

extract this Substance, and broke some Part of it off, but was forced to dilate the *Rectum*, and so extract it that Way. It was a hard unequal ragged flinty Stone, [see the Figure of it in TAB. IV. at F.] was Ten Inches and an half round, and weighed Eight Ounces and an half, after it was extracted. The Woman has been easy from that Moment; the Wounds, by the Care and Skill of her Chirurgions, are healed; she goes about her Business, has got a good deal of Flesh, and is recovered perfectly, except a Numbness and Contraction she has in some of her Fingers of both Hands, and both Feet and Toes.

J. Mackarness.

IX. *An Account of Mr. Leeuwenhoek's Microscopes; by Mr. Henry Baker, F. R. S.*

HAVING been favoured by this Illustrious SOCIETY with an Opportunity of examining the much-talked-of Microscopes of the famous Mr. *Leeuwenhoek*, who, by his Glasses, made such wonderful Discoveries in the *Minutiae* of Nature, as have laid the Foundation of a Philosophy unknown to preceding Ages; I think it incumbent on me to shew the Use I have been making of them.

Upon opening the Cabinet that contains these Microscopes, I laid before me an Account of them, drawn up, and presented to this SOCIETY, some Years ago, by its present worthy Vice-President
Martin

Martin Folkes, Esq; * and found it such an exact and full Description of their Structure and Uses, as renders any farther Attempt to that Purpose intirely needless. I had likewise the Pleasure to find, that the judicious Observations of this Gentleman, on the Goodness of the Glasses, and the admirable Dexterity of Mr. *Leewwenhoek* in the Management and Application of the Objects fitted to them, had reduced my Task to so narrow a Compass, that little more is left for me to offer than a Calculation of their magnifying Powers, some Reflections arising from such Calculations, and a brief Account of what Improvements in Microscopes have lately been made amongst us.

In order to this, the first thing I went about, was to view attentively the Objects applied to these Microscopes by Mr. *Leewwenhoek* himself, which Mr. *Folkes* has given a List of in his Account; but the greatest Part of them were, I found, destroyed by Time, or struck off by Accident; which indeed is no Wonder, as they were only glewed on a Pin's Point, and left quite unguarded. Nine or Ten of them, however, are still remaining; which, after cleaning the Glasses, appeared extremely plain and distinct, and proved the great Skill of Mr. *Leewwenhoek*, in adapting his Objects to such Magnifiers as would shew them best, as well as in the Contrivance of the Apertures to his Glasses, which, when the Object was transparent, he made exceeding small, since much Light in that Case would be prejudicial: But, when the Object itself was dark, he enlarged the Aperture, to give it

* *Philosophical Transactions*, N^o 380.

all possible Advantage of the Light.—The Lens being set so as to be brought close to the Eye, is also of great Use, since thereby a larger Part of the Object may be seen at one View.

It must be remembered, that all these Microscopes are of one and the same Structure, and that the most simple possible, being only a single Lens, with a moveable Pin before it, on which to fix the Object, and bring it to the Eye at Pleasure.

Though I was sensible it must cost much Trouble to measure the focal Distances of these 26 Microscopes, and thereby ascertain their Powers of magnifying, I considered that, without so doing, it would be impossible to form a right Judgment of them, or make any reasonable Comparison between them and our own. This Task therefore I have performed, with as much Care and Exactness as I was able; and have shewn, in the following Table, how many of them have the same Focus, and consequently magnify in the same Degree; how many times they magnify the Diameter, and how many times the Superficies of any Objects applied to them. I have given the Calculations in round Numbers, the Fractions making but an inconsiderable Difference; and hope any Mistakes I may have made in so nice a Matter will be excused.

A Table of the Focal Distances of Mr. Leeuwenhoek's 26 Microscopes, calculated by an Inch Scale divided into 100 Parts; with a Computation of their magnifying Powers, to an Eye that sees small Objects at 8 Inches, which is the common Standard.

Microscopes with the same Focus.	Distance of the Focus.	Power of magnifying the Diameter of an Object.	Power of magnifying the Superficies.
	Parts of an Inch.	Times.	Times.
* 1.	$\frac{1}{20}$ or $\frac{5}{100}$	160	25600.
1.	$\frac{6}{100}$	133 nearly.	17689.
1.	$\frac{7}{100}$	114 nearly.	12996.
3.	$\frac{8}{100}$	100.	10000.
3.	$\frac{9}{100}$	89 almost.	7921 almost.
8.	$\frac{1}{10}$	80.	6400.
2.	$\frac{11}{100}$	72 something more.	5184 something more.
3.	$\frac{12}{100}$	66 nearly.	4356 nearly.
2.	$\frac{14}{100}$	57	3249.
1.	$\frac{15}{100}$	53 nearly.	2809 nearly.
1.	$\frac{1}{5}$	40.	1600.
<u>26.</u>			

* This largest Magnifier of all is in the Box marked 25.

