ſtand upright, but bent ſo as to make almoſt a right Angle with it: In *Roſes* there ſtands a Column conſiſting of ſeveral Tubes, clung cloſely together, tho' eaſily ſeparable, each leading to its peculiar Cell, having the Stamina in great Numbers planted all round. In *Tithymalus* or *Spurge*, there ariſes a tricoccous Veſſel, that, whilſt it is ſmall and ſo not eaſily diſcernable, lies at the Bottom, till it is impregnated; but afterwards it grows up and ſtands ſo high upon a tall Pedicle of its own, as would incline one to think, that there was to be no

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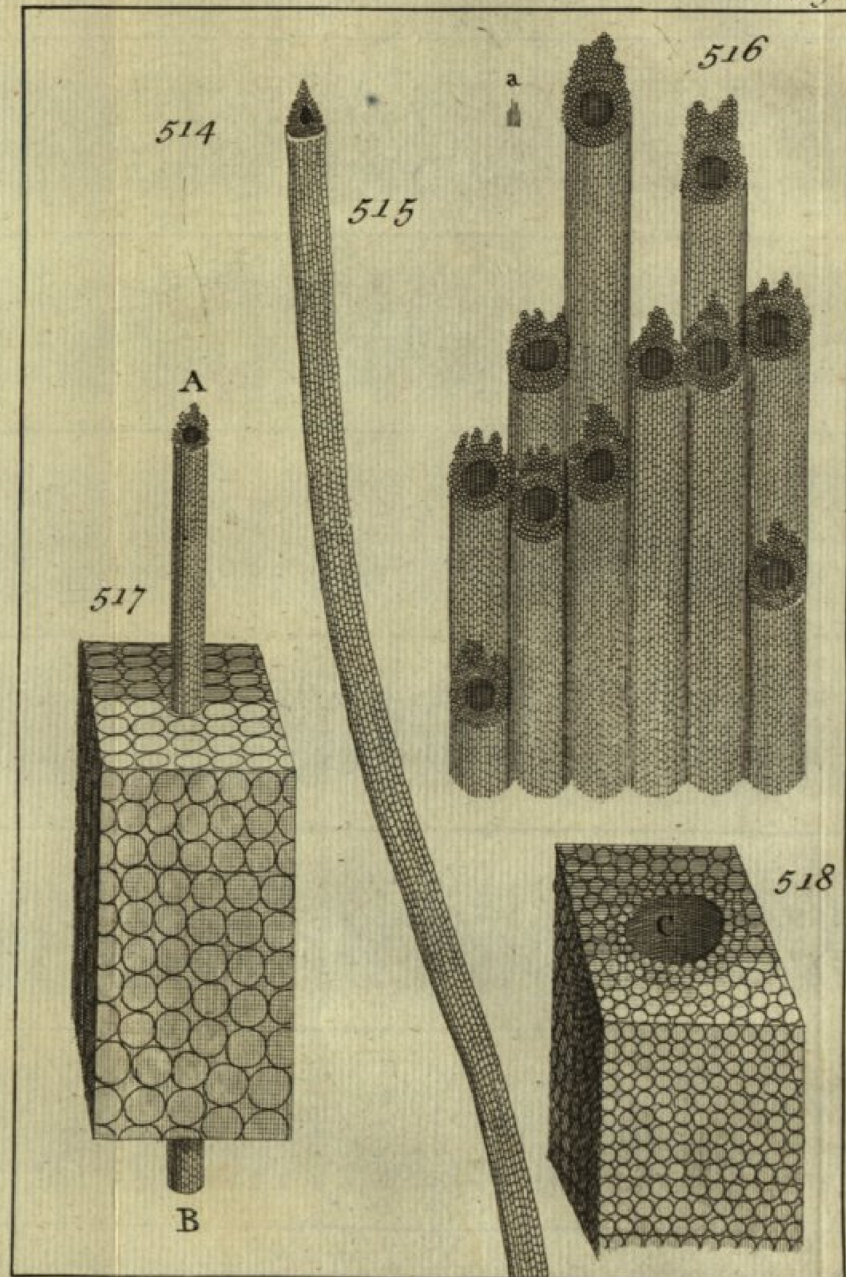
Pl. 58.



Front.^e Pag 216.

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Communication between this and the *Apices*, which he ſees dying below. In *Strawberries* and *Raſberries*, the Hairs which grow upon the ripe Fruit are ſo many Tubes, each leading to its particular Seed; and therefore we may obſerve, that in the firſt opening of the Flower there ſtands a Ring of *Stamina* within the *Petala*, and the whole inward Area appears like a little Wood of theſe Hairs or Pulp, which when they have received and conveyed their Globules, the Seed ſwells and riſes in a carnous Pulp.

Fig. 527. repreſents a yellow Lilly. A, the Top of the Piſtil or Tube, at which the ſeminal Plants are ſuppoſed to enter, and through which they are conveyed to the unimpregnated Seeds in the Seed-Veſſels; b b the Apices Semini-formes, which when open, ſhed that Powder which enters the Tube at A; C the Place of the Seed-Veſſel at the Bottom of the Tube, the Tube and Veſſel itſelf being concealed under the Leaf in this Figure.

Fig. 528. repreſents the *Siliqua* in a Flower of a Pea kind, E the Tube which ariſes from the *Siliqua*, and conveys the Plants thereto; F the membraneous Coat which involves the Siliqua laid open; g g g g the Apices, which before the membraneous Tegument is laid open, appear to riſe from its Edges, and by the Petala of the Flower are kept cloſe upon the Orifice of the Tube, that they may conveniently ſhed their Farina into it.

Hence we learn from the general Structure of the Flowers of Plants, though diverſified infinite Ways, that ſome have no ſenſible Piſtil, others no Stamina, others have Stamina without any Apices; and what exceeds all the reſt, ſome Plants have no Flowers.

Mr. *Bradley* obſerves, that at the Bottom of the Piſtil of the Lilly, there is a Veſſel which he calls the *Uterus*, or Womb, wherein are three Ovaries filled with little Eggs, or Rudiments of Seed, which, ſays he, always decay and come to nothing, unleſs impregnated by the Farina of the ſame Plant, or ſome other of the ſame Kind.

It is this Farina or Duſt falling out of the Apices on the Piſtil, fœcundifies the Grain or Fruit incloſed therein; and hence they call it the *Farina fecundans.* Thus the Farina ſhould be the male Part of the Plant, and the Piſtil the female.

The Fruit is uſually at the Baſis of the Piſtil, ſo that when the Piſtil falls with the reſt of the Flower, the Fruit appears in its Stead. The Piſtil is frequently the Fruit itſelf, but ſtill they have both the ſame Situation in the Center of the Flower, whoſe Leaves diſpoſed around the little Embrio, only ſeem deſtined to prepare a fine Juice in their little Veſſels for its Support. Mr. *Bradley* imagines their Uſe to be only to defend the Flower.

The Diſpoſition of the Piſtil, and the Apices about it is always ſuch, as that the Farina may fall on its Orifice; it is uſually lower than the Apices; and when we obſerve it to be grown higher, we may conjecture the Fruit has begun to form itſelf, and has no further Occaſion for the male Duſt. Alſo, as ſoon as the Work of Generation is over, the male Parts, together

 with

with the Leaves, fall off, and the Tube leading to the Uterus begins to ſhrink. Nor muſt it be omitted, that the Top of the Piſtil is always either covered with a Sort of Velvet Tunicle, or emits a gummy Liquor, the better to catch the Duſt of the Apices. In Flowers that turn down, as in the *Acanthus*, *Cyclamen*, and the *Imperial Crown*, the Piſtil is much longer than the Stamina; that the Duſt may fall from their Apices in ſufficient Quantity thereon.

This Syſtem ſavours much of that admirable Uniformity found in the Works of Nature, and carries with it all the ſeeming Characteriſticks of Truth. Mr. *Geoffroy* ſays, that the Plant is rendered barren, and the Fruits become abortive, by cutting off the Piſtils before the Duſt could impregnate them, which is ſince confirmed by other Experiments of Mr. *Bradley*.

In many Kinds of Plants, as *Willow*, *Oak*, *Pine*, *Cypreſs*, *Mulberry Tree*, &c. the Flowers are ſterile, and ſeparate from the Fruit; but then they have their Stamina and Apices, which may eaſily impregnate the Fruits, which are not far off.

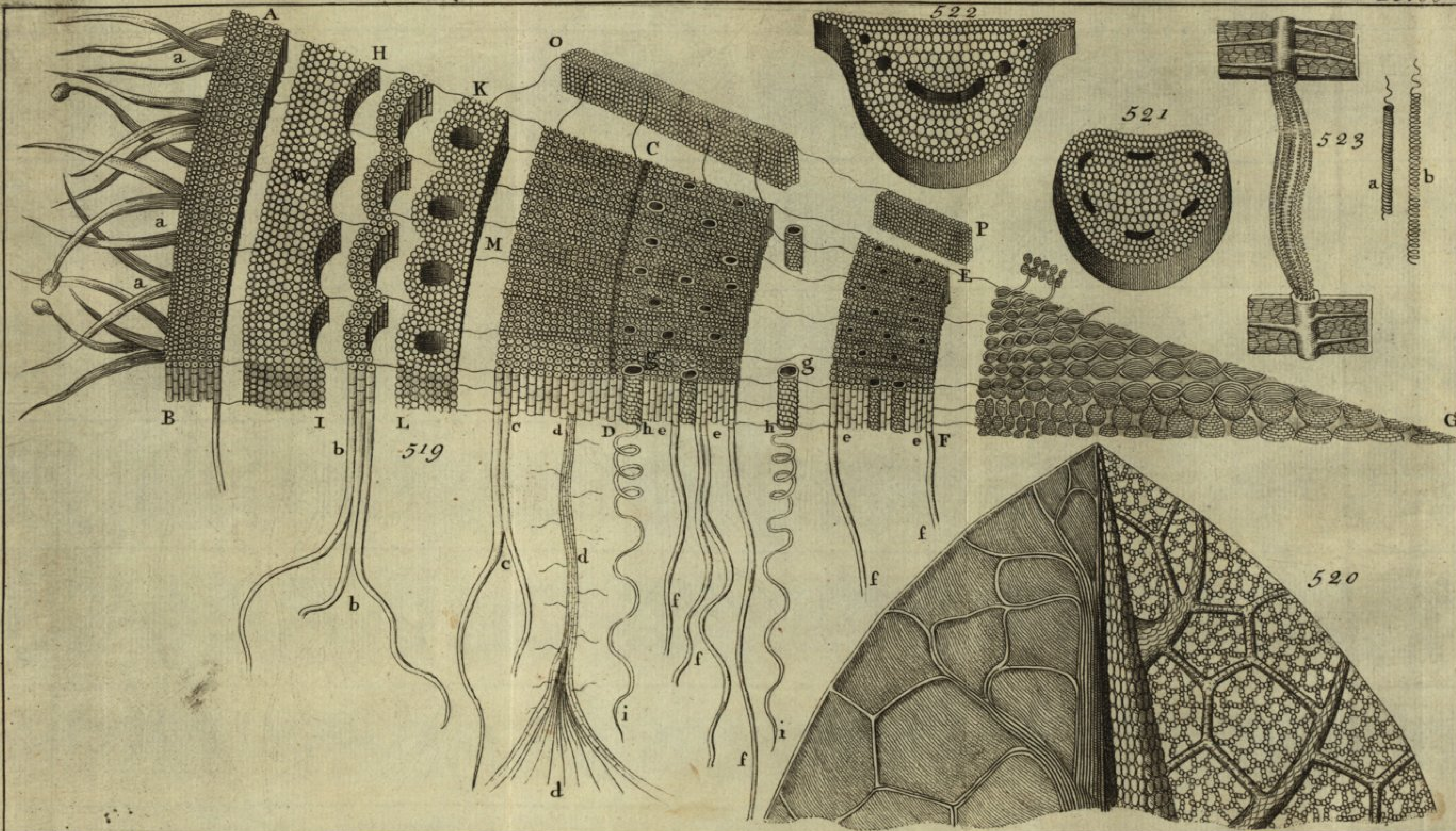
There is ſome Difficulty in reconciling this Syſtem to a Species of Plants, which bear *Flowers* without *Fruits*, and another Species of the ſame Kind and Name, which bear *Fruits* without *Flowers*; hence diſtinguiſhed into Male and Female; of which Kind are the *Palm-Tree*, *Poplar*, *Hemp*, *Hops*, &c. for how ſhould the Farina of the Male here come to impregnate the Seed of the Female. Mr. *Tournefort* imagines, that the fine Down always found on the Fruit of theſe Plants, may ſerve inſtead of Flowers, and do the Office of Impregnation; but Mr. *Geoffroy* rather takes it, that the Wind doing the Office of a Vehicle, brings the Farina of the Males to the Females.

For the Manner wherein the Farina fecundifies, Mr. *Geoffroy* advances two Opinions, 1. That the Farina being always found of a ſulphurous Compoſition, and full of ſubtile penetrating Parts, falling on the Piſtils of the Flowers, there reſolves, and the ſubtileſt of its Parts penetrating the Subſtance of the Piſtil and young Fruit, excite a Fermentation ſufficient to open and unfold the young *Plant*, contained in the Embrio of the Seed; in this Hypotheſis the Seed is ſuppoſed to contain the Plant in Miniature, only wanting a proper Juice to unfold its Parts and make them grow.

The ſecond Opinion is, that the Farina of the *Flower* is the firſt Germ, or Bud of the new Plant, and needs nothing to unfold it, and enable it to grow, but the Juice it finds prepared in the Emb io's of the Seed.

The Reader will here obſerve, that theſe two Theories of *vegetable Generation*, bear a ſtrict Analogy to thoſe of *Animal Generation*, viz. either that the young Animal is in the *Semen Maſculinum*, and only needs the Juice of the Ma rix to cheriſh and bring it forth, or that the Animal is contained in the *Female Ovum*, and needs only the Male Seed to excite a Fermentation.

Mr.



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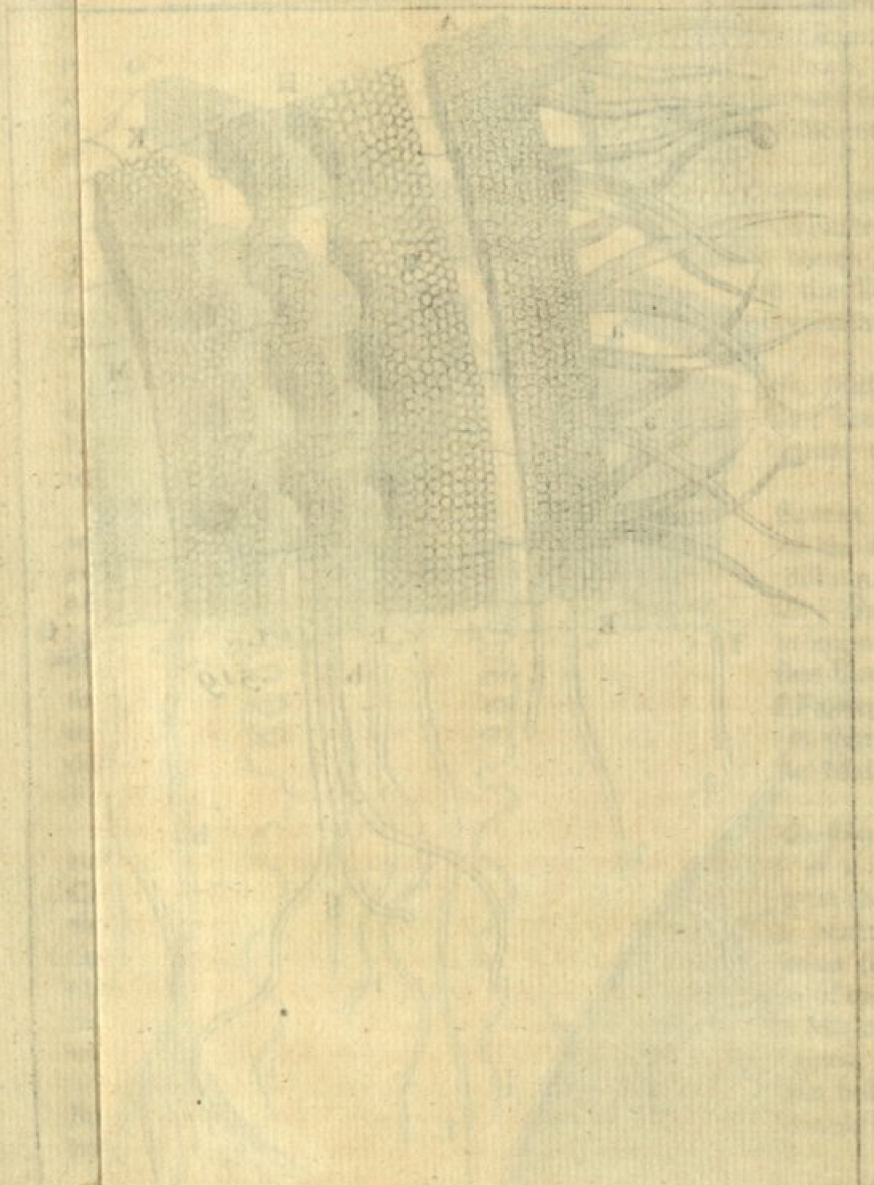


Mr. *Geoffroy* takes the proper Seed to be in the Farina, becauſe the beſt *Microſcopes* do not diſcover the leaſt Appearance of any Bud in the little Embrio's of the Grains, when examined before the Apices have ſhed their Duſt.

