

Fig: 1.

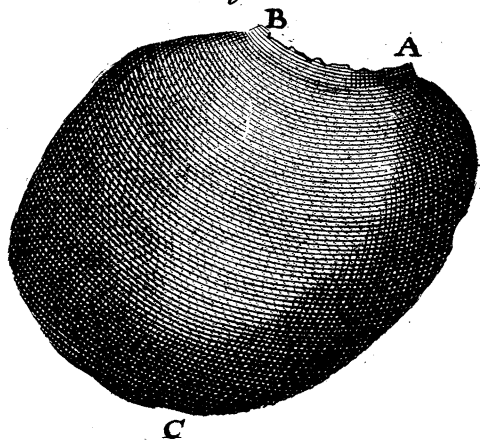


Fig: 2.

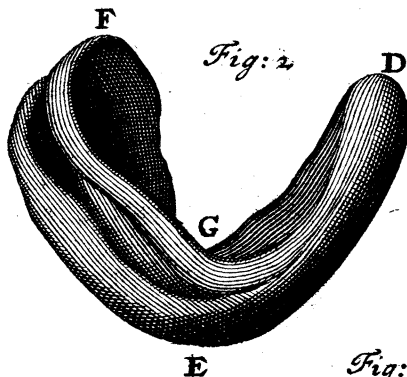


Fig: 4.

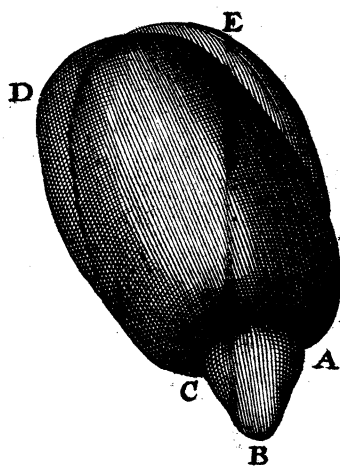


Fig: 5.



Fig: 3.

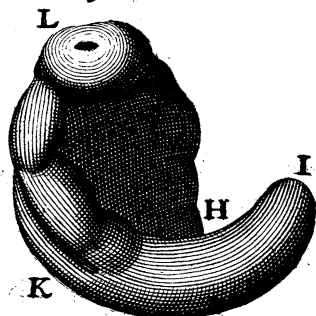


Fig: 6.

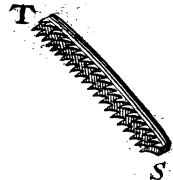
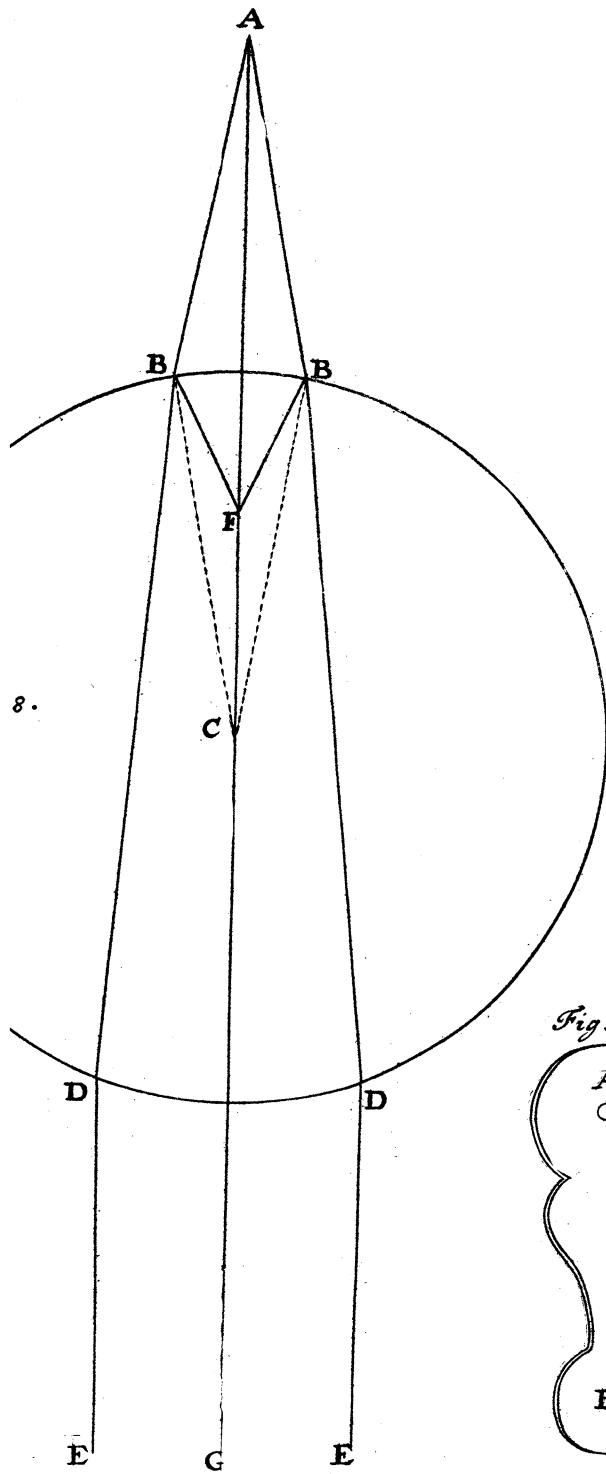