It appears, by the foregoing Table, that One only of these 26 Microscopes is able to magnify the Diameter of an Object 160, and its Superficies 25600 times; all the rest falling much short of that Degree. And therefore, I am fully persuaded, and believe I shall be able to prove, that many of the Discoveries Mr. *Leeuwenhoek* gives an Account of, could not possibly be made by Glasses that magnify no more than this.

I beg Leave to observe, that our Cabinet is but the Second in Mr. *Leeuwenhoek's* Collection, and is very far from containing all the Microscopes he had, as many wrongly have imagined. We find here indeed, 26 Microscopes in 13 little Boxes: Each Box contains a Couple of them, and is marked in Two Places with a Number, to distinguish it from the rest. But as the first of these Boxes is marked 15, and the rest with following Numbers on to 27; it necessarily implies there were 14 preceding Boxes, since no Man begins with the Number 15.—Mr. *Leeuwenhoek*, then, had another Cabinet, that held 14 Boxes before ours in numerical Order, and probably each Box contained a Couple of Microscopes, as our Boxes do. But, besides these Two Cabinets, he had several other Microscopes of different Sorts, as his own Writings will make appear.

The Cabinet now before us seems to have been only his Repository of Objects; for every Microscope herein was engaged by an Object affixed to it, and thereby rendered useless for any other Purpose; whereas those he employed in his daily Observations must have been always ready, and at full Liberty, to examine whatever offered. Many of them too

must certainly have been much greater Magnifiers than any in our Possession.—And we are assured by himself, that such he had; for he often mentions his shifting Objects from his common to his better, and thence to his most exquisite Microscopes: And, besides, (in the Second Volume of his Works, Part 11d. pag. 290.) he says, “ *Mihi quidem sunt centum* “ *centumque Microscopia*, &c. “ I have an hundred “ and an hundred Microscopes, most whereof are “ able to shew Objects so distinctly, even in the “ cloudiest Weather, and by Day-light only, that if “ the *Animalcula in Semine masculino* of Animals “ had the Extremity of their Tails forked, (as described by a certain Writer) I should easily have “ discovered it.”—Among this Number, many, without doubt, were contrived for the Examination of Fluids, since great Part of his Observations were made on them: He informs us also, that his Method was to put them into an exceeding small or capillary Tube of Glass, which there does not seem to be any Means of applying to the Microscopes in our Cabinet, even had they been at Liberty; and much less for the larger Tubes he made use of to view the Circulation of the Blood in *Frogs, Eels, Fishes, &c.* his Apparatus for which we find in the Fourth Volume of his Works, pag. 180.—But to proceed:

Mr. *Leeuwenhoek*, in a Letter to this SOCIETY concerning the *Animalcula* observed by him in the *Semen masculinum* of a *Dog*, which he describes and gives a Draught of, says, they were so minute, that he believed a Million of them would not equal the Size of One large Grain of Sand. Vol. I. Part I. pag. 160. Again, in his 113th Letter, speaking of the
Semen

Semen virile, he declares, that a Million of the *Animalcula* seen therein would not equal a large Grain of Sand; and yet he gives a full Description of their Form; for he says, their Bodies are roundish, somewhat flat before, but ending sharp behind, with Tails exceedingly transparent, Five or Six times longer, and about Five times slenderer, than their Bodies; so that their Figure cannot better be represented, than by a small *Earth-nut* with a long Root or Tail.

Now the Focus of the greatest Magnifier of his being $\frac{1}{10}$ of an Inch, as near as can well be measured, it is capable of magnifying the Diameter of an Object (to an Eye that sees small Objects best at Eight Inches) no more than 160, and the Superficies 25600 times: So that Objects, One Million whereof scarce equal a Grain of Sand, viewed through such a Lens, (as only the Superficies can be seen) could appear no larger than Two Grains and half of Sand would be to the naked Eye; and I submit it to be considered, whether that is not too small a Size for any Man to describe so particularly, and delineate the Form and Parts of.

But Mr. *Leeuwenhoek* goes yet abundantly farther: For, to mention only one Instance, of which there are several in his Writings; he tells this SOCIETY in his Letter of *July 25. 1684.* that he could discern Vessels in the human Eye, so amazingly minute, that, desiring to know their Smallness, he measured them by the Diameter of a Grain of Sand, (the Process of which Mensuration is there set down) and found by arithmetical Calculation, that a large Grain of Sand must

must be divided into * Eighteen thousand Three hundred Ninety-nine Millions Seven hundred Forty-four thousand Parts, ere it can be small enough to enter these minute Vessels.—What shall we now say?—Why, in regard to the Memory of this great Man, to whom the World, and this SOCIETY, are much obliged, I must insist, that he certainly had Glasses, that were much greater Magnifiers than any we have of his.