In leguminous *Plants*, if the Leaves and Stamina be removed, and the Piſtil, or that Part which becomes the Pod, be viewed with the *Microſcope*, ere yet the Flower be opened, the little green tranſparent Veſiculæ, which are to become the Grains, will appear in their natural Order, but ſtill ſhewing nothing elſe but the mere Coat or Skin of the Grain.

If the Obſervation with the *Microſcope* be continued for ſeveral Days ſucceſſively, in other Flowers as they advance, the Veſicula will be found to ſwell, and by Degrees to become replete with a limpid Liquor; wherein when the Farina comes to be ſhed, and the Leaves of the Flower to fall, we obſerve a little *greeniſh Speck*, or *Globule*, floating about at large. At firſt there is no Appearance of Organization in this little Body; but in Time, as it grows, we begin to diſtinguiſh two little Leaves like two Horns. The Liquor inſenſibly diminiſhes as the little Body grows, till at length the Grain becomes quite opake; when upon opening it, we find its Cavity filled with a young Plant in Miniature, conſiſting of a *Plumula*, *Radicle*, and *Lobes*.

The Tops or Apices ſometimes ſtand erect above their Chives or Stamina, as thoſe in *Lark-heel*, but generally hang a little down by the Middle like a *Kidney Bean*, as in *Mallows*, they have for the moſt Part a double Cleft, tho' it is in ſome ſingle, from which they diſburſe their Powders, which ſtart out, and ſtands upon the Lips of the Cleft, as at Fig. 529. which repreſents one of the Apices of the Flower of St. *John's Wort* magnified.

The Particles of theſe Powders altho' like Meal or Duſt, yet if viewed thro' a Microſcope, they have all of them very curious and regular Forms. In *Dog's-Mercury* and *Borage* they are extreamly ſmall, but in *Mallows* fairly viſible to the naked Eye. In ſome Flowers theſe Powders are yellow, as in *Dogs-Mercury*, *Goats Rue*, &c. And in ſome of other Colours, but in moſt they are white; thoſe of *yellow Henbane* are very elegant, being to the naked Eye as white as Snow, and in the *Microſcope* as tranſparent as Cryſtal.

The *Tops* or *Apices* which contain the Farina, are for the moſt Part either white or yellow, ſometimes blue, but never red, whatever Colour the Flowers be of. They differ in Poſition, ſometimes ſtanding double upon one Chive, as in *Toad-Flax*, *Snap-Dragon*, &c. In ſome they are faſtned to their Stamina at their Middle, as in *Spaniſh Broom*, *Hyſſop*, *Scabeous*, *Behen*, &c. in ſome erect, as in *Clematis*, *Auſtriaca*, *Ladies Looking-Glaſs*, *Rape Craw-foot*, &c. *Coded Arſmat* hath no Chives, but ſtand upon a large Baſe.

Their Number are alſo different, in great *Celandine*, *Roſe*, *Rape-Crow-foot* they are numerous; in great *Plantain*, and ſome other Herbs, much more conſpicuous than the Foliature itſelf. In *Germander Chickweed*, they are always two, and no more; in ſome they follow the Number of the Leaves, eſpecially in the Number five; as in *Blattaria*, *black Henbane*, &c. In *Stichwort* and *Lychnis ſylveſtris* they are ten, juſt double to the Number of Leaves.

Their Shape is different, and always very elegant, with great Variety. In *Borage*, like the Point of a Spear; in *Blataria*, like an Horſe-ſhoe; in *Clematis* like a Spatula, wherewith Apothecaries make their Mixtures: In *Mallow* like a Head-roll; in *Hyſop* they have one Cleft before, in *Blattaria* one round about; in *Water Betony* one at the Top; in *Scabious* they have a double Cleft, one on each Side.

In *Colocynthis* the Farina is not contained in ſeveral Thæcæ or Apices ſtanding upon Chives, but is all of one entire Part, like a thick Column in the midſt of the Flower, having ſeveral little Ridges or Furrows winding from the Top to the Bottom round about, in the Middle of each of which runs a Line, where the Skin, after ſome Time, opens into two Lips, and preſents the globular Particles contained in the Hollow of every Ridge.

But where the Seeds are contained in the Apices, a Stilus or little Column ſtands upon the Top of the true *Seed-Caſe*, which is alſo regularly and variouſly figured. In *Bind-weed* it hath a round Head like that of a great Pin. In the *common Bell*, *St Johnwort*, &c. it is divided into three Parts. In *Gerarium* into five; in *Aſarum* into ſix, ſometimes the Head is ſmooth, and in others it is beſet with little Thorns, as in *Hyoſcyamus*.

The Piſtil is a little upright Part in the Middle of the Calx, or the Leaves of *Flowers*, called alſo the Style.

It is an eſſential Part of a Flower, and the principal female Organ of Generation, it being in this that the Seeds or young Plants are formed. It ariſes from the Pedicle of the Flower, or the Center of the Calx, and at length becomes the young Fruit, which is ſometimes hid in the Calx, and ſometimes quite out.

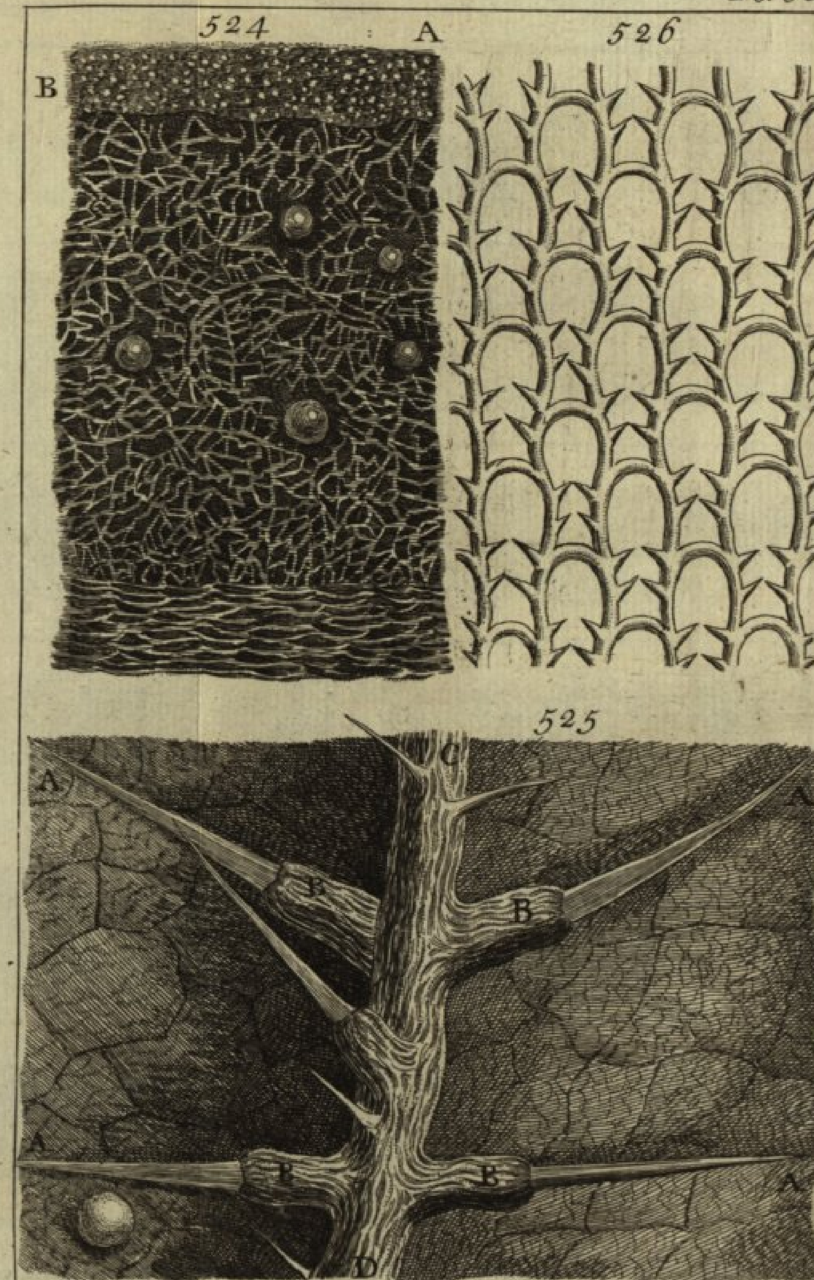
Its Figure is very different in different Flowers; in ſome it is a little Stalk, which enlarges at the two Ends, in others a mere Stamen or Thread, ſometimes it is round, ſometimes ſquare, triangular, oval, *&c.*

Almoſt all Piſtils are furniſhed at Top, either with fine Hairs, or little Filaments diſpoſed in Plumes, or are beſet with little Veſicles full of a glutinous Juice.

Some Flowers have ſeveral Piſtils, or rather the Piſtils terminate in ſeveral Branches, which have their Riſe from as many young Fruits, or as many Capſulæ containing Seeds.

Whatever Form the Piſtils are in, they have certain Apertures at their Tops, or Clefts, continued their whole Length, to the Baſe or Embrio of the Fruit.

The Seed Veſſels conſiſts ſometimes of two, and for the moſt part of three



Front.⁹ Pag. 220.

Bowles sc.

three Pieces; for which Reaſon they are called Suits, as at a b c d, Fig. 527.

The outer Part of each Suit, according to *Grew*, is its Floret, whoſe Body or Tube is divided at the Top (like that of a Cowſlip) into five Leaves as at b, which forms a Flower in Miniature, and is all the Flower in many Plants, as *Mugwort*, *Tanſie*, &c. Upon the Expanſion of the Floret, the next Part c, of the Suit begins to appear from within its Tube, which may be called the Sheath (with reſpect to that within it). This Sheath in a ſhort Time divides at Top, through which Aperture the Blade d diſplays itſelf. This is the third Part of the Suit, and terminates in a forked Point, about which appears little Globules.

In ſome Flowers every one of the before-mention'd Florets is encompaſſed with an Hedge of Hairs, and every Hair branched on both Sides, almoſt like a Sprig of Fir, as at c d in golden Rod, Fig. 530. which ſhews one of the Suits thereof as it appeared in the *Microſcope*, in which at e is the little Column or Blade that contains the Farina, which is alſo ſeen by itſelf at F.

The Baſe of the Floret is generally cylindrical, but ſometimes ſquare, as in *French Marigold*, at a, Fig. 531. and the Leaves thereof, which for the moſt part are ſmooth, in the ſame Flower are all over hairy. The middlemoſt of the three Parts or Sheath b, is uſually faſtned to the Top, or elſe at the Bottom of the Floret, and is rather indented than parted into Leaves: The Surface ſeldom plain or even, but wrought into five Ridges and as many Gutters, running almoſt parallel from Top to Bottom.

The inmoſt Part or Blade runs through the Hollow of the two former as at a, Fig. 531. and is faſtned with the Floret to the Convex of the Seed Caſe; the Head and Sides of this Part is always beſet round about with Globulets. In ſome growing cloſe to the Blade, as in common Marigold; and in the *French* Marigold, as at Fig. 532. and others, upon little ſlender Stalks. Theſe, as the Blade ſprings up from within the *Sheath*, are rubbed off and ſtands like a Powder upon them both. In ſome, as in *Chicory*, they ſeem to grow within-ſide the Sheath, as will appear if it be ſplit * with a ſmall Pin, as alſo in *Knapweed* they are very numerous.

The Head of the Blade is always divided into two, and ſometimes into three Parts, as in *Chicory*, Fig. 533. which gradually curl outwards after the Manner of Scorpion Graſs.

This Deſcription agrees principally to the corimbiferous Kind, as Tanſy, Camomile, *&c.* but in *Scorzonera*, *Chicory*, Fig. 533. *Hawk-weed*, *Mouſe-ear*, and all the intibous Kind, with many more. The Piſtil is ſeparated from the Foliature, ſo as to ſtand alone therein, every Leaf a b c of the Flower having a Piſtil of its own; for which Reaſon the Baſe of each Leaf is formed into a little Tube a, Fig. 533. that incloſes the Piſtil, which commonly conſiſts of

* *Grew An. Plants, p.* 170.

a

a Sheath and Blade e; the Leaf itself answering to the Floret in other Flowers. The Blade (or rather Stamina) is seen drawn out of its Sheath at f g of the same Figure, and at g the Head of the Blade is open'd into three Parts, which are full of those globular Particles before-mention'd.

The Time in which the *Flower* is generated, is hardly any where, if at all taken Notice of among so many Observers of Plants. It is therefore to be remarked, that all the Parts of the Flower in all Flowers, are perfectly finished long before they appear in Sight, usually three or four Months, and in some six. And that in Perenial Plants, those Flowers which appear in any one Year are not formed in that, but were actually in Being and intire in all their Parts the Year before. The Flower of *Mezeron*, which opens in *January*, is intirely formed about the Middle of *August* in the foregoing Year; at which Time, if the green Leaves of the Bud be carefully removed, the Leaves of the Flower and Seed-like Attire, encompassing the Seed-Case, may be distinctly seen when placed before the *Microscope*.

In order to observe the mealy *Powder* or *Farina*, let it be gathered in the midst of a Sun-shiny Day when all the Dew is off, shake, or else gently brush it off with a soft Hair-Pencil upon a clean Piece of white Paper; then breathe upon a single Talc, and instantly apply it to the Farina, which will adhere to it. If too great a Quantity of Powder sticks to the Talc, blow a little of it gently off, if not enough breathe on it again, and touch the Farina with it as before, then fix it in a Slider as before directed.

But I would here advise the Curious not to neglect an Examination of the little Cells that contain the Farina, and also of the Pistils and Uteri, and other Parts of Generation of the *Flowers*.

Fig. 534, represents the Flower of St. Johnwort a little magnified, in which may be seen the Stamina and their Apices surrounding the Seed-Case. Fig. 529, is one of the Apices more magnified.

Fig. 530, represents one Suit of golden Rod Flower, consisting of a Seed-Case A, and a Stamina e, one of which is seen by itself at F.

Fig. 531, shews one of the Suits of *French Marigold*, or *Flos Africanus* magnified, of which there are about 12 in one Flower, each consisting of three Pieces, the middlemost of which is seen alone at Fig. 532.

Fig. 535, represents one Suit of *Chrysanthemum-Creet*, consisting also of three Pieces, of which there are about 80 in one Flower.

Fig. 536, exhibits one Suit of *Knapweed* magnified, consisting of three Pieces, a b is the Seed-Case, at the Bottom of every Suit.

Fig. 537, is a microscopick Representation of one of the Suits of a *Marigold*, of which there are about 40 in one Flower.

Fig. 533, represents the Pistil and Blade, proper to each Leaf in the Flower of *Chicory*.

Fig. 538, represents one of the Flowers in the Bud of *Mezeron* perfectly formed

Front.^s Pag. 222. Bowles fc.

formed in all its Parts the Year before it appears, but differs in Shape as a Fœtus doth when newly formed.

Fig. 539, ſhews the ſame Flower cut open, wherein may be ſeen the ſpermatick Thæcæ and the Uterus.

CHAP. XL.

Of the Fruit of an Apple, Lemon, Cucumber, and Pear.

SECT. I.

THE general Compoſition of all *Fruit* is one, that is, their eſſential Parts are in all the ſame, and but a Continuation of thoſe which have been already obſerved in the other Parts of a Plant. Yet from the different Conſtitutions and Tinctures of thoſe Parts, the ſeveral Varieties in Fruits proceed.

An *Apple* conſiſts of a Skin, Parenchyma, Veſſels and Core, the Parenchyma or Pulp is the ſame with that of the Bark of the Tree, as is apparent not only from the viſible Continuation thereof, from the one through the *Stalk* into the other, but alſo from their Structure, being both compoſed of Bladders, with this Difference, that whereas in the Bark they are very ſmall and ſpherical (as may be plainly ſeen when viewed through the *Microſcope*,) here they are oblong and very large, in Proportion to the Size and Tenderneſs of the *Fruit*, being all uniformly ſtretched out by the arching of the Veſſels, from the Core towards the Circumference of the Apple.

The Veſſels, as in the other Parts of a Plant, are ſucciforous, and for Air, both the Branches of the former and the ſingle Veſſels of the latter are extremely ſmall, running every where together; not collateral, as Veins and Arteries do in Animals, but the latter ſheathed in the former.

They are diſtributed into twenty principal Branches, the ten outermoſt a little within the Apple, are diverted from a ſtreight Line into ſo many Arches; from which a few ſmall Branches are without any Order diſperſed through the Apple; the five middlemoſt and the five inmoſt run in a ſtrait Line as far as the Core, and are there diſtributed into as many leſſer Arches, the former at the outer and the latter at the inner Angles of the Core, upon which laſt the Seeds hang.