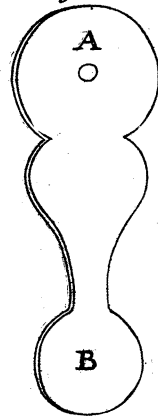
Fig: 8.





8.

Fig: 7.



I should have sooner answered to your very acceptable Letter, had not my design to Dissect some Eels more then once, and also to send a Cut thereof with this hindered me.

In the mean time I remain

Tours, &c.

III. *Several Microscopical Observations and Experiments, made by Mr. Stephen Gray.*

HAVING not long since attempted to make some of these Microscopes, which Mr. *Butterfield* describes and instructs to make, in the Philosophical Transactions, N^o 141. P. 1026. of the manner then lately brought out of *Holland* by Mr. *Hugens*; but for want of such a Lamp, as the before-named Person mentions, I proceeded after a somewhat different Method.

Experiment. 1. I took a small Particle of Glass, about the bigness I designed my Globule, and laying it on the end of a Charcoal, I could, by the help of a blast Pipe, with the Flame of a Candle, soon melt it into a Spherule, and by this means I could make them indifferently clear, and the smallest very round, and I could make them much larger, then by the unassisted heat of the Candle; but these latter were attended with an inconvenience, they were on that side that rested on the Coal flated, and received a rough Impression from it; nor were they without those Improperities (for which, or rather) to Remedy which, the ingenious Person above-said, substituted his spirituous Lamp, for a Wax or Tallow-Candle, *viz.* small Specks or Opacous Particles lodged

lodged within them : To remedy the inconvenience of the former, I was wont to Grind them and Polish them on a brass Plane, and so reduce them to Hemispherules, but I found the clear small Globules, not to mention that they magnifie more, shew Objects more distinctly.

Those Congrous Properties, known to be in small Drops of Water, *viz.* Transparency, Refraction and Spherility, led me to Conjecture, that they might, if aptly Disposed, be not unfit for Microscopes, since they have the Requisites above-mentioned, that make the Glass Globules excellent ones, and accordingly, Experience informs me, that tho' the latter are to be preferred, yet the Water, upon a necessity, may be very well used, as a *Succedaneum* to Glass Microscopes, which I have sometimes made Tryal of in manner following.

Experiment 2. I take a thin piece of Brass, Filing it into the Form Fig. 7. *A. B.* (but this every one may please themselves in) making a small hole at *A.* this serves for an Aperture; then holding it by the other end *B.* I pour a few Drops of Water on the Table, taking up a small Globule thereof with a Pin, which I lay on the hole *A.* then removing the Pin, the Water will remain on the Aperture, in form of an Hemisphere, or to speak with *Opticians*, a *Plano Convex lens*. But if I have a mind to make a double Convex of Water, I thrust the Pin (which must be less then the hole) through the hole, till the Water be entred therein; then with drawing the Pin Perpendicularly to the plane of the Aperture, the Water remains there in form of an *Aquæous double Convex lens*. Then that which I have a mind to see I take upon a Pin or a piece of Glass, according to the Nature of the Object; and taking up this natural Microscope by the end *B.* I move the Object to and fro, till it be in the *focus* thereof, and by this means I

can see Objects little less distinctly, than by Glass Microscopes, especially by Candle, which I find much better than Day-light.