It may perhaps be objected, that Mr. *Leeuwenhoek* declares, he did not use such small Glasses as some People boasted of; and that, although for 40 Years together he had been possessed of Glasses exceedingly minute, he had employed them very seldom; since, in his Opinion, they could not so well serve to make the first Discoveries of Things, as those of a larger Diameter. In Answer to this, I must beg Leave to observe, that Mr. *Leeuwenhoek*, in this Place, is reflecting on a certain Physician, who boasted of an extraordinary † Microscope scarce bigger than a visible Point, whereby he pretended to discover the *Animalcules in Semine virili* to be exactly of an human Shape, with only a Skin over it. For he says, that while he was attentively observing these *Animalcules*, one of them (a little bigger than the rest) presented itself, having almost slipped off its Skin: And then there plainly appeared Two naked Thighs and Legs, a Breast, and Two Arms, above which, the Skin being thrust up, covered the Head as it were a Cap.

* Vol. I. p. 39.

† Epist. 116. Vol. II. Part II. pag. 84.

The Sex he confesses he could not distinguish, and adds, that it died in endeavouring to get clear of the Skin.

Mr. *Leeuwenhoek* very justly exposes this romantic Discovery, pretended to be made by this Speck of a Microscope; and takes occasion therefrom to let us know, he does not think such minute Glasses are so much to be depended on as those of a larger Diameter. But there are so many Degrees between the smallest Glass we have of his, (whose Focus is at $\frac{1}{10}$ of an Inch) and this almost invisible Point, that we must not infer from hence he used none of a Size between. Nay, this very Letter seems to imply the contrary; for it tells us, that, in examining the *Semen virile*, he made use of Eight or Ten Microscopes of different magnifying Powers: But as all the Microscopes we have of his, have Objects fastened to them, and besides have no Apparatus for Fluids, I think they could not probably be the same he employed for that Examination. May we not rather suppose he had Eight or Ten different Sizes of Microscopes, that magnified more than ours? For we know, Fluids require to be examined by the greatest Magnifiers; and doubtless he made use of such for that Purpose.

There is no Advantage in employing a greater Magnifier for any Object, than what is requisite to shew the same distinctly; but when the Object is exceedingly minute, the magnifying Power of the Glass must be proportionably great, or else it will be impossible to see the Object clearly. A Lens, (for Example) that shews a whole *Flea* distinctly, magnifies

nifies not near enough to shew the *Animalcules* in the *Semen* of that *Flea*.

I am sensible, that Mr. *Leeuwenhoek*, by long Practice, and uncommon Attention, might be able to discern many Objects with these Microscopes, which others, less accustomed to Observations of this kind, cannot readily do: His Eyes too might be somewhat different from the Standard I measure by. But all these Allowances will not, I think, suffice to reconcile the Passages I have quoted with the Powers of the Glasses under Examination.

While I was overlooking these Microscopes of Mr. *Leeuwenhoek*, an Opportunity presented of examining and comparing with them a curious Apparatus of Silver with Six different Magnifiers, belonging to Mr. *Folkes*, and then newly made for him by Mr. *Cuff*, in *Fleetstreet*.—The Body of this Instrument, into which the Glasses are occasionally to be fastened, is after the Fashion of *Wilson's* Pocket Microscope, and contrived to screw into the Side of a Scroll fixed on a Pedestal, from which a turning *Speculum* reflects the Light upwards upon the Object: It is likewise contrived to be used with the Apparatus of the Solar Microscope: Descriptions and Figures of both of which I have since given in a Book intituled, *The Microscope made easy*. Edit. 2^d. Lond. 1743. 8^o.

I measured the focal Distances, and magnifying Powers, of the Six Glasses, and found them to be as follows:

A Table of the Six Magnifiers belonging to Mr. Folkes's Microscope, calculated by an Inch Scale divided into an hundred Parts, with a Computation of their Powers, to an Eye that sees Objects at Eight Inches.

Glas-	Distance of	Magnifies the	Magnifies the
ses.	the Focus.	Diameter.	Superficies.
1ft. . .	$\frac{1}{50}$ of an Inch. . .	400. . .	160,000.
2d. . .	$\frac{1}{20}$	160. . .	25,600.
3d. . .	$\frac{8}{100}$	100. . .	10,000.
4th. . .	$\frac{18}{100}$	44. . .	1,936.
5th. . .	$\frac{3}{10}$	26. . . .	676.
6th. . .	$\frac{1}{2}$	16. . . .	256.