All theſe main Branches meet together at the Top of the *Apple*, where originally they all ran into the Flower.

A *Lemon* hath a three-fold Parenchyma, ſeemingly derived from each other; the Texture upon every Derivation being ſomewhat altered, by being made more cloſe and elaborate. The outmoſt called the Rind, hath the moſt open and coarſeſt Texture, being compoſed of the largeſt Threads, and

and theſe wove up into larger Bladders. Thoſe little Cells which contain the eſſential Oil of the Fruit, and ſtand near the Surface of the Rind, are ſome of the ſame Bladders, but more dilated.

From this outmoſt Parenchyma, nine or ten Inſertions are produced, betwixt as many Portions of the pulpy Part towards the Center, where they all unite into one Body, anſwerable to the *Pith* in the *Trunk* or *Root* of the *Tree*; and are a conſpicuous Demonſtration of the Communication between the *Bark* and *Pith*.

Throughout this Parenchyma the Veſſels are diſperſed, but the chief Branches ſtand on the inner Edge of the Rind, and the outer Edge of the Pith, juſt at the Extremities of every Lamellæ from thoſe Branches at the Edge of the Pith; other little and very ſhort ones ſhoot into the Pulp of the *Fruit*, upon which the Seeds are appendant. In the Center of the Pith are eight or nine in a Ring, which run through the Fruit up to the Flower.

Between the Rind and Pith, and thoſe ſeveral lamelated Inſertions which join them together, ſtands the ſecond Sort of Parenchyma, being cloſer and finer, and divided by the Lamels into ſeveral diſtinct Bodies, every one of them being an entire Bag; in every one of which the third Parenchyma is contained; which is alſo a Cluſter of other leſſer Bags, all disjoined from one another, each having their diſtinct Stalks of ſeveral Lengths, by which they are all faſtned to the utmoſt Side of the great Bag wherein they are contained. Within theſe leſſer Bags alſo the *Microſcope* can ſhew many Hundreds of Bladders, conſiſting of extremely fine Threads, as it were wove together into that Figure; and within theſe Bladders lies the acid Juice of the Lemon.

A *Cucumber* hath alſo a three-fold Parenchyma, the outermoſt is derived from the Bark, which being expoſed for ſome Time to dry, and then tranſverſly cut with a Razor; not only the Bladders but alſo the Threads whereof the Bladders conſiſt, are plainly viſible when viewed through the Microſcope.

Throughout this Parenchyma are diſperſed the Sap Veſſels, in ten or twelve very large Branches, each of which emboſoms another of Air Veſſels.

The middle Parenchyma is derived from the Pith, and divided into three triangular Columns, within which are a diſtinct Sort of Sap Veſſels, whence ſeveral ſmall and ſhort Fibres ſhoot into the inmoſt Parenchyma, whereupon the Seeds do hang.

The inmoſt Parenchyma wherein the Seeds do lie (and which anſwers to the Pulp of a *Lemon*) ſeems to be produced from the Seed-fibres, by three Inſertions from the Columns, and as many from the outmoſt Parenchyma, and theſe reinſerted; it is divided into ſix triangular Bodies, and every Triangle into three Ovals.

A *Pear*, beſides the Skin, conſiſts of a two-fold Parenchyma of Veſſels, *tartareous Knots*, or *Grains*, and a *Core*; the Skin when viewed in the *Microſcope*, appears to be lined with a great Number of theſe tartareous Grains, which are alſo diſperſed round about the Fruit, for about the Thickneſs of the Third of an Inch, as will appear on applying a tranſverſe Slice of a Pear to the *Microſcope*.

The outer Parenchyma is of the ſame Original and general Structure as in an Apple, but the Bladders not altogether ſo long with reſpect to their Breadth.

The Bladders here have alſo a different Poſition from that they have in an Apple, being in that all ſtretched out towards one common Center, which is that of the Apple itſelf. But here they every where bear a Reſpect to the ſaid tartareous Grains, every Grain being the Center of a certain Number of Bladders.

Throughout this Parenchyma, the *Veſſels* for Sap and Air are likewiſe diſperſed into fifteen principal Branches. The five utmoſt make as many Arches, but commonly not ſo deep as in an *Apple*; from theſe ſome ſmall Fibres are diſperſed throughout the Parenchyma. The ten inner Branches proceeding to the Seed, and from thence with the other five to the Flower.

Next the Core ſtands the inner Parenchyma, conſiſting of ſmall roundiſh Bladders, anſwerable to that of the Pith, from which it ſeems to be derived.

Between this and the outer Parenchyma, the ſaid tartareous Grains begin (firſt) to ſtand nearer together, to grow bigger, and of a more unequal Surface; and by Degrees to unite into a Body, in ſome *Pears*, and eſpecially towards the Cork, they are almoſt as hard as a Plumb-Stone.

On cutting a Pear lengthwiſe, through its Center, theſe tartareous Grains will be apparent.

At the Bottom of the Core in moſt Pears, and a little below the Center of the Fruit, is a Kind of umbelical Knot; from whence extends a ſtreight Channel, which opens at the Middle of the Cork or Stool of the Flower, ſcarce wide enough to admit the ſmalleſt Pin.

SECT. II.

Of a Plumb, *and ſome other* Fruits *of the ſame Kind.*

A *Plumb* conſiſts of a Parenchyma, the two general Kind of Veſſels, and a Stone; and in Proportion to the Bulk of the Fruit, hath more Veſſels than an *Apple* or *Pear*. Alſo in *Plumbs*, all theſe Veſſels are braced together into one uniform Piece of *Net-Work*, every where terminating at an equal Diſtance from the Circumference, the Skin is fibrous and tough.

The Stone is compoſed of two, or rather three diſtinct Parts, one of them the Lining, taking its Riſe from the Parenchyma, which the Seed Branch brings along with it, through the Channel in the Side, and at laſt into the Hollow of the Stone, and is there ſpread all over it.

The Foundation or Ground of the outer and more bulky Part of the Stone, is the inner Part of the Parenchyma, upon which the tartareous Parts of the Sap are continually precipitated, and thereby petrified, as appears on comparing the ſeveral Ages of the ſame Fruit together; on the Surface of many Stones, ſome of the ſaid tartareous Parts appear in diſtinct *Grains*.

An *Apricock* is of the *Plumb* Kind, but ſome Things are herein better obſerved, as firſt the Poſition of the Bladders of the Parenchyma; for the tartareous Parts of the Sap, not being here diſperſed in little Grains, throughout the Fruit as in a *Pear*, but are all thrown off into the Stone; therefore the Bladders all radiate exactly to the Center of the Stone, conveying thereto the feculent Sap, in ſo many little Streams. This is beſt ſeen when the Fruit is full ripe.

The gradual Tranſmutation of the inner Part of the Parenchyma into a Stone, is alſo more apparent in this Fruit, and ſo are the three Coats which ſerve for the Generation of the Seed; being now all very diſtinct and remarkable.

A Peach hath a much bigger Stone, and therefore when full ripe, it hath a more defecated or better refin'd *Juice*; the Reaſon why the Stone is ſo great, is becauſe the Veſſels run ſo numerouſly through the Body of it; and ſo cauſe a more copious Perſpiration of the Lees therein.

A *Cherry* is likewiſe nearly related to a *Plumb*, but the Bracement or Reticulation of the Veſſels, is here carried on farther, ſo as to be all round about contiguous to the Skin.

A *Walnut* is a *Nuciprune*, or between a *Plumb* and a *Nut*, for the Rind anſwers to the Pulp, and the Shell, as the Stone, is alſo lined; but the *Seed-Veſſels*, which in a *Plumb* run thro' a Channel, made on Purpoſe in the Stone, do here enter as in a *Nut*, at the *Center* of the Shell; by which Means they are inveſted with a more fair Parenchyma.

SECT. III.
Of the Grape.

A *Grape* is as it were a *Plumb* with two Stones, for their Thickneſs are as hard as any other. The principal Fibres run directly between the Stones; and the ſmaller Fibres, and make only one ſingle *Net*; near the Circumference they all meet together at the Top of the *Grape*. Many lignous Fibres are alſo mixed with the Skin itſelf, whereby it becomes very thick and tough.

The Parenchyma, or Pulp of a *Grape* ſeems to be derived from the Pith, at leaſt as far as the Reticulation of the Fibres.

CHAP.

CHAP. XLI.

The Anatomical Preparation of Vegetables.

THose *Leaves* of *Plants* are only fit for this Purpoſe, whoſe internal Structure is compoſed of woody Fibres, and are of a pretty good Thickneſs, as the Leaves of *Oranges*, *Lemons*, *Jeſſamin*, *Bays*, *Roſes*, *Cherries*, *Apricocks*, *Peaches*, *Plumbs*, *Apples*, *Pears*, *Poplars*, *Pines*, *Oaks*, *Ivy*, &c.

There are ſeveral other that have no woody Fibres or Veins, but theſe diſſolve without ſeparating, as thoſe of *Vines*, and *Lime-Trees*.

The *Leaves* are to be gather'd * in *June*, or *July*, when they are full grown, and have not been damaged by *Worms*, or *Caterpillars*; put them into an earthen Pot or large Glaſs, with a good deal of *Rain-Water*. The Pot or Glaſs being kept uncover'd; and ſo expos'd to the Sun, or open Air. The Leaves muſt be quite cover'd with Water, and as it evaporates a freſh Quantity muſt be pour'd in. In about a Month's Time, ſome of the Leaves will begin to putrify, but the others muſt be kept two Months longer. When the two external Membranes begin to ſeparate, and the green Subſtance of the Leaf to grow liquid, then it is Time to perform the Operation. The *Leaf* is to be put into a white and flat earthen Plate or Diſh, filled with clear Water; then upon gently ſqueezing it with the Finger, it will open on one Side, and the green Subſtance will run out; immediately on that the two outer Membranes muſt be ſtripp'd off, chiefly in the Middle, and along the Nerves, where they adhere cloſely. If there be once an Opening, they will go off very eaſily; the Skeleton that remains between, is afterwards waſhed in clean Water, and kept between the Leaves of a Book.

The Method of preparing Fruits, as *Apples*, *Plumbs*, *Cherries*, *Peaches*, and the like, is as follows:

The fineſt and largeſt *Pears*, that are ſoft and not ſtony, are fitteſt for this Purpoſe; firſt pare them nicely, without ſqueezing them, taking Care not to hurt the Stalk or Crown; then put them into a Pot of Rain or freſh ſpring Water, cover it and let them boil gently, till they become throughly ſoft; then take them out, and put them into a Baſon of cold Water, then take out one of them, and holding it by the Stalk with one Hand, and with one Finger and the Thumb of the other Hand, rub the Pulp gently off, beginning near the Stalk, and rubbing equally towards the Apex; and you will eaſily ſee in the Water how the Pulp ſeparates from the Fibres, which being tendereſt near the Extremities, there the greateſt Care muſt be

* *Phil. Tranſ.* No. 416.

taken. No Instrument is of Use in this Operation, except last of all a Penknife, to separate the Pulp sticking to the Core. In order to see how the Operation advances, fling away the muddy Water from Time to Time, and pour on clean. All being separated, the Skeleton is to be preserved in Spirits of Wine, the same is to be observed with *Apples*, *Plumbs*, *Peaches*, and the like.

Carrots, and other Roots, that have woody Fibres, must be boiled without paring, till they grow soft, and the Pulp comes off; not only several Sorts of Roots, but likewise the Barks of several Trees, may be reduced into Skeletons, presenting rare and curious Views of Vegetables.

CHAP. XLII.

To preserve the Specimens of Plants.

PRepare two Iron Plates as large as the *Specimens* you intend to preserve, let them be pretty thick, and very smooth on one Side, with Holes for Screws at each Corner; then take your *Flowers*, *Leaves*, &c. when full ripe, and of their true Colour, spread them on a brown Paper, with the Leaves as distinct as you can; if the Flowers are large, more Paper must be laid under them; and if thick you may pare away half thereof, as also of the Stalk so as to lie flat; then put these between the Iron Plates, screw them fast, and set them in an Oven for two Hours; after which take out the Flowers, and with a Brush dipp'd in equal Quantities of *Aqua fortis*, and *Aqua vitæ*, or Brandy, pass over the *Leaves* and *Flowers*; then lay them to dry on fresh brown Paper, and take the Quantity of a Walnut of *Gum Dragon*, which in less than 24 Hours will be dissolved in a Pint of Water, and with a Brush rub the Back-sides of the *Leaves* and *Flowers* to make them stick; then lay them in your Paper-Book, and they will always look fresh. *

CHAP. XLIII.

Of Charcoal, or burnt Vegetables.

C*Harcoal*, or a *Vegetable* burnt black, affords an Object no less pleasant than instructive; for if a small Piece of *Charcoal* be suddenly broke, it will appear to have a very smooth Surface, but if examined by the *Microscope*, Abundance of Pores are discoverable in many Kinds of Wood, ranged round the Pith both in a circular and a radiant Order; and most of these so exceeding small, and so close to each other, that but a very little Space is

* *Phil. Trans.* No. 227.

left between them to be filled with a ſolid Body. Theſe Pores, or rather Tubes, are ſo extreamly ſmall, that in a Line of them $\frac{1}{18}$th Part of an Inch long, Mr. *Hook* reckoned no leſs than 150, therefore in a Line an Inch long were no leſs than 2700 Pores, and in a circular Area, or of a Stick of an Inch Diameter, are contained 5,725,350 Pores or minute Tubes, * a Number that to ſome perhaps may ſeem incredible, were they not left to the Judgment of their own Eyes to the Truth thereof. In *Cocus*, *black* and *green Ebony*, *Lignum Vitæ*, &c. theſe Perforations are abundantly ſmaller than thoſe of ſoft light Wood; ſo prodigiouſly curious are the Contrivances, Pipes or Sluices, thro' which the Juice of *Vegetables* are conveyed.

To prepare or make Charcoal of any Kind of Wood, in order to examine it with the Microſcope.

The Body to be charred or coaled may be put into a Crucible, a Piece of a Muſket Barrel, a Pot, or any other Veſſel that will endure to be made red-hot in the Fire without breaking; cover it over with Sand, ſo that no Part of it be expoſed to the open Air. Then ſet it into a good Fire, and keep it there till the Sand has continued hot, for a Quarter, Half, an Hour, or two, more or leſs, according to the Nature and Bigneſs of the Body. Then take it out of the Fire, and let it lie till the Sand be very near cold. The Wood may be taken out of the Sand well charr'd, and clear'd of all its watery Parts.

CHAP. XLIV.

Of the Texture of Cork.

IF an exceeding thin Slice of *Cork* be cut off with a very ſharp Penknife, or Razor, and applied to the *Microſcope*, in an Ivory Slider, or held between the Nippers, it will appear to be all perforated and porous; having but a little ſolid Subſtance in Proportion to the empty Cavity, as is manifeſt on a Sight of Fig. 540. Theſe Pores are not very deep, but conſiſt of many little Cells, ſeparated out of one continued long Pore, by certain Diaphragms, † viſible in Fig. B, which repreſents them ſplit the long ways: Hence the *Microſcope* informs us, that the Lightneſs of Cork proceeds from its being a very ſmall Quantity of a ſolid Body, extended into exceeding large Dimenſions, and alſo why it is a Body ſo very unapt to ſuck in Water, and conſequently to preſerve itſelf floating on the Top thereof, tho' left on it never ſo long; and why it is able to confine Air in a Bottle, tho' conſi-

* *Hook's Myc. p.* 101. † *Ibid. p.* 113.

ſiderably

derably condenſed, and preſſing very ſtrongly to procure a Paſſage without admitting the leaſt Bubble to paſs through its Subſtance. As to the firſt, the Microſcope hath informed us that the Subſtance of Cork is filled with Air, and that this Air is perfectly incloſed in little Boxes or Cells diſtinct from each other: This therefore makes it very plain, that neither Water nor any other Air can eaſily inſinuate itſelf into them, their being already within them an *intus exiſtens*; * for this Reaſon Pieces of Cork are good Floats for *Nets* and *Stopples* for *Vials*, &c. and is capable of being compreſſed into a twentieth Part of its uſual Dimenſions, and to reſtore itſelf to its former State by means of the included Air in the before-obſerved conſtituent *Cells* or *Bladders*. Mr. *Hook* told ſeveral Lines of theſe Pores, and found that there were generally about 60 placed Endwiſe in a Line of the $\frac{1}{18}$ Part of an Inch long: Whence there muſt be 1160 in the Length of an Inch, and in a ſquare Inch 1166400; therefore a cubick Inch muſt contain 1259712000, a Thing almoſt incredible, did not the *Microſcope* aſſure us of it by ocular Demonſtration. If you cut off a Piece from a Board of Cork tranſverſly to the Flat of it, you will as it were ſplit the Pores, which will appear juſt as they are repreſented at Fig. B, but if a very thin Piece be cut off parallel to the Plane of it, the Pores of it will be tranſverſly divided, and will appear as expreſſed in Fig. A.