Experiment 3. But I observed, that those Irregular Particles, which were inherent in the Globules of Glass, mentioned in the first Experiment, were seen distinctly and prodigiously magnified, as was easie to imagine, both from their nearness to the Eye, and that they did not hinder the Globules either by Day or Candle-light, from appearing throughout Transparent, being so minute as not to be discernable, except held close to the Eye, as in time of Observation, and not then neither, if too near the light, but at a Competent distance, they appeared as above-said. I knew not well how at that time to account for this strange Phenomenon, that an Object should be placed so far within the Focus of a Spherule, as to be within the Glass, and yet seen distinctly to the Eye so near it; but since by matter of fact, I found it was so, I made this Inference, and concluded, that if I conveyed a small Globule of Water to my Eye, and that there were any opacous or less transparent Particles then the Water therein, I might see them distinctly.

Experiment 4. Having by me a small Bottle of Water, which I knew to have in it some of those Minute Insects, which the deservedly famous Observator Mr. *Leewenhoek* Discovered, by the help of Excellent Microscopes: Having seen them with the common Glass Microscopes, and with the first *Aqueous*, as above-mentioned, I poured a few Drops of this Water on the Table, and taking a small Portion thereof on a Pin, I laid it on the end of a small piece of Brass Wire (there lay then by me) of about one tenth of an Inch Diameter; I continued to lay on two or three Portions
of

of Water, till there was formed somewhat more than an Hemisphere of Water; then keeping the Wire Erect, I applied it to my Eye, and standing at a proper distance from the light, I saw them and some other Irregular Particles, as I had predicted, but most Enormously Magnified; for whereas they are scarce discernable by the Glass Microscopes, or the first *Aqueous*, one within the Globule, they appeared not much different both in their form, nor less in Magnitude than ordinary Peas. They cannot well be seen by Day-light, except the Room be Darkned, after the manner of the famous Dioptrical Experiment, but most distinctly by Candle-light; they may be very well seen by the full Moon Light.

The Pin sometimes takes up the Water round enough to shew its Objects distinct.

The Insects I have as yet this way observed, are of two sorts, Globular and Elliptical; I shall first describe the former.

They are of a Globular Form, they are but a little less Transparent than the Water they swim in; they have sometimes two Dark spots Diametrically opposite, but these are rarely seen; there are sometimes two of these Globular Insects sticking together; where they are joyned 'tis opacous, possibly they may be in the act of Generation; they have a twofold motion, a swift Progressive Irregular one; and at the same time a Rotation on their Axes at Right Angles to the Diameter that has the dark Spots, but this is seen only when they move slowly. They are almost of an incredible Minuteness. Mr. *Leewenhoek* is moderate enough in his Computation, when he tells us (*Philosophical Transactions*, N^o 213. Page 198.) he saw Insects in Water, so small, that 30000 could not more than equal a Course Sand; but I believe it will seem a Paradox.

radox to him, when one that tells him so, shall at the same time say, that he can see them only by applying the bare Eye, to a Portion of Water wherein they are contained.

I have Examined many Transparent Fluids, as Water, Wine, Brandy, Vinegar, Beer, Spittle, Urine, &c. and do not remember to have found any of these without more or less of the Bodies of these Insects; but I have not seen any in motion except in common Water, that has stood for sometimes a longer, at others a shorter time, as has been observed by Mr. *Leeuwenhoek*; tho' I do not remember he has observed that they are existent in the Water, before they revive. In the River, after the Water has been thickned by Rain, there are such infinite numbers of them, that the Water seems in great part to owe its Opacity and Whiteness to these Globules. Rain Water, so soon as it falls has many, and Snow Water has more of these Globules: The Dew that stands on Glass-Windows has them; and forasmuch as Rains and Dews are continually Ascending or Descending, I believe we may say the Air is full of them, they seem to be of the same Specifick Gravity with the Water they Swim in, the Dead remaining in all parts of the Water; of many thousands that I have seen, I could discern no sensible difference in their Diameters, they appearing of equal bigness in Water that has been boyled; they retain their shapes, and will sometimes revive.