CHAP. XLV.

SECT. I.

Of a Plant growing on the blighted, or yellow Specks of Damask-roſe Leaves, Bramble Leaves, &c.

IT is obſervable that in the Months of *June*, *July*, *Auguſt*, and *September*, that many of the green Leaves of *Roſes* begin to dry and grow yellow, but eſpecially the Leaves of the old Shrubs of *Damaſk-Roſes*, are all ſpotted with yellow Stains, and the Under-ſides juſt againſt them have little yellow Hillocks of a gummy Subſtance, and ſeveral of them have ſmall black Spots in the midſt of thoſe yellow ones. Upon examining theſe with the *Microſcope*, Multitudes of little black Bodies like Seed-cods were perceived to ſpring out of ſeveral ſmall yellow Knobs, and to be faſtned to theſe Knobs by a ſmall Straw-coloured and tranſparent Stem, many of thoſe Hillocks were bare as if thoſe Bodies lay yet concealed, as at G, Fig. 541. In others they were juſt ſpringing out, as at A; in others, as at B, they were juſt out, with very little or no Stalk; in others, as at C, the Stalks

* *Hook. Mi. p.* 113.

plainly appear; in others, and at D, thoſe Stems were grown bigger and larger; and in others, as E F, *&c.* thoſe Stems and Cods were grown a great deal bigger, and the Stalks more bulky about the Root, and very much tapered towards the Top: As they increaſed in Bulk they began to turn their Tops towards their Roots, in the ſame Manner as that of Moſs is obſerved to do. The whole Square of this Figure repreſents a ſmall Part of a *Roſe-Leaf* no bigger than the Letter H.

Theſe kind of vegetable Sprouts are to be found on ſeveral Kinds of Roſe-Leaves, and on the Leaves of divers Sorts of Briars, and on Bramble Leaves in ſuch Cluſters, that 3 or 400 of them make a conſpicuous black Spot or Scab on the Backſide of the *Leaf.*

SECT. II.

Of Mouldineſs, or the Principals of Vegetation ariſing from Putrifaction.

MR. *Leeuwenhoek* obſerved, that *Mouldineſs* on Skin, Fleſh, or other Things, ſhoots up firſt with a ſtreight tranſparent Stalk, in which a globular Subſtancé riſes that commonly ſettles at the Top of the Stalk, and is followed by another Globule driving out the firſt either on the Side or at the Top, and that again is ſucceeded by a third, *&c.* all which form on the Stalk one great Knob, much thicker than the Stalk itſelf; and this large Knob burſting aſunder repreſents a kind of Bloſſoms with Leaves. *

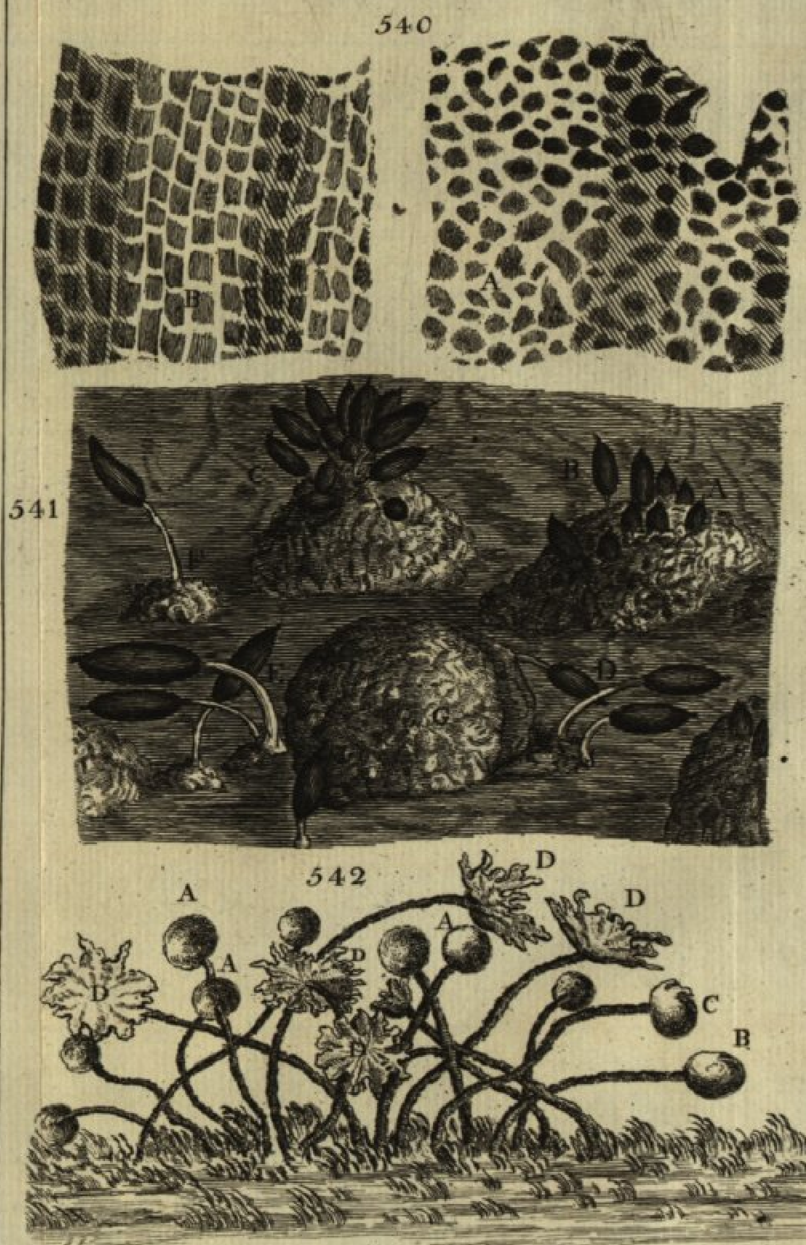
The blue, white, and ſeveral Kinds of hairy mouldy Spots that are obſervable on divers Kinds of putrify'd Bodies, whether *animal* or *vegetable* Subſtances, ſuch as the *Skin*, *raw* or *dreſs'd Fleſh*, *Blood*, *Humours*, *Milk*, *Cheeſe*, &c. or rotten ſappy *Wood*, *Herbs*, *Leaves*, *Barks*, *Roots*, &c. are a kind of ſmall but variouſly figured *Muſhrooms*; a Specimen of which is repreſented at Fig. 542. which is nothing elſe but the microſcopick Appearance of a ſmall white Spot of hairy Mould found upon the Covers of a Book that was bound in Sheep's Skin. Theſe Spots appeared through the *Microſcope* to be a very pretty ſhaped vegetative Body, which ſhot out Multitudes of long and ſlender cylindrical Stalks, not exactly ſtreight, but bent with the Weight of a round white Knob growing upon the Top of each as at A A A; others a little oblong as at B, others a little broken as at C, and others that were burſt aſunder forming a kind of Bloſſoms with Leaves as at D.

* *Phi. Tranſ. No.* 94.

SECT. III.
Of Moss, &c.

MOSS is a Plant no less worthy a microscopick Consideration than the most elegant Plant that grows, and for its Shape and Beauty may be compared with any other. It has a Root almost like a seedy *Parsnip*, Fig. 543. furnished with small Strings and Suckers, all of them being as curiously branched as the Roots of much bigger Vegetables; from this springs the Stem or Body of the Plant, which is finely creased or fluted; on the Sides of this are close and thickly set a Multitude of well shaped Leaves, some of them of a roundish, others of a longer Shape; all the Surface on each Side the Leaf is curiously cover'd with a Multitude of little oblong transparent Bodies, as at D, Fig. 546. From the Tops of the Leaves proceeds a transparent Hair or Thorn: The Stem shoots out into a long round Stalk, which on cutting is found to be hollow without any Knot or Stop, from its Bottom where the Leaves encompass it, to the Top on which grows a large Seed-Case A, covered with a thin and more whitish Skin B, Fig. 544. terminated in a long thorny Top, which at first covers all the Case, and by degrees, as that swells, the Skin cleaves, and at last falls off together with its thorny Top, leaving the Seed-Case to ripen, and scatter its Seed, at a Place underneath this Cap B, which before the Seed is ripe appears like a fluted Metal Button, without any Hole in the Middle; but, as it ripens, the Button grows bigger, and a Hole appears in the Middle of it E, Fig. 545. out of which, in all Probability, the Seed falls; for as it ripens by the Provision of Nature that End of this Case turns downwards. On opening several of these dry red Cases F, they were found to be quite hollow; whereas when they were cut asunder with a sharp Penknife when green, in the Middle of this great Case was found another small round Case, the Interstices between the two Cases being filled with Multitudes of stringy Fibres which seemed to suspend the lesser Case in the Middle of the other, in which without doubt the Seeds were contained; it grows on the rotten Parts of *Stone*, *Bricks*, *Wood*, *Bones*, *Leather*, &c.

This small Vegetable is wanting in nothing of the Perfections of the most conspicuous and vastest Vegetables of the World, and deserves to be ranged in as high a State; for we do not know but that all the Contrivances and Mechanism requisite to a perfect Vegetable, are crowded into exceedingly less Room than this of *Moss*; for that Plant already described, which grows on *Rose-Leaves*, is so exceeding small that near 1000 of them would hardly make the Bigness of one single Plant of *Moss*; and by comparing the Bulk of the latter to that of the biggest Vegetable (some Trees being, as we are informed, near 20 Foot in Diameter in *Guinea* and *Brazil*) whereas the



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the Body or Stem of *Moss* is generally not above $\frac{1}{80}$ Part of an Inch, we shall find that the Bulk of one will exceed that of the other, no less than 2985,984,000,000; and supposing the Production of the Rose-Leaf to be a Plant, those *Indian* Plants will exceed it 1000 Times the former Number, so prodigiously various are the Works of the *Creator*, and so *all-sufficient* is *he* in his Performance of Things which to *Man* would seem impossible.

SECT. IV.
Of Sponge.

THE *Microscope* hath shewn us, that *Sponge* is composed of an infinite Number of small and short Fibres, curiously joined together in the Form of a Net, as appears by Fig. 547. which represents a Piece of Sponge as it appeared before the Microscope, wherein may be seen the Joints which for the most part are, where only three Fibres meet together, the Length of each between the Joints is very irregular, the Distance between some two Joints being ten or twelve Times more than between others. The Mashes likewise of this reticulated Body are also various, some bilateral, others trilateral, and quadrilateral Figures, &c.

SECT. V.
Of the Beard of a wild Oat.

THE Beard of a wild *Oat* is a Body of a very curious Structure; it grows out of the Side of the inner Husk that covers the Grain of a wild *Oat*. Its whole Length when extended does not exceed an Inch and a half. When the Grain is ripe and very dry, which is usually in the Months of *July* and *August*, the Beard is bent almost to a right Angle, and its under Part is wreathed and very brittle.

If you take one of these Grains and wet the Beard in Water, the small bended Top will presently turn and move round, and by degrees, if it be continued wet enough, the Joint or Knee will streighten itself, and if it be suffered to dry again, it will gradually bend into its former Posture. Its Appearance in the Microscope is represented by Fig. 548. which shews Part of the Beard at the Knee or Bend. Its whole Surface is adorned with little Channels and interjacent Ridges, which run the whole Length of the Beard, and are streight where the Beard is not twisted, and wreathed where it is, being thickly set with small Bristles; in the wreathed Part was two very conspicuous Channels which seemed to divide the wreathed Cylinder into two Parts, a bigger and a less, the biggest at the convex Side of the

Knee; these Clefts are filled with a kind of spongy Substance, very conspicuous near the Knee.

This odly constituted Vegetable is sometimes used, as an Hygrometer,* to discover the various Constitutions in the Moisture and Dryness of the Air; and this it does to Admiration.

CHAP. XLVI.

SECT. I.

Of Salts.

UNDER the Denomination of *Salt*, is to be understood most of that which gives Solidity to Bodies, is dissolvable in Water, and affects the Taste with a peculiar Pungency. There are three distinct Sorts which generally pass under this Name, the *fixed*, *volatile*, and the *essential*: The fixed is what remains after Calcination, and is procured by dissolving the saline Parts of the Ashes in hot Water, and evaporating it until the Salt is left dry at the Bottom; for that will not rise in Vapours. The *volatile* is what easily passes over the Helm, as the Salts of Animals. The *essential Salt* is that which is obtained by Chrystilization from the Juices of Plants, and is of a Nature between the other two, and may most properly be termed essential, having no Force used in its Production.

If there be in a strict Sense any such Thing as a *Principal*, *Salt* is so; but then it must be termed *fossil Salt*, or *Sal Gemma*; for this not only appears to be the plain Production of Nature, but to be the most homogeneous and uncompounded Part Nature can be divided into.

Its first Appearance is in Springs and Rivers, being washed into them by subterraneous Currents; thence by the Sun it is in some measure exhaled by Vapours; from whence it again returns, in *Snow*, *Hail*, and *Dews* (for common Rain-Water does not seem to partake of it;) from this Return the Surface of the Globe is saturated with it; whence it re-ascends in the Juices of Vegetables, and enters into all those Productions, as Food and Nourishment which the Creation supplies.

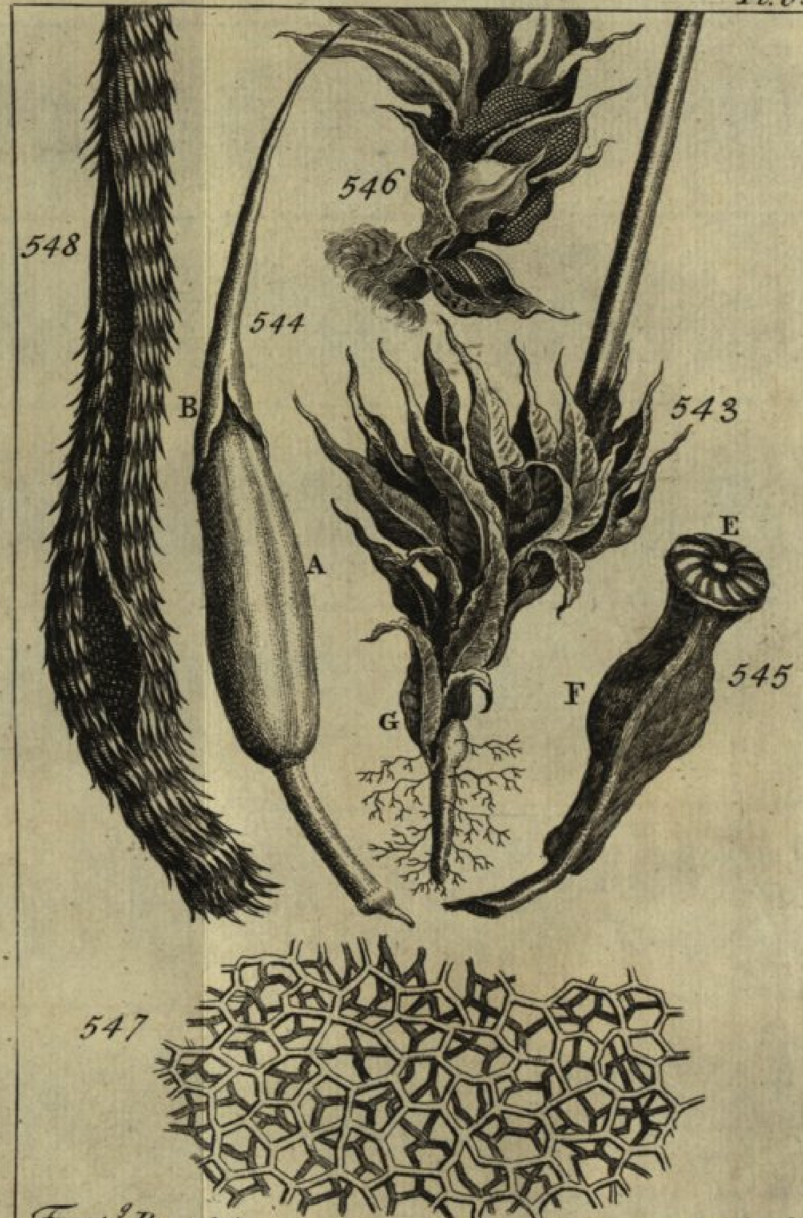
SECT. II.

To extract vegetable Salts.

BURN any Sort of *Herb*, *Flower*, *Fruit*, *Wood*, or whatever it be, and make Ashes thereof; with the Ashes and pure Water in its natural Temper, make Lee; which afterwards strain through moist Paper or a

* If the Reader is desirous of one of these Hygrometers, he may be furnished with them at my Shop, &c.

Filter,



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Filter, ſo that it may become as clear as poſſible; then put the Lee into a Glaſs Veſſel, and let it remain in *Balneo Mariæ*, until a great Part of it evaporates; the Quantity of Water is not determined, generally five Pounds of Water will extract all the Salt from two Pounds of Aſhes; Salts extracted in this Manner, are wont to melt when the Air is ſoft; to prevent which, when you burn the Materials, in order to reduce them to Aſhes, it is requiſite to uſe with them a proper Quantity of Sulphur; and if it happens that the Aſhes are made to your Hand, you may mix them with Sulphur, and keep the ſame at the Fire, till ſuch Time as it be burnt; by this Means the Salt will never come to run, but become more white and cryſtalline. There is no general Rules for the Quantity of Sulphur to be put into the Materials you thus burn, but at a Gueſs, to 100 Pounds of Material, 4 or 5 Ounces of Sulphur is uſually ſufficient. All Salts have a peculiar and determined Figure, which they always keep, altho' they are often reſolved into Water, and afterwards congealed; yet notwithſtanding ſome Sorts of Salts are obſerved to have 2, 3, and 4 Sorts of Figures. Two Sorts have been ſeen in Lettice, in the *Scorzoneras*, in the *Muſk-Melon*, the *Scopa*, in the Roots of *Eſula*, in the *black Hellebore*, in *Endive*, *Eye-bright*, *Wormwood*, *Sorrel*, and in Shoots of *Vines*; three Sorts in *black Pepper*, and in incarnate *Roſes*; four Sorts in white *Hellebore*. Beſides the above-mentioned Diverſity of Figures which are found in *Salts*, it is obſervable, that amongſt all *Salts*, of what Figure ſoever, there are found ſome *cubical*, which though they be never ſo often diſſolved and congealed, appear ſtill of a cubical Figure, or inclining to it. To make the Bodies of the Salts when they congeal; remain diſtinct from each other, that their Figure may be obſerved, and not be entangled and heaped together; it is neceſſary, that very great Diligence be uſed in evaporating the Lee; for if that be wholly evaporated, or too great a Part thereof, the *Salts* make a confuſed Cruſt at the Bottom of the Veſſel; if the Lees are left too weak, the Salts require a very long Time to congeal, and therefore it is requiſite to uſe ſuch Diligence as is not to be gained without long Practice.

Cryſtals of *Salts* are ſuch a Combination of ſaline Particles, as reſemble the Form of a Cryſtal, variouſly modified, according to the Nature and Texture of Salts.

The Method herein uſed is this, diſſolve the *ſaline Body* in Water, after which filter the Solution, which being evaporated until a little Film appears upon it, runs into Cryſtal. Diſſolution and Filtration are made Uſe of, that the Salts may be purged from all Droſs; otherwiſe if any foreign Matter ſhould get in, not only the Tranſparency of the Cryſtals would be impaired, but their Figure alſo would be mangled and broken.

SECT. III.

Of the Figures of Salts.

IT is generally agreed, that all Bodies have their *Salts*, which produce many ſurpriſing Changes, by their different Configurations and Impreſſions, both in Solids and Fluids, in Things animate and inanimate. As to the Figures of them, they are obvious to every Beholder; their Beauty and Variety are ſo admirable, that ſcarce any Thing in Nature can entertain the Eye more agreeably than theſe do, when it is aſſiſted with a good *Microſcope*.

In common *Salt*, we plainly diſcover *quadrilateral Pyramids* with ſquare Baſes. In *Sugar*, the ſame *Pyramids* with oblong and rectangular Baſes. In *Allum*, they riſe with ſix Sides, ſupported with an hexagonal Baſe. The Cryſtals of *Vitriols*, reſemble Icicles, united one to another with great Variety, among which lie ſome Polygons. *Sal-Armoniack* very elegantly imitates the Branches of a Tree; and *Hart's-Horn* looks like a Quiver of Arrows; *Glauber*'s *Sal Mirabilis*, which is made of common *Salt* and *Vitriol*, exhibits the Figure of both Salts. *Nitre* appears in certain priſmatick Columns, not much unlike Bundles of Sticks; among which there are interſpers'd ſome of a Rhomboidal, and Pentagonal Figure, which ſeem to come very near thoſe of common *Salt*. Hence *Lemery* very juſtly remarked, that *Nitre* could not be purified by any Art or Contrivance whatſoever, but ſomething of a *Sal Gem*, or *foſſil Salt*, would ſtick to it; but *Salt* of *Tin* out-does all for Beauty, in which are Lines like little Needles, that ſpread themſelves every where from a Point, as from a Center, ſo as to repreſent a Star, much like what we ſee in the *Regulus of Mars*.

Salts have this peculiar Property, that let them be ever ſo divided and reduced into minute Particles, yet when they are formed into Cryſtals, they each of them re-aſſume their proper Shape; ſo that they may be as eaſily diveſted and deprived of their Saltneſs, as of their Figure. Whence by knowing the Figure of the Cryſtals, we may underſtand what the Texture of the Particles ought to be, which can form theſe *Cryſtals*. And by knowing the Texture of the Particles, we may determine the Figures of the *Cryſtals*. For ſince the Figures of the moſt ſimple Parts remain always the ſame, 'tis evident the Figures which they run into, when compounded and united, muſt be uniform and conſtant.

Eſſential Salts are made by expreſſing the Juice of any Plant, and ſetting it in a Cellar to ſhoot; which ſome do in ſmall Quantities.

Fixed Salts are made as follows:

Take any Plant, and burn it on a clean Hearth, and rake the Aſhes as long as any Fire appears among them; put thoſe Aſhes into an unglazed Pan, which ſet in a calcining Furnace, make Fire about it till the Pan is red-hot; where keep it, continually ſtirring the Aſhes without any Blackneſs. Then put them into a clean Pan, and pour hot Water upon them; when that Water is ſufficiently impregnated with Salt, filter it, and evaporate to a Dryneſs, until the Aſhes are left inſipid.

The Salts of *Metals* or *Minerals* are to be come at, by quenching them, when red hot in Water, then filtering, evaporating, and cryſtallizing.

If *Allum* be burnt, diſſolved in Water, and ſtrained, its Cryſtals will conſiſt of two ſexangular Planes, whoſe Sides are bounded by ſix other, three of which are quadrilateral, having between them three of a ſexangular Figure; as at Fig. 548.

Green Vitriol affords Cryſtals, which are made up of ten unequal ſided Planes, the Middle-moſt are Pentagons, and each of its ſharp Ends triangular Planes; as at Fig. 549.

The Cryſtals of our Inland *Salt* Springs are of a cubical Figure, as at Fig. 550.

Salt-Petre ſhoots into long Cryſtals, whoſe Sides are ſix Parallelograms; as at Fig. 551.

It has been already mentioned, that Vinegar owes its Pungency to the Salts which float therein; their Shape is ſeen at Fig. 552. Expoſe a Drop or two of Vinegar to the open Air for an Hour or two upon the Object-carrying Glaſs R, that its watery Parts may evaporate; then apply it to the *Microſcope.*

The *Salts* of *Sugar candy'd*, are repreſented at Fig. 553. The *Salts* of *Nitre* are ſeen at Fig. 554. The *Salts* of *Camphire*, at Fig. 555. *Sal Gem* is repreſented at Fig. 556. and *Sal Armoniack* at Fig. 557.

It is beſt to examine all *Salts* in the ſmalleſt Maſſes, for in them their Shape will be beſt diſcovered.

CHAP. XLVII.

SECT. I.

On ſtriking Fire with a Flint and Steel, &c.

ON ſtriking Fire with a Flint againſt a Steel, little Particles of Steel are ſtruck of, and melted into Globules by the Colliſion; which will be evident on ſpreading a Sheet of white Paper, and obſerving the Place where ſeveral of theſe little Sparks ſeem to vaniſh. Mr. *Hook* examined ſeveral of them with a Microſcope, and found that a black Particle, no bigger

ger than a Pin's Point, appear'd like a Ball of polish'd Steel, as at Fig. 558. and strongly reflected the Image of the Window, and of a Stick which he moved up and down between the Light and it. Others were, as to their Bulk, pretty round, but their Surface not so smooth; some were cracked, as Fig. 559. others broke in two, and hollow, as Fig. 561. several others were found of other Shapes; but that represented at Fig. 560. was observed to be a big Spark of Fire, and stuck to the Flint, by the Root F, at the End of which Stem was fastened an Hemisphere, or hollow Ball. It is also remarkable, that some of these Sparks are Slivers, or Chips of Iron vitrified, others are only the Slivers melted into Balls, without Vitrification, * and the third Kind are only small Slivers of the Iron, made red-hot with the Violence of the Stroke given on the Steel by the Flint.

Many Sorts of Sand, some gather'd on the Sea-shore, or on the Sides of Rivers, and some found on the Land, differ in the Size, Form, and Colour of their Grains, some being transparent, others opake, some have rough, and others quite smooth Surfaces. It would be endless to describe all the Figures to be met with in these Kind of minute Bodies, they being spherical, oval, pyramidal, conical, prismatical, *&c.* Mr. *Hook* trying several magnifying Glasses, by viewing a Parcel of white Sand, casually hit upon one of the Grains, which was exactly shaped and wreathed like a Shell, which he separated from the rest of the Granules, and found it to appear to the naked Eye no bigger than a Pin's Point, but when viewed in the *Microscope*, it appear'd as in Fig. 562. resembling the Shell of a small Water Snail; † it had twelve Wreathings, growing all proportionably one less than the other, towards the Middle or Center of the Shell, where there was a very small round white Spot. In this minute Shell we have a very good Instance of the Curiosity of Nature, in another Kind of Animals, removed by their Smallness beyond the Reach of the naked Eye; and as there are several Sorts of Insects and Vegetables, so small as to have had no Names; so likewise by this, we find there are also exceeding small, or rather minute Shell-fish. Nature, by the Assistance of the Microscope, having shewn to us her Curiosities, in every Tribe of *Animals*, *Vegetables*, and *Minerals*.

SECT. II.

Of small Diamonds or Sparks in Flint.

A *Flint Stone* being broke in Pieces, the inside Cavity of it appear'd to be crusted all over with a pretty candid Substance, reflecting the Light from some of its Parts very vividly; but on examining it with the *Microscope*, the whole Surface of that Cavity could be perceived to be beset with

* *Hook's Micr. p.* 44. † *Ibid. p.* 80.

a Mula Multitude of little cryſtalline or adamantine Bodies, curiouſly ſhaped, as at B, Fig. 563. and afforded a very agreeable Object.

An Atom, or Globule of *Quickſilver*, when placed before the Microſcope, ſeems like a convex Mirrour, in which may be ſeen all the circumambient Bodies; as the Windows, Trees, and Furniture, *&c.*

SECT. III.
Of Mercurial Powders, &c.

IN thoſe chymical Preparations of Mercury, which is called *Turbith Mineral*, *Mercurius Vitæ*, *Dulcis*, *Sublimate*, *Precipitate*, and *Mercury Coſmetical*, *Calomel*, and all other mercurial Powders, are found, when examined by the *Microſcope*, to be full of minute Globules of crude and unalter'd Mercury; which ſhews, that thoſe chymical Preparations are not ſo purely exalted and prepared as they are preſumed to be, nor the Mercury any Way tranſmuted, but by an atomical Diviſion rendered inſenſible.

CHAP. XLVIII.
The Nature of Snow, &c.

MANY of the Parts of *Snow*, are for the moſt Part of a regular Figure, and as it were ſo many Rowels or Stars with ſix Points, and are as perfect and tranſparent *Ice* * as any we ſee on a Pool of Water; at each of theſe ſix Points are ſet other collateral Points, and theſe always at the ſame Angles with the principal Points themſelves; that amongſt theſe, many others alike regular, but far ſmaller, may be diſcover'd; there are alſo ſome others, which ſeem to have loſt their Regularity, by various Winds, being firſt gently thawed, and then frozen again into irregular Maſſes; from all which, *Snow* ſeems to be an infinite Number of *Icicles*, regularly figured, not only in ſome few Parts thereof, but originally in the whole Body of it; not ſo much as one Particle of ſo many Millions being originally indeterminate or irregular; that is, a Cloud of Vapours being gather'd into Drops, do forthwith deſcend; in which Deſcent, meeting with a freezing Wind, or at leaſt paſſing through a colder Region of the Air, each Drop is immediately frozen into an *Icicle*, ſhooting itſelf into Points or *Icicles* on all Sides from the Center; but ſtill continuing their Deſcent, and meeting with warmer Air, ſome are thawed and blunted, others broken, but the greateſt Number cling together in ſeveral Parcels, and form what we call *Flakes of Snow*; hence we underſtand why Snow, tho' it ſeems to be ſoft, is really hard, be-

* *Philoſ. Tranſ.* No. 92.

cauſe

cauſe it is a real *Ice*, whoſe inſeparable Property is to be hard, its Softneſs being only apparent. The firſt Touch of the Finger upon any of its ſharp Edges or Points inſtantly thaws them, otherwiſe they would pierce the Fingers like ſo many Lancets; and hence alſo why *Snow*, tho' a real *Ice*, and ſo denſe and hard a Body is notwithſtanding very light, which is the extream Thinneſs of each Icicle in reſpect of its Breadth: Hence it alſo appears, why Snow is white, becauſe it conſiſts of Parts, each of which ſingly is tranſparent, but mixed together, appear white, as the Parts of Froth, Glaſs, Ice, and other tranſparent Bodies, whether ſoft or hard.

A B C D E F, Fig. 564. repreſents a few of an infinite Variety of curious Figures that are to be obſerved in *Snow*.

In which it was obſervable, that if they were of any regular Figures, they were always branched out with ſix principal Branches, of equal Length and Shape. As theſe Stems were for the moſt Part of the ſame Make in one Flake, ſo were they in differently figured Flakes, very different; but this was conſtantly obſerved, that of whatever Figure one of the Branches were of, the reſt were exactly the ſame.

The Point of an exceeding ſmall Needle, appeared, when greatly magnified like Fig. 565. neither round nor flat, but very irregular, and tho' to the naked Eye it was very ſmooth and ſharp, yet upon this Examination, it appear'd to be full of Holes * and Scratches; ſo unaccurate is human Art in all its Productions, even in theſe which ſeem to be the moſt neat, that if examined with an Organ more accurate than that by which they were made, the more we ſee of their Shape, the leſs Appearance will there be of their Beauty; whereas in the Works of Nature, the deepeſt Diſcoveries ſhew us the greateſt Excellencies; for in the Sting of a Gnat, or a Bee, the Proboſcis of a Butterfly, or Flea, they appear, when examined by the Microſcope, to be formed with the moſt ſurpriſing Beauty, exquiſite Workmanſhip, and an exact Regularity of, and Likeneſs in Parts is preſerved in each Particular of every Species; an evident Argument, that he who was, and is the Author of all theſe Things, is no other than OMNIPOTENT; being able to include as great a Variety of Parts and Contrivances in the moſt minute Point, as in the largeſt Body.

Fig. 566. repreſents a very ſmall Dot, Tittle, or Point, that is generally the Mark of a full Stop or Period. Amongſt Multitudes that were obſerved by the *Microſcope*, few could be found ſo round and even as this here delineated, † but when greatly magnified, it appear'd to be rough, jagged, and uneven all about its Edges, and very far from being truly round, as at Fig. 567. the moſt curious and ſmoothly engraved Strokes and Points, when examined by the Microſcope, look but like ſo many Furrows and Holes; and their printed Impreſſions, but like ſmutty Daubings on a Mat,

* *Hook's Micr. p.* 2. † *Ibid. p.* 2.

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or uneven Floor, made with a blunt extinguiſhed Brand. Several Pieces of ſmall Writing, reckoned very curious of their Kind, one of which in the Breadth of a Silver Two-pence, compriz'd the *Lord's Prayer*, the *Apoſtles Creed*, the *Ten Commandments*, and about ſix Verſes beſides out of the *Bible*, being examined by the *Microſcope*, ſhew'd what the Writer had aſſerted was true, but withal diſcovered it to be compoſed of as ſhapeleſs, barbarous, and uncouth Letters, as if written in *Arabian* and *Chineſe* Characters.

A Part of the *Edge* of a very keen *Razor* was ſo placed between the Microſcope, and the Light, that there appear'd a Reflection from the very Edges, and was perceived to be ſharper in ſome Places than in others, indented at others, broader and thicker at others, and unequal and rugged; that Part of the Edge which is poliſhed by the Hone, appear'd to be prodigiouſly full of Scratches, croſſing each other every Way; beſides it had ſeveral deep Furrows. That Part of the *Razor* which was poliſhed upon the Wheel, looked almoſt as rough as a plowed Field. *

Mr. *Leeuwenhoek* cauſed himſelf to be ſhaved with the ſharpeſt *Razor* he could pick out of five by the Help of a magnifying Glaſs. At firſt it was very ſoft and eaſy, but at laſt it grew ſo painful he could not endure it, and upon viewing it with his *Microſcope*, he found in it many more Notches than at firſt. In another he found little Holes in ſix ſeveral Places near the Edge. He waſhed the Back of his Hand with plain Water, and then with this ſame *Razor* ſcraped off the little Hairs, and on obſerving the *Razor* again, found that thoſe little Holes were turn'd into Notches, and that ſeveral Pieces of the Razor were broken out. From whence it appears, that if the Razor be too ſoft, it yields to the Hairs, if too hard, the Hair cauſes ſeveral Notches in it. In ſhort when we obſerve thro' a Microſcope the ſeveral Notches there are in the fineſt Razor, it is ſurpriſing how any of them can cut ſo well. †

Fig. 568. repreſents a Piece of exceeding fine *Lawn*, as it appear'd thro' the *Microſcope*, which from the great Diſtances between its Threads, appears like a Lattice, and the Threads themſelves ſeem coarſer than Rope-Yarn.