There is another sort of Insects I have this way seen, but these are not so frequently (at least this Winter Season) to be found, they are much longer then the former; they can Transform themselves into many shapes; they are for the most part Elliptical, but sometimes they contract themselves so as to be almost Globular; and sometimes they extend themselves so, as to be twice
or

or three times longer then broad, these sometimes turn themselves round on their *axes* and Diameters as they go, they consist of Transparent and Opacous Parts.

The first of these natural Microscopes performs its effects by the same Laws, *viz.* by the Refraction of the Rays of Light, as do the Glass ones, and differs from them in nothing but its material Water: But when I began to attempt to satisfy my self how Objects are distinctly seen in a Spherule of Water; I found it at first somewhat difficult to explain, for whereas (*Molineux, S. R. S. Dioptrica Nova Prop. XXXII.*) Objects being placed in the Focus of a Convex Glass (and consequently of Water) are seen distinctly to the Eye, on the other side the Glass, and so the Reason of the former is obvious enough; but 'tis as certain (*Dioptrica Nova, Prop. XLI. Confered with Prop. XXVIII.*) that if an Object be placed so much nigher to the Eye then the focus of a Spher, as to be within its Surface, the Rays of Light must come too much Diverging to shew the Objects they come from distinctly.

But at length, that other known Property, if I may so call it, of light falling on different *Mediums* coming into my thought, *viz.* Reflection, I found there might be a very easie and natural Reason given of its Performance, which I shall now endeavour to demonstrate, upon supposition that the inferior Surface of the Spher is Reflective.

Let the Circle in Figure 8. represent a Spher of Water, *A* an Object placed in its Focus, sending forth a Cone of Rays, two of which are *AB AB* which Opticians know coming into the Water at *B* and *B*, will be Refracted from their direct Course and become *BD* at *D*, they will, at their passing into the Air, be again Refracted into *DE DE*, and so run Parallel to one another, and to the axis of the Sphear *A E C G* now 'tis

a known and fundamental Principle in Opticks, that the Angle of Refraction is equal to the Angle of Incidence; wherefore let the Rays $BD BD$ be imagined to come from some point of an Object placed within a Spher of Water, by being Reflected from the interior Surface of the Spher at $B B C B D$ is the Angle of Reflection, to which making $C B E$ equal, so will F be the place where an Object sending forth a Cone of Rays, two of which are $F B F B$, which are Reflected into the Rays $B D B D$, and then coming to the other side, the Sphear at D and D , they are Refracted into $D E D E$ as before, and consequently be as fit for distinct Vision, whether the Object be placed in F within or in A without the Spher, if its interior Surface be considered as a Concave Reflecting *Speculum*.

That the interior Surface of Glafs, and consequently of Water is Reflecting, common Experience shews; but whether any Body have before taken Notice, that the Air is Specular is to me unknown: But I have, a very few Days since, as I was endeavouring to improve this natural Catadioptrick Microscope stumbled upon an Aereal Concave *Speculum* which I shall now describe.

A Darkned Room being somewhat troublesome to make, I thought it proper to try, if this Inconvenience might not be remedied; so I took a stiff piece of brown Paper, pricking a small hole therein, then applied the Drop of Water to my Eye, and holding the Paper with the hole at a little distance before me, I could see the Globules therein little less distinctly than in a Darkned Rome: But before I had removed the Water, there appeared to me a very strange and surprising Appearance; I saw the Needles point together, with the Water inverted, I could scarce at first believe
my

my Eyes; to be farther satisfied, I removed the Water and found, that whether I held the Needle Perpendicular Horizontal, or inclined to all these postures it was inverted, I then made many holes, and in every one I saw the inverted Picture of the Needle; the nearer the Needles was to the Holes, 'twas so much the more Magnified, but less distinct, if the Needles point were so held, as that its Image were near the edge of the Hole, its point seemed Crooked: So that it seems these small Holes, or somewhat in them, performs the Effects of a Concave Speculum, and so I take leave to call them aerial Speculums; but how the Rays of Light can be Reflected, before they come to a *Medium* of a different Densitie, or how, or by what means the Air remains in small Holes, in a Concave Spherical Form, I must leave to the Consideration of the Learned to Determine.