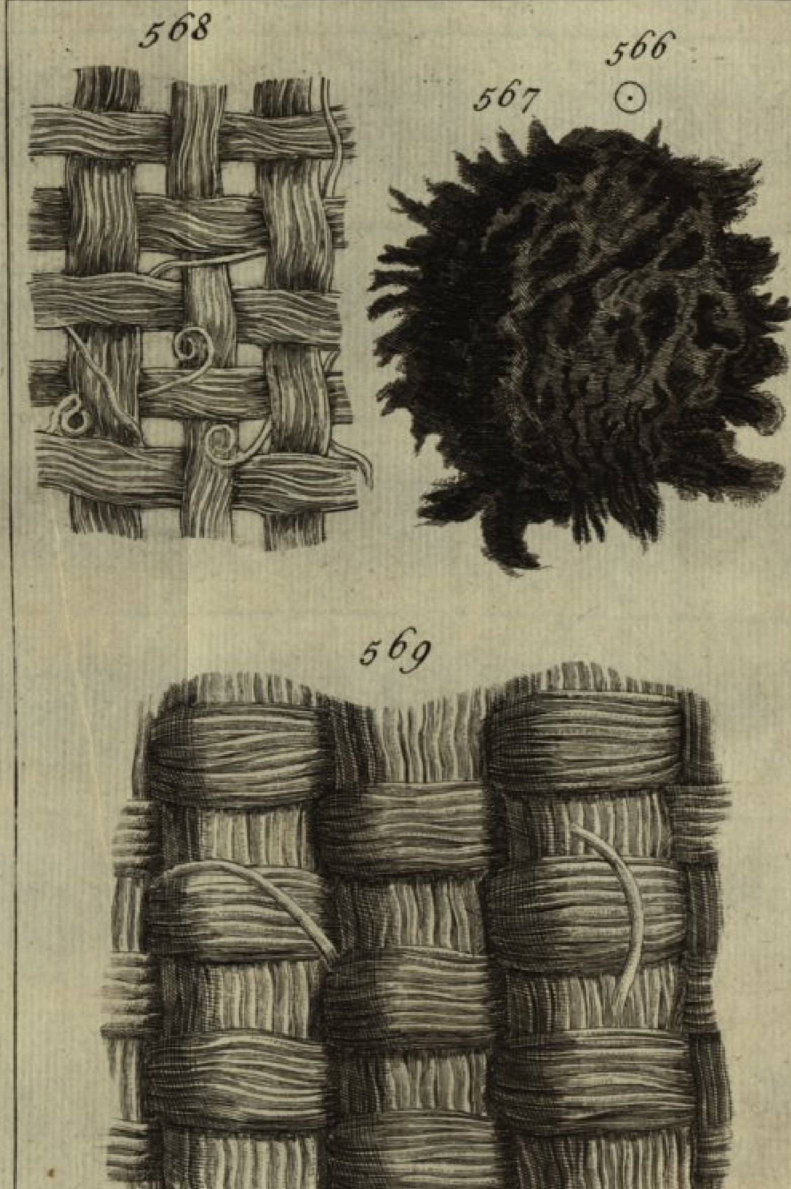
Fig. 569. exhibits a microſcopick Appearance of a very fine Piece of Ribband, being not much unlike that Subſtance of which *Door-Mats* are made. If the Silk be white, each Thread appears like a Bundle or Wreath of tranſparent Cylinders; if colour'd, they appear curiouſly tingid, each of which affording in ſome Part or other a vivid Reflection, in ſo much, that the Reflection of Red appear'd as if coming from ſo many Garnets or Rubies.

Hence it is evident, that there are but few *artificial* Things worth obſerving with a *Microſcope*, for which Reaſon I ſhall conclude here; the

* *Hook*'s *Micr. p.* 4. † *Phil. Tranſ.* No. 273.

Productions of *Art* being such rude mishapen Things, that when viewed with that Instrument, we can observe very little in them but their Deformity. The most curious Carvings, appear no better than those rude *Russian* Images mentioned by *Purchas*; where three Notches at the End of a Stick stood for a Face: And the most smooth and polished Surfaces that we can possibly meet with, appear rough and uneven. Therefore why should we endeavour to find Beauties in Things which were designed for no higher a Use than to be viewed by our naked Eye? But only that we may see the *Defects* of human Art, when compared to those of *Nature*, in whose Forms there are something so surprizingly small and curious, and their design'd Business so far removed beyond the Reach of our natural Sight, that the more we magnify those minute Objects, the more Excellencies and Mysteries appear; and the more we are enabled to discover the Weakness of our own Senses, as well as the Omnipotency and infinite Perfections of the *Great* CREATOR.

FINIS.



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A

CATALOGUE

OF

Mathematical, Philosophical, and *Optical*

INSTRUMENTS,

As *Made* and *Sold* by

GEORGE ADAMS,

At Tycho Brahe*'s Head, in* Fleet-Street, London.

THE Study of the Mathematicks is now so generally esteemed, as to become a necessary Part of almost every Gentleman's Education. Nor need we wonder at the great Progress, which this Science has, of late Years, made in most Parts of *Europe*; since it contains such an inexhaustible Fund of useful Knowledge, as is sufficient to gratify almost every Taste, and employ every Talent. The noblest Genius may, in the Pursuit of it, exert his utmost Faculties; and the meanest will not fail of finding something that is within his Reach. The Theory affords an ample Field to the speculative Part of Mankind, and the Practice is productive of several Advantages to Men of Action and Business.

In order, therefore, to render this Treatise, in some Measure, of general Use, I have subjoined an extensive CATALOGUE, of the greatest Part of *Mathematical*, *Philosophical*, and *Optical* Instruments, that are now in Use among the most judicious and learned Men throughout *Europe*.

Mathematical Instruments are the Means by which those noble Sciences, Geometry and Philosophy, are render'd useful in the Affairs of Life. By their Assistance an abstracted and unprofitable Speculation, is made beneficial in a thousand Instances: In a Word, they enable us to *connect Theory* with *Practice*, and so turn what was only bare Contemplation, into the most substantial Uses.

 The

The Knowledge of theſe leads to that of *practical* MATHEMATICKS, and *experimental* PHILOSOPHY; ſo that the Uſes of mathematical and philoſophical Inſtruments, make perhaps one of the moſt *ſerviceable Branches* of Learning in the whole World; and the natural Way, therefore, of rendering this Knowledge general and diffuſive, is by making that of its *Inſtruments* ſo.

As *practical* Mathematicks, and *experimental* Philoſophy, teach us the *Powers* of Nature, the *Properties* of natural Bodies, and their mutual Actions on one another: This Knowledge cannot be attained without *Inſtruments*, and the Concluſions and Proofs we expect from it, depend very much upon their *Exactneſs.* In order therefore to give a ſufficient Satisfaction to thoſe Gentlemen who have honour'd me with their Cuſtom, it hath always been my particular and greateſt Aim to produce ſuch *Inſtruments* as *might facilitate* the *Progreſs* of *Mathematical* and *Philoſophical Learning*, which *Motive* hath been, and ſtill is as preſſing with me as that of *Intereſt*. For,

In the Conſtruction of all the Machines I have ever made, my firſt and greateſt Care hath been to procure good *Models* and *Drawings*, ſeveral of them I have imitated from the *beſt Authors*, as well *Foreigners*, as thoſe of *our own Country*; I have alter'd and improved others, and have added many new ones of my *own Invention.* And,

1. In all my Peformances I endeavour not to *augment* the Inſtruments and Machines with *ſuperfluous Ornaments*, both that they may be of *frequent Uſe* to thoſe of *middling Fortunes*, and that their *Neatneſs* may render them not unworthy of a Place in the Cabinets of the Curious.

2. That their *Exactneſs* may be particularly attended to, I always inſpect and direct the ſeveral Pieces myſelf, ſee them all combined in my own Houſe, and finiſh the moſt *curious* Parts thereof with my own Hands.

3. To the End that their *Conſtruction* may be as *ſimple* and *ſubſtantial* as the *Uſes* of the Inſtruments will *admit*; it is my conſtant Study to contrive them in ſuch a Manner that they may be managed with the *greateſt Eaſe.*

4. I alſo have Reſpect to their being made applicable to *ſeveral Operations*, eſpecially when the *Extent* of their *Uſe* does not *prejudice* their *Simplicity*, to the End that Inſtruments may not be multiplied without Neceſſity.

In the following CATALOGUE I have ranged the Inſtruments in *Claſſes* under the Heads of their ſeveral *Branches*, and have *number'd* each particular *Inſtrument*, ſo that if a Gentleman is deſirous of any one or more of them, and is at any Diſtance from LONDON, he need only ſend me the Numbers adjoining to thoſe he intends to purchaſe, and he ſhall be ſerved with Fidelity, and at the loweſt Prices.

Instruments for Geometry, Drawing, &c.

VAriety of Pocket Cases of *Drawing Instruments*, in Silver, Brass, *&c.* Containing,

1 *Plain Compasses* for measuring Lines, *&c.*

2 *Drawing Compasses*, with three moveable Points, *viz.* an Ink Point for sweeping Circles, or Arches of any determinate Thickness, a dotting Point, and a black Lead Point.

3 A *Drawing Pen*, either with or without a protracting Pin.

4 A *Sector* for finding Proportions between Quantities of the same Kind, as between Lines and Lines, Surfaces and Surfaces, *&c.* either of Box, Ivory, Brass, Silver, *&c.*

5 *Plain Scales*, or,
6 A *square Protractor*, or,
7 *Parallel Ruler*, which is also a Protractor, *&c.*
} either of Box, Ivory, Brass, Silver, *&c.*

8 A *Semicircle Protractor* of Brass.

In the best Cases, the Compasses are always made with Steel Joints, and the Knibs of all the Pens are made to turn up, or open with a Joint, in order to clean them, in which are also sometimes put,

9 A Pair of *Hair Compasses*, so contrived on the Inside of one of the Legs, that an Extent may be taken to an Hair's Breadth.

10 A Pair of *circular Compasses*, with which a Circle as small as a Pin's Head may be described.

In a *Magazine Case* of *Drawing Instruments*, is generally contain'd all the above Instruments, together with the following Particulars.

11 A Pair of *Drawing Compasses*, with moveable Legs longer than those of No. 2.

12 A Pair of *strong Compasses*, with Calliper and cutting Points.

13 A Pair of *Beam Compasses*, for drawing larger Circles, and taking larger Extents.

14 A Pair of *Proportionable Compasses*, for the ready diminishing Plans or Drawings, in any assigned Proportion.

15 A 12 Inch *Brass Sector*, of a peculiar Make.

16 A Pair of *Triangular*
17 A Pair of *Quadrangular*
} *Compasses* for transferring three or four Points at once, from a Map or any Drawing to another to be copied.

18 A Pair of *Compasses*, with two Pair of Points, whose shorter Legs are at all Openings always half the Distance of the longer ones.

19 A Pair of *Plat Compasses* for measuring Charts.

20 A *tracing Point* having at its upper End an oval Plate for clearing the Drawing Pen of any Dirt or Grit that may happen between the Knibs, and in the Middle thereof is a protracting Pin.
21 *Elliptical Compasses* for drawing Ellipsis or Ovals of various Sizes.
22 A *Bow* for drawing curved Lines.
23 A *Porté craiyon.*
24 A large *Plain Scale,*
25 A *Plotting Scale,* } Sometimes these are all made in one Instrument.
26 A *Protractor,*
27 *Plain* and *Parallel Rulers,* of several Sizes.
28 Bottles and Shells of Water Colours.
29 *Ivory Pallates* for *Indian* Ink and Colours.
30 A *Pointrel* and *Feeder.*
31 A Pair of *Gunners Callippers.*
32 A *Recipient Angle* for measuring the external and internal Angles of Fortifications, Buildings, *&c.*
33 *Dialling Scales,* &c.

In these Magazine Cases, Gentlemen may have what Number of Instruments they think proper.

34 The *Solids* in *Euclid*'s *Elements* cut in Wood, with all their proper Sections, design'd on Purpose for the Ease of those Persons, who would inform themselves demonstratively in the Practice of *Perspective, Mensuration, Sphericks,* &c.
35 The five *regular Solids,* or *Platonick Bodies* cut in Wood.
36 A *Cylinder* bisected.
37 A *Cone* with all its proper Sections.

Rules of all Sorts,

For Measuring of Timber, Stone, Painting, Brick-work, Plaistering, Glazing, Gauging, *&c. Viz.*

38 C*Arpenters* Rules.
39 *Folding* Rules.
40 *Coggeshall*'s *Sliding* Rules for measuring Timber.
41 *Scammozzi*'s Rules.
42 *Everard*'s Sliding Rule for Gauging.
43 *Leadbeater*'s Sliding Rule.
44 *Veroy*'s Sliding Rule.
45 *Brenan*'s Rule.
46 *Malt Canes.*
47 *Dimension Canes.*

48 *Four-Foot Gauging Rule* with Joints.
49 *Five Foot* Ditto.
50 Tape Boxes.
51 Five Foot Rods, for meaſuring Brick-work, Wainſcotting, Painting, *&c.*
52 ———— Ditto, in Canes.
53 *Horſe* Meaſures in Sticks and Canes, *&c.*

Surveying Inſtruments.

54 *PLain Tables*, with an Index and Sights, whereby the Draught or Plan is taken on the Spot, without any future Protraction, having a Compaſs fitted to one of its Sides, and the whole fixed upon a Ball Socket, with a three legg'd Staff, upon which it may be turn'd round, or faſten'd with a Screw, as Occaſion requires.

55 *Plain Tables improv'd*, with an Index of a peculiar Make, whereby the Line of Sights in viewing, is always over the Center of the Table, which alſo is readily ſet over the Station Hole, the Station Lines are likewiſe drawn parallel to thoſe meaſured on the Land; and the Table is ſet horizontal by a Spirit Level, *&c.*

Plain Tables are very uſeful in taking the Ground Plot of Buildings, and meaſuring Gardens, or ſmall Encloſures (where the Shortneſs of Lines, and Multiplicity of Angles are apt to breed Confuſion in protracting) but by no Means fit for ſurveying large Tracts of Land, becauſe the leaſt Moiſture, or Dampneſs in the Air, makes the Paper not only ſink, but run up when dried again, and thereby the Lines drawn thereon, make the Content leſs than it ſhould be, and in the leaſt Rain or Miſt the Inſtrument is not at all to be uſed, which Reaſons has induced moſt Perſons to uſe fitter Inſtruments for large Tracts of Ground. As the

56 *Theodolite*, for meaſuring Angles, Diſtances, Altitudes, *&c.* Thoſe Inſtruments are made various Ways, ſome being more ſimple and portable, others more accurate and expeditious.

57 The *Plain Theodolite*, which conſiſts of four plain Sights, two faſten'd to the Limb, and two on the Ends of the Index, with a Compaſs on the Index Plate, divided into Degrees, and the Limb ſubdivided into Minutes by a Nonius Diviſion, the whole fitted on a Ball and Socket, and that placed upon a three-legg'd Staff.

58 *Theodolites*, with all the above Particulars, and the Addition of a Teleſcope.

59 *Theodolites of the lateſt Improvement*, being the moſt accurate Inſtrument yet invented for ſurveying Land, which by a peculiar Con-

trivance in the Head of the Staff, may be ſet truly horizontal. On the Index, and over the Compaſs-Box is fixed a double Sextant, to move exactly in a vertical Circle, within which is a Spirit Level, and over that a Teleſcope, ſo contrived, that when the Bubble reſts in the Middle of the Spirit Tube, the Interſection of the Hairs in the Teleſcope will cut an exact Level, the double Sextant is divided in ſuch a Manner as to ſhew on one Side thereof the Degrees and Minutes of any Altitude or Depreſſion within the Extent of its Diviſions. On the other Side are Diviſions for taking the Height of Timber ſtanding in Feet; and on the Limb there are alſo Diviſions for meaſuring its Breadth. It muſt be alſo obſerved here, that both horizontal and vertical Angles are obſerved at the ſame Time, which is extreamly uſeful in laying down Plots, when the hypothenuſal are to be reduced to horizontal Lines; when the Teleſcope is directed to any Object, the whole Inſtrument is fixed in ſo firm a Manner, that on directing the Teleſcope to the next, the Limb remains entirely ſtedfaſt, which in other Inſtruments of this Sort, is very difficult to be effected.

60 *Circumferentors*, the principal ſurveying Inſtrument uſed in the *Weſt Indies.* It is very ſimple, yet expeditious in the Practice, and conſiſts only in a Braſs Circle, with a Compaſs divided into 360 Degrees, on the Center of which is ſuſpended a magnetical Needle, and an Index, on whoſe Extremities are two Sights; the whole is mounted on a Staff, and ſometimes for Conveniency of its Motion, on a Ball and Socket.

61 *Gunters*, or four Pole *Chains.*

62 *Offset Staves.*

63 Sets of *Arrows* for the Chain.

64 Air *Levels* which ſhew the Line of Level, by Means of a Bubble of Air and Spirits of Wine hermetically incloſed within a Glaſs Tube, which is mounted in a Braſs Tube, on a particular Frame, and may be included in a Caſe for the Pocket.

65 Air *Levels*, with Sights, which conſiſt of an Air Level ſet in a Braſs Tube, with an Aperture in the Middle, being fixed on a ſtraight Ruler on whoſe Ends are Sights for taking the Level of any Place.

66 Air *Levels*, with Teleſcope Sights, are ſomewhat like the former, but with this Difference, that inſtead of plain Sights it carries a Teleſcope to determine the Point of Level preciſely, at a good Diſtance, theſe Levels are mounted on a three-legg'd Staff, and have a particular Contrivance; by which they may be adjuſted (if put out of Order) to a true Level at any one Station.

67 *Artillery Levels.*

68 *Gunners Levels.*

69 Le-

69 *Levelling Staves.*
70 Plotting *Scales.*
71 Sets of feather-edg'd *Scales.*
72 Hair *Scales.*
73 *Parallel Rulers* for Plotting.
74 An *improv'd Protractor*, and Plotting Scale, in Form of a Beam-Compass.
75 *Parallelograms*, for the ready and exact Reduction, or copying of Designs, Schemes, Prints, *&c.* which is done hereby without any Knowledge or Habit of Designing.
76 *Pedometers*, somewhat like a Watch, by which the Way may be measured in Walking.
77 *Measuring Wheels* for Surveying of Land.
78 *Way-Wisers*, for Coaches.
79 *Way-Wisers* of a curious and particular Contrivance for Chaises, *&c.*
80 *Gunners Quadrants*, Heights, *&c.*
81 *Surveying Quadrants*, made of Brass, or Wood, *&c.*

Navigation Instruments.

82 *GUnter's Scales.*
83 Sliding *Gunter's.*
84 *Davies Quadrants.*
85 Mr. *Hadley's* reflecting *Quadrants.*
86 Mr. *Smith's* reflecting *Quadrants.*
87 Mr. *Smith's*, Capt. *Middleton's*, and Capt. *Harrison's* improv'd *Azimuth* Compass.
88 The common *Azimuth* Compass.
89 *Azimuth* Compass, on Friction Wheels.
90 An artificial *Horizon* of a new and curious Contrivance.
91 Mariner's *Compasses*, either for the Binacle or Cabin.
92 *Nocturnals*, adapted to the Polar Star, and the first of the Guards of the little *Bear*; and also to the Polar Star, and the Pointers of the great *Bear.*
93 *Nocturnals*, which are a Projection of the Sphere, such as Planispheres, Hemispheres, *&c.*
94 *Rectifiers* for determining the Variation of the Compass, in order to rectify the Ship's Course.
95 Plane *Scales.*
96 An *Instrument* for taking the Latitude of a Place at any Time of the Day. May be easily understood, it immediately shews the Lati-

 tude

tude of the Place, and gives the Time of the Day at *Sea*, when no other Inftrument will.

97 A *Machine* to meafure the *Strength* of the *Wind*.
98 A *Machine* to found the *Depth* of the *Sea* without a Line.
99 A Contrivance to fetch up Water from any Depth of the Sea.
100 *Marine Barometers*, for foretelling Storms at Sea.
101 Sinical *Quadrants*.
102 *Telefcopes*, *Profpects*, and *Spy-Glaffes*.
103 Navigation *Books*, *Charts*, &c.

Inftruments for fhewing the Motion, Attraction, Weight, and Equilibrio of Bodies, &c.

104 A *Machine* and *Glafs-Planes* for the Drop of Oil of Oranges.
105 Two *Planes* in a Frame to be fet in a Veffel of tingid Liquor.
106 *Capillary Tubes* and Apparatus.
107 A *Column* with fliding Arms, additional Pieces, Nuts, Screws, Hooks, Pullies, *&c.* of a very ufeful, curious, and particular Contrivance, adapted to fupport a great Number of the Apparatus, in which Pullies, Leavers, Ballances, Weights, Pendulums, *&c.* are ufed both in Mechanicks and Hydroftaticks.
108 A *ftrong Ballance* graduated, for explaining the Properties of Leavers, in which the *Power*, *Refiftance*, and Point of Sufpenfion are moveable; and may be readily placed in any given Proportions.
109 A *Prifm* with a *Steel* Edge.
110 *Awls* in Brafs Handles to illuftrate the Center of Gravity.
111 An Inftrument and Apparatus for 3 *Leavers*.
112 Compound *Leavers*.
113 An *Axis* in *Peritrochio*.
114 A *double Cone*, that runs up an inclin'd Plane, which is two Rulers, fo difpos'd as to be inclined to each other, and to the Horizon, which double Inclination may be varied as the Experiment requires.
115 A *Cylinder* that runs up an inclined Plane.

The two laft Machines prove, that a Body cannot remain at reft, when its Center of Gravity is not lowermoft.

116 A Machine to demonftrate the Properties of an inclined Plane, fo contrived, that its Inclination may be changed from an horizontal Plane to that of a vertical one, and the acting Power may be placed in any given Direction.
117 A little Carriage, and its Appendages, for fhewing the Advantage

great

great Wheels have over little ones, and that in all Sorts of Roads, as Clay, Gravel, Sand, Pavements, *&c.*

118 Machines for oblique Forces.

119 *Blocks*, or *Sheaves* of *Pullies*, after all the various Sorts of Combinations and Constructions, curiously framed, and turned in Brass, and running either on Steel Arbors, or Pivots, in which all possible Care is taken to diminish their Friction.

120 A Machine to explain the Nature and Properties of the *Wedge*. In which the Wedge is formed of two jointed Rulers, that may be set to any Inclination from each other, by which Means the Base of the Wedge is varied, as may also its Force and Resistance, by a new and curious Contrivance.

121 A Collection of several Wheels and Pinions, to shew that either of these act as *Pullies*, and their Proportions as *Leavers*.

122 A Model of *Archymedes*'s *Screw*, the Effect of which becomes sensible, by the rising of several little Balls therein.

123 A Machine for explaining the Nature of the *Watch-Spring* and *Fussey*.

124 An Instrument to explain the Effects of *Friction* in Machines.

125 A Machine for shewing the Accelleration of *falling Bodies*.

126 A *strong Ballance*, and its Appendages for the same Uses.

These two last Machines do not only shew that Bodies are accellerated by falling, but also makes the Laws of this Accelleration evident.

127 An Instrument to illustrate *Motion* and *Velocity*.

128 A double Pendulum, mounted on a Trough, divided into two equal Parts by aPartition, for shewing the Proportions of *resisting* Mediums.

129 An Instrument for comparing the Swiftness of a Body falling in a *Cycloid*, with that of another Body, down an inclined Plane.

130 Another Instrument for comparing the Descent of two Bodies, from any Part of an inverted *Cyloid*.

131 A *Machine* to shew the Direction of a Body that is impressed with a perpendicular and horizontal Motion.

132 Another *Machine*, by which is also shewn a Motion produced from two Directions.

133 A *Machine* for shewing the Line that a Body describes in falling, after having received an horizontal Direction.

134 A *Machine* for shewing the Motion of a Body, neglecting its proper Weight, after having received by falling, a Direction oblique to the Horizon.

As the Curve in Question depends upon the Obliquity of its Direction, the Instrument is constructed in such a Manner, that the Degrees of its Obliquity may be varied.

135 A *Machine* for explaining the Theory of *central Forces*; contrived in such a Manner, that its Friction makes no sensible Error: The

Celerity and Bulk of the Bodies may be varied at Pleaſure. Their Times are ſhewn by Sound, and the Spaces run through by an Index.

136 A *Glaſs Globe* fixed to a double Axis, which may be whirl'd with any Degree of Velocity, both in a vertical and horizontal Direction.

With this Machine the Effects of central Forces may be ſeen on Fluids of different ſpecifick Gravities, when mixed together, or on Solids which float therein.

137 A *flexible Globe*, or *Sphere*, whoſe Poles are capable of being depreſſed, on its being turned, by which Means the centrifugal Force raiſes the Equator, and repreſents the Form of an oblate Spheriod to the Eye, which is the Figure attributed to the Earth from the late Diſcoveries.

138 A Machine for the *Congreſs* of *Bodies*, both elaſtick and non-elaſtick. Its Parts are adapted in the moſt convenient Manner, to facilitate a Contact which does not change the Direction of the Bodies, whoſe Solidities or Maſſes are in known Proportions; the Points of Suſpenſion are advantageouſly diſpoſed, and their Effect made ſenſible by an Index.

139 A *Chronometer*, or Inſtrument to meaſure ſmall Spaces of Time.

140 A *Machine* and Table for *compound Motion*, in which the Hammers are ſuſpended in ſuch a Manner, as to regulate the Quantity of Motion, either by their Celerity or Weight.

141 A graduated *Arch*, and *ſwinging Scale*, for ſhewing that a Body thrown up perpendicular from any other Body in Motion, will fall exactly on the ſame Place, notwithſtanding both the Bodies are moved.

142 An Apparatus to ſtrain Wires or Strings a-croſs a Room for Experiments of the like Nature.

143 An Inſtrument to explain the Force of *Springs*, &c.

145 Models
- of a Preſs.
- of a Capſtan.
- of Cranes of various Sorts.
- of Mr. *Allen*'s Crane at *Bath*.
- of an Engine to drive Piles, *&c.*
- of an Engine to ſaw off the Tops of Piles under Water.

Many other Models of Machines, which are principally deſigned to explain the Application of ſimple Machines, in thoſe which are combined, in all which Care is taken to leave thoſe Places expos'd, where the chief Motions are to be obſerved.

146 An Inſtrument to explain the Laws of *Elaſticity*, on Springs and Wires, *&c.*

147 *Large Weights*, for ſeveral Experiments.

148 *Smaller Weights*, of a peculiar Shape, from half an Ounce to Six Pounds.

149 A *moveable Table* for various Experiments, that may be rais'd or lower'd.

150 A Pair of *Scales* for various Experiments.

Inſtruments for Experiments on the Motion, Weight, and Equilibrio of Fluids.

151 A *Trough* lin'd with Lead, and furniſhed with a Cock; for ſeveral Hydroſtatical Experiments.

152 A *Glaſs Phial*, with a ſolid Stopper, which in this State is heavier than a like Bulk of Water.

153 Several Tubes bent in different Forms.

154 An Apparatus for proving how Fluids preſs againſt the Bottom and Sides of their containing Veſſels, being compoſed of ſeveral Veſſels, which may be ſucceſſively placed upon one common Baſe; the Piſton, which is the Bottom hereof, is ſo adjuſted, as to cauſe no ſenſible Error by its Friction, the Columns of the Fluid remain always at the ſame Height, and the Weights act in a uniform Manner.

155 *Hydroſtatical Bellows.*

156 A Glaſs Tube with a Bladder fixed at one End.

157 A Glaſs Bucket and wooden Cylinder.

158 An *Hydroſtatical Ballance* of a commodious Structure.

159 An hollow Glaſs Ball with a Cock to it, to prove that Water weighs in Water.

160 *Areometers*, or Liquor Proofs, of Glaſs.

161 *Hydrometers* of Braſs or Copper.

162 A Glaſs Veſſel for changing Water into Wine, and *vice verſâ*.

163 A Braſs cylindrical Veſſel, with a Solid of the ſame Size, to ſhew that Bodies plunged in Fluids become lighter.

164 A Glaſs Veſſel to be ſuſpended to the Arm of a Ballance, for Experiments of the ſame Kind.

165 Two Balls of the ſame Weight, but of different ſpecifick Gravity, to be hung to the Arm of a Ballance, for ſhewing, that what Bodies loſe of their Weight, on being plunged into Water, is in Proportion to their Bulk.

166 A Machine for ſhewing that a Body emerged in a Fluid, changes its relative Weight, when the Bulk of the Fluid in which it is, is either condenſed or rarified.

167 A

167 A *Syphon*, open at Top, to which may be fixed an exhausting Syringe, mounted on a Frame with a graduated Scale, for comparing the Densities of two Fluids at the same Time.
168 A cylindrical Glass Vessel, and hollow Images.
169 Two cylindrical Glass Vessels, mounted in a Frame, in which the hollow Glass Images may be moved by Compression, without being perceived by the Spectators.
170 A Model of the *diving Bell* and Apparatus.
171 A common Syphon, and others of different Forms.
172 A double Syphon.
173 A Syphon, whose Arms are moveable by Means of a Knee-like Joint.
174 A *Tantalus Cup* of several Fashions.
175 Glass Models of *Sucking*, *Forcing* and *Lifting* *Pumps*, (with or without Air-Vessels) which shew the Reasons of Fire-Engines, playing with a continual Stream.
176 A Fountain of *Command*.
177 ——— *Hiero*.
178 ——— *Double*.
179 A *large Fountain by compressed Air*, with Variety of Jet d'Eaux, to which also may be applied an Apparatus for shewing the various Curves that are made by Projectiles.
180 A *Ballance to weigh Levity*.
181 An Apparatus to make Lead swim.
182 An Apparatus to make Cork sink.
183 A Column and *Reservoir* for *spouting Water*, with Tubes that may be inclined to any Angle Jet d'Eaux's, &c.
184 Two tall cylindrical narrow Jars, and several solid Cylinders of different Woods, to shew that they will sink differently according to their specifick Gravities.
185 A Glass-Bottle full of Holes.
186 Glass Bubbles, which, on being immerged in Water, become specifically heavier, lighter, and of the same specifick Gravity of the Water successively.
187 A Machine for shewing that Bodies emerged in Fluids, change their relative Weight, and will sink or rise therein, as the Fluid in which they are become more dense or rarified.

This may be called an hydrostatical Thermometer.

188 Two Glass Bubbles, one swimming at the Top, and the other lying at the Bottom of the Water in a Glass Jar, so contrived, that by pouring in more Water, the Bubbles shall change Place.
189 A Machine for *spouting Mercury*, which shews the various Parabola's that are made by Projectiles, and particularly the Truth of the several

veral Rules in the Art of Gunnery, being constructed in such a curious Manner, that the Force may be varied as Occasion requires.

190 A peculiar Sort of Syhon, the Orifices of its two Legs being in the same Line, and yet the Water will run out, and tho' the Orifices be but in Part immerged, yet the Water will rise. This Machine produces its Effects tho' continuing dry for a long Time, that either of the Apertures being open'd, and the other remaining shut for Hours, or a whole Day, and then opened, the Water will flow out, and will rise and fall indifferently in either Leg.

N. B. All the Models of Pumps, Fountains, Syphons, *&c.* are made of Glass, in which all the Parts of Action may be easily seen.

Instruments for Pneumatical Experiments.

191 A Small single Barrel *Air-Pump.*

192 A large double Barrel standing, or tall *Air Pump* and *Apparatus.*

193 A double Barrel *Table Air-Pump*, which is the most useful of any, with a large Apparatus.

194 A Machine particularly applicable to the double Barrel *Table Air-Pump*, for whirling Bodies in Vacuo, of a new Contrivance, by which all the electrical Experiments on whirling Globes, either exhausted of their Air, or not, may be repeated.

195 An Apparatus for the Experiments of Fire in Vacuo.

196 An Apparatus for the Experiments on Electricity in Vacuo.

197 A Sortment of necessary Things for Experiments on Electricity in Vacuo.

198 A very tall Receiver composed of several Pieces, with a curious Machine at Top, by which Experiments on falling Bodies may be five Times repeated in Vacuum, when the Air is only once exhausted.

199 A double Transferer for communicating a Vacuum from one Receiver to another.

200 Two Brass Hemispheres, with a Stop-Cock and Rings.

201 A Bottle with a Jet d'Eaux, and a long Tube with a Receiver, for shewing that a small Quantity of included Air, presses equally with the whole correspondent Column of the Atmosphere.

202 A Glass with a wooden Vessel at its Top, to prove the Porosity of Vegetables.

203 A proper Vessel for proving the Skins of Animals are porous, and that an abortive Skin is not so.

204 A

204 A Machine to ſhew that denſe Air will drive a yielding Solid into a Space occupied by rarer Air.

205 A Machine to ſtrike two Hammers againſt a Bell in Vacuo, and compreſſed Air.

206 A Machine of a new Contrivance for making Experiments in compreſſed Air, and Apparatus thereto belonging.

207 An injecting Syringe.

208 A Wind-Gun, with a condenſing Syringe in its Stock, having a Magazine of ſix Balls, from which one Ball at a Time may be put into the Barrel, without letting the Air eſcape, and once charging it with Air is ſufficient for the Diſcharge of all the Balls.

209 Capillary Tubes of various Sizes.

210 An Apparatus for the *Mercurial Phoſphori*.

211 An *Eolipile*.

212 An *Eolipile* on a Carriage.

A ſolid Globe to be heated, and a Frame to receive the ſame.

213	*Thermometers*, for	of Spirits of Wine.		
214	meaſuring the In-	by Sir *Iſaac Newton*'s.		Spirits,
215	creaſe, and Decreaſe	by *Farenheit*'s,	Standard,	Oyl,
216	of the Heat and	by *Reaumer*'s.	either of	or
217	Cold of the Air,	by *D'Liſle*'s, &c.		Mercury.

218 Monſ. *Azont*'s Apparatus, for determining that it is the Air's Preſſure which raiſes the Mercury in the Barometer.

219	Diagonal	
220	Stagnant	
221	Portable	*Barometers.*
222	Marine	
223	Dr. *Moreland*'s Statical	

224 Mr. *Caſwell*'s Baroſcope.

225 An Apparatus for an *artificial Storm*.

226 An Apparatus for the Exploſion of Gun-powder in Vacuo.

227 A *Pyrometer* of a new and curious Contrivance, for meaſuring the Expanſion of Metals.

Optical Inſtruments.

228 *SPectacles* ground on Braſs Tools, ſet in Silver, Tortoiſeſhell, Horn, *&c.*

229 *Reading-Glaſſes*, ſet in Variety of curious Frames.

230 *Concaves* for Myopes, or ſhort-ſighted Perſons.

231 *Proſpect-Glaſſes* of all Lengths.

232 *Opera Glaſſes.*

233 Diagonal *Proſpects.*

234 *Telescopes* of all Lengths.
235 *Newtonian* reflecting *Telescopes* } The Speculums of which are finished
236 *Gregorian* reflecting *Telescopes* } with the greatest Care.
237 *Microscopes*, *Wilson*'s
238 ——— Opake
239 ——— Double
240 ——— *Adams*'s *new invented* Universal One. And,
241 ——— solar Apparatus to do.
242 *Camera obscura* of various Sorts.
243 *Camera obscura*, of a peculiar Contrivance, by which the Images of external Objects, are exhibited distinctly on a Sheet of Paper, each cloathed in their native Colours, perfectly like their Objects; and at the same Time all their Motions are expressed, which last no other Art can imitate. By Means of this Instrument, a Person unacquainted with Drawing, will be able to delineate Objects, to the last Accuracy and Justice; and another well vers'd in Painting, will find many Things herein to perfect his Art.

Instruments for Experiments on Lights and Colours.

244 AN *Heliostata*, or Machine for directing the Sun's Rays into a dark Chamber, which of itself directs the Mirrour in a proper Manner, to cast the Rays in the same Line for several Hours together.
245 A Machine for shewing Experiments on the Attraction and Repulsion of the Rays of Light. Several Machines for Experiments on the Laws of the Refractions of the Rays of Light, *viz.*
246 Boxes with Glass Sides.
247 A wooden Box with sliding Sides, and changeable Ends.
248 Boxes, with Segments of Spheres, fixed in their Sides.
249 A solid Glass Cube.
250 A particular Stand to manage these Boxes upon, by which they may be rais'd, depressed, or turn'd round at Pleasure.
251 An artificial Eye, furnished with Lens's of different Foci or Ages, to shew the Reasons how Glasses help decayed Sights and Myopes.
252 A Semicircle and *Prism*, with Glass Sides to determine the Angles of Refraction.
253 Three *Prismatick* Boxes.
254 Solid Glass *Prisms*, mounted on Feet, by which Means they may be raised, depressed, inclined, or turned upon their Axis.
255 Other *Prisms*, mounted on a vertical Foot, which may be raised, or depressed, and turned upon their Axis.

256 *Priſms* of ſolid Glaſs not mounted.
257 A Plane *metalline Speculum*, mounted on a Foot that may be rais'd, depreſſed, inclined, or turned round at Pleaſure.
258 A *plain* Glaſs *Mirrour*, mounted in the ſame Manner.
259 Several Glaſs *Lens's*, mounted in Frames, on Feet.
260 An Inſtrument to open a Paſſage for the Sun's Rays, with Holes of different Sizes.
261 A large double *Convex Lens* compoſed of two Segments, and mounted on a Foot for Experiments, on the Refraction of different coloured Liquors.
262 A large Paper *Screen* for Experiments on the Priſms, and the Solar Microſcope.
263 *Concave* } Mirrours of all Sizes.
264 *Convex* }
265 Metalline { *Cylinders*, } with deformed Pictures.
266 Metalline { *Cones*, } with deformed Pictures.
267 Metalline { *Pyramids*, } with deformed Pictures.
268 Metalline { *Octagons*, } with deformed Pictures.
269 Pictures for a *pyramidical* Glaſs.
270 *Magick* Lanthorns.
271 Pictures to Ditto.
272 Hollow *Priſms* that may be exhauſted.
273 An Inſtrument to determine the Refraction of Fluids.

Inſtruments, &c. for Experiments on Electricity, &c.

274 NAtural armed *Load-Stones.*
275 *Artificial Loadſtones.*
276 A Box of Filings, and Bits of Iron Wires, little Iron Balls, and Cylinders.
277 A Trough with enamelled Swans and Frogs.
278 An Iron Rod.
279 A poliſhed Iron Blade.
280 A Compaſs Dial.
281 A long Needle in an oblong Box.
282 A Sea-Compaſs.
283 Several Steel Needles touched on the Load-ſtone.
284 A large Glaſs Tube, open at both Ends.
285 Another that may be exhauſted.
286 A Glaſs Globe for whirling.
287 Another that may be exhauſted and applied to the whirling Machine.
288 Glaſs Plates.

289 Several little Stands.
290 A solid Stick of Sealing-Wax, of a proper Length and Diameter.
291 A Tube of Ditto.
292 A Stick of Brimstone.
293 A Cone of Ditto, cover'd with a Glass.
294 A little Amber Ball, and another of Coral.
295 Several little Ivory Cups.
296 A Metal Pyramid for the Communication of Electricity.
297 A Suspendor furnished with Ribbands of different Colours.
298 A Rosin Cake.
299 A Cake of Rosin and Gum Lac.
300 A Suspendor furnished with Silk Lines for communicating Electricity to living Bodies.
301 A very long Packthread String, with Balls for communicating Electricity a great Way.
302 Silken Lines for the same Purpose.

All the Apparatus necessary to perform electrical Experiments, as well in the open Air, as in Vacuum, are, if desired, carefully disposed in one Box to make them portable.

Instruments for Astronomy, Geography, &c.

303 GLobes, *celestial* and *terrestrial*, of all Sizes, neatly fitted up, *viz.* of 3, 9, 12, 17, and 28 Inches Diameter, from the latest Observations.
304 *Globes*, fitted up in such a Manner, that the Poles of the diurnal Motion in a celestial Globe, pass in a Circle round the Poles of the Ecliptick, and serve the Purposes of Chronology and History for Times past, and will also answer the same Things for any succeeding Times to come; by which Means a View of the Heaven is obtained suitable to every Period, and will answer the antient Descriptions, as *Eudoxus*, who is supposed to have borrowed his from the most early Observations, and of *Hipparchus*, &c. Nor can any Contrivance better enable the meanest Reader to judge of the Merits of the Controversy about the *Argonautick* Expedition, as far as it depends on this, for it will verify to the Sight, the Place of the Colures, *&c.* at any Time. By this Contrivance the celestial Globe may be so adjusted, as to exhibit not only the Risings and Settings of the Stars in all Ages, and Latitudes, but the other Phænomena, likewise, that depend upon the Motion of the diurnal Axis round the annual ones.
305 *Armillary Spheres* of any Size.

306 Large *Astronomical Quadrants*, fitted with a Telescope for taking the Declination of the Sun, Moon, and Stars, in the Meridian.

307 *Transit Instruments*, for determining their right Ascensions.

308 *Portable Astronomical Quadrants*, that have both a true horizontal and vertical Motion, for observing the Altitudes of the Sun or Stars in any Position, with which (having a good portable Pendulum) the Meridian and Latitude of the Place will be readily determined; which may be of great Use on the Sea-Coast, and in the Surveys of Countries.

309 *Equal Altitude Instruments* for observing Stars of equal Heights, with which having a good portable Pendulum, the Meridian and Latitude of a Place may be very accurately found.

310 *Telescopes*, fitted with a *Micrometer* for observing the apparent Magnitudes of the Sun, Moon, and Planets, with the Apulses of the Moon and Planets to the fixed Stars.

311 Mr. *Gray*'s Instrument for drawing a Meridian Line and Telescope for observing the Time of the Night by the Pole Star.

312 *Helioscopes*, or Instruments for observing the Spots in the Sun.

313 *Parrallactick Telescopes.*

314 An *Astronomical Sector*, which is a very commodious and accurate Instrument, for taking such Differences of right Ascension and Declination, as are too large to be observed thro' a fixed Telescope, being very useful for observing the Places of the Planets or Comets when they are near any known Star.

315 *Meridian Telescopes* for correcting the Motion of a Clock or Watch, and finding the ascensional Differences of any Objects in the Heavens, by taking the Times of their Transits over the cross Hairs. The Differences of Declination of two such Objects as will pass over the Apertures of the Telescope, may be also found.

316 Large *double Instruments*, containing two chief Parts connected together, having four several Motions, all moved by Rack Work. 1. A circular Motion to shew all horizontal Angles. 2. A Semicircular vertical Motion. 3. A circular equinoctial Motion, or for any Place at right Angles to the Vertical. 4. A Motion thro' a double Sextant, at right Angles to the Third, that has a refracting Telescope fixed to it. By this Instrument, all Angles, either horizontal, or of Elevation or Depression, the Azimuth and Altitude of any Star, the Meridian and Latitude of the Place, with the Hour of the Day and Night, are directly given; also the right Ascension and Declination of the Moon, a Planet, Comet, or any Star, at one Observation; which, if a Comet of quick Motion should appear, may be repeated every five or six Minutes, and thereby its Path well known.

317 A new *Universal Sun Dial*, having all the abovesaid four Motions but performed in a different Manner, with a particular and curious Contrivance for finding the Time of the Day, within a few Seconds of Time.

318 *Horizontal Sun Dials* of all Sizes and Sorts, for Pedestals in Gardens, or elsewhere.

319 *Portable Sun Dials* of various Kinds.

320 *Gnomonick Polyhedrons*, with several Faces, whereon various Kinds of *Dials* are projected; of this Sort, that in the *Privy-Garden*, *London*, now gone to Ruin, was antiently the finest in the World.

321 *Sutton*'s or *Collins*'s *Quadrants*.

322 *Gunter*'s *Quadrants*, &c.

323 Two *Hemispheres*, projected on the Plane of the Ecliptick, containing all the Stars in Mr. *Flamstead*'s Catalogue.

324 Two *Hemispheres* on the Plane of the Equator, shewing the right Ascension and Declination of the Stars in the same Catalogue.

325 The *Zodiack*, containing all the Stars in the Way of the Planets, with Dr. *Halley*'s Method for finding the Longitude at Sea.

326 *Planispheres*, or Projections of the celestial Sphere, upon the several Planes, *viz.* that of *Ptolemy*, where the Plane of the Projection is parallel to the Equator; that of *Gemma Frisius*, where the Plane of Projection is the Colure, or solstitial Meridian; that of *John de Royas*, or *Annelemma*, whose Plane of Projection is a Meridian, and Place of the Eye in the Axis of that Meridian, at an infinite Distance; that of M. *de la Hire*, the Plane of which Projection is also a Meridian, and Place of the Eye in that Point where the Divisions of the Circles projected are sensibly equal.

327 *Orreries*, or *Planetariums*, of about 12 Inches Diameter, which shew the Motion of the Earth and Moon about the Sun.

Orreries, about two Foot Diameter, which shew the Motion of the Earth and Moon together, with the Inclination of the Moon's Orbit, the Retrogradation of the Nodes. The annual and diurnal Motions of the Earth, and Motion of the Sun round his Axis, *&c.*

328 A *Planetarium*, about two Foot Diameter, with all the Motions of the last Number, and the Addition of the two inferior Planets *Mercury* and *Venus*, the former having its annual, and the latter both its annual and diurnal Motions. By this Instrument the Situations of the Planets, with Respect to the Earth at different Times, as they appear direct stationary or retrogade, are plainly visible, as is also the Eclipses of the Sun and Moon, and the Vicissitudes of the Seasons, *&c.*

329 A *Planetarium*, of two Feet and an half Diameter, with all the Properties of the two foregoing Numbers, and the Addition of

the three ſuperior Planets, *Mars*, *Jupiter*, and *Saturn*, with their annual Motions.

330 A *Planetarium* of about three Feet and an half Diameter, handſomely ornamented, containing all the Particulars of the three foregoing Numbers, and the Addition of the diurnal Motions of *Mars*, and *Jupiter*, together with the Motions of all the ſecondary Planets round their reſpective Primaries in their proper Periods, *&c.*

All theſe Planetary Machines are ſo conſtructed, as to render all the Phænomena (they are intended to demonſtrate) very eaſy and intelligible.

331 The famous *Glaſs Sphere* of the Reverend and Learned Dr. *Long*'s Invention, which exhibits at one View both the real and apparent Motion of the Heavens.

332 The *Uranium* invented by the Reverend Dr. *Long*.

333 *Aſtronomical Clocks*, or Regulators carefully performed.

334 A particularly new and curious Machine, containing a Movement which plays either an Organ, or Harpſichord, (or both if deſired) in a maſterly Manner; ſhews the exact Time of the Day and Night, and ſets a going a tranſparent Firmament, which exhibits the apparent riſing, ſouthing, and ſetting of the Sun, Moon, and Stars, their right Aſcenſions, Declinations, Altitudes, and Amplitudes, *&c.* the Times of their Appearance and Diſappearance to an Inhabitant on any Part of the terraqueous Globe, the Place of the Sun and Moon in the Zodiack, and amongſt the fixed Stars, whereby the coſmical, heliacal, and achronical Riſings and Settings thereof, are eaſily diſcover'd, and the natural apparent Face of the Heavens, at all Times of the Day and Night, and that in any particular Part of the World, and many other Obſervables of the Earth, *&c.* In ſhort, it is a moſt beautiful, inſtructive, and ornamental Piece of Furniture, not unworthy the grandeſt Apartment in any Gentleman's or Nobleman's Houſe.

335 A COSMOTHEORION, or Machine, of a new Invention, which at preſent is without a Parallel.

It is about four Feet and a half Diameter, ſtanding upon a Pedeſtal of curious Workmanſhip.

In its Center the Sun is ſeen to perform a Revolution about its own Axis in 25 Days, its Axis being at the ſame Time inclined to the Plane of the Ecliptick, in an Angle of 66¼ Degrees. The other Planets, move round it, in which Motion, particular Regard is had both to their proportionable Diſtances and Eccentricities, as well as to their reſpective Inclination in the Plane of the Ecliptick. Their proportionable Times and Magnitudes are likewiſe

wise remarked; (according to the System generally received among Astronomers) and the Planets themselves are surrounded by a transparent Firmament, whereon the several Constellations are delineated, by which Means the Variety of Aspects the Planets appear under to a Spectator in either of them, with Respect to their Motions and Situations amongst the fixed Stars, are plainly seen, sometimes direct, sometimes stationary, and at other Times retrogade. The Earth (on which the principal Kingdoms are described, is accompanied by a natural Horizon, and a representative Inhabitant, which may be set to any Latitude) makes its Revolution in the Plane of the Ecliptick. Besides its diurnal Motion about its Axis, its Axis remaining parallel to that of the World, shews the Causes of Day and Night, and the Mutations of the Seasons. Round this Globe revolves the Moon, in an inclined eliptick Orbit (in one of whose Foci the Earth is placed) the Apsides of which advance and recede every Lunation, so as to perform a Motion in Consequentia in its proper Period, whilst the Nodes move round in Antecedentia. The Eccentricity of this eliptick Orbit, is continually changing into a new Curve, and its Latitudes both northern and southern are fully shewn. It also shews the periodical and synodical Month, the several Phases of the Moon, her Age, and Place in the Zodiack, which gives a clear Idea of the Manner in which lunar Eclipses are occasioned, and may be very ingeniously demonstrated. The Tides are also accounted for in a very intelligible Manner, and as the Observations of the Eclipses of *Jupiter*'s Satellites is of great Use in Astronomy, a particular Regard hath been had to construct their Motion in inclined Planes, as well as those of the Satellites of *Saturn*; and their Distances, Magnitudes, and true Periods, are also shewn, together with their Immersions into, and Emmersions out of the Shadow of their respective Primary. A Celidography of *Venus* is also exhibited.

All the Planetary Bodies are put in Motion at once, and the Movement that sets them a going, is regular, and easy, and capable of being continued for a very considerable Time. In short the Contrivance of the whole Machine is such, that all the Problems of Astronomy, Geography, *&c.* (the Physicks excepted) may be either explain'd or illustrated by it.

FINIS.

ADAMS'S
MICROGRAP.
ILLUSTRA.