The above Calculation shews, that Mr. *Folkes's* First Glass magnifies the Superficies of an Object Six times as much as the greatest Magnifier of Mr. *Leeuwenhoek*: And that the *Animalcula* (a Million whereof, he says, scarce equalled the Bigness of a Grain of Sand) would, if viewed with this Magnifier, appear as large as Sixteen Grains of Sand do to the naked Eye. And I cannot suppose but Mr. *Leeuwenhoek* had Glasses to magnify even more than this, though they are not come to us. For I cannot otherwise conceive, how he could observe the *Animalcules* in the *Semen masculinum* of a *Flea*, and of a *Gnat*, as we find he did, (Vol. IV. pag. 21, 22.) or assert, as he does in the strongest Terms, (pag. 23.) that he could see the minutest Sort of *Animalcules* in *Pepper-water*, with his Glasses, as plainly as he could Swarms of *Flies* or *Gnats* hovering in the Air with

his naked Eye, though they were more than Ten Millions of Times less than a Grain of Sand.—And lest this should be imagined only a random Guess, he gives immediately a regular Arithmetical Calculation to prove his Computation right. But I believe we must all be sensible, that no Glasses in this Cabinet are able to render such minute Objects distinguishable.

I am desirous to do all possible Justice to these Microscopes, by acknowledging their Excellence, as far as their magnifying Power extends: But I should do Wrong to Mr. *Leeuwenhoek*, should I suffer the World to believe these were his greatest Magnifiers; since whoever hereafter should examine them with that Imagination, would be apt to entertain a bad Opinion of his Veracity.

Experience teaches, that Globules of Glass extremely minute, though they magnify prodigiously, are seldom able to shew Objects sufficiently distinct, and therefore are very apt to lead People into Errors: Which certainly was a good Reason for Mr. *Leeuwenhoek*'s rejecting them: But a ground convex *Lens*, though much smaller than any of his before us, if rightly applied, will shew exceedingly minute Objects magnified to a surprising Degree, and with sufficient Light and Clearness, as Mr. *Folkes*'s First Glass witnesses.

I hope I shall not be imagined to intend any Disrespect to this famous Man, if I suppose, that our present Microscopes are much more useful and convenient than these of his. Let him always be remembered with the highest Honour, for the wonderful Discoveries he made, and the Microscopes he

has left us, which are indeed extraordinary, when considered as the First almost of their Kind: Let us reverence him as our great Master in this Art. But the World since must have been strangely stupid, if it could have improved nothing, where there was room for so much Improvement. I do not mean as to the Glasses (for the Goodness of these before us, gives just Reason to believe he might have others as excellent as can perhaps be ever made); but as to the Structure of the Instrument they are set in, and the Manner of applying Objects to them. And I fancy most People will allow, that herein great Improvements have been made: And it is with Pleasure I find, that a large Share of the Credit belongs to our own Countrymen.

One thing alone (which, when slightly considered, may appear but trifling) has conduced greatly to these Improvements; and that is, the making use of fine transparent *Muscovy Talc* or *Isinglass*, placed in Sliders, to inclose Objects in. Had Mr. *Leeuwenhoek* known this Way, it would have saved him a vast deal of Expence and Trouble: For then, we may reasonably suppose, instead of making an intire and separate Microscope for every Object he was desirous to keep by him in Readiness to shew his Friends, he would probably have secured his Objects in Sliders, as we at present do, and have contrived some such Means as ours, of screwing his several Glasses of different magnifying Powers, occasionally, to one and the same Instrument, and of applying his Sliders to which of them he judged best.—A few good Glasses, gradually magnifying one more than other, would, by such a Method, have answered all the

Purposes of his great Number, and his Objects would have been preserved in a much better Manner.

I shall forbear troubling you with the different Microscopes invented by *Wilson, Marshal, Culpeper, Scarlet*, and others, (though all deserving Praise) since you are already so well acquainted with them: But Two extraordinary Improvements have appeared within these Two Years, which I beg Leave to lay before you, as I think it has not been yet done.— I mean, the Solar or *Camera Obscura* Microscope, and the Microscope for opaque Objects. Both these Inventions we are obliged for to the ingenious Dr. *Liberkhun*, who, when he was in *England* last Winter was Twelvemonth, shewed an Apparatus of his own making, for each of these Purposes, to several Gentlemen of this SOCIETY, as well as to some Opticians, amongst whom Mr. *Cuff*, in *Fleetstreet*, has taken great Pains to improve and bring them to Perfection; and therefore the Apparatus prepared by him is what I am about to describe.

This Solar Microscope is composed of a Tube, a Looking-glass, a convex Lens, and a Microscope. The Tube is of Brass, near Two Inches in Diameter, fixed in a circular Collar of *Mahogany*, which, turning round at Pleasure, in a square Frame, may be adjusted easily to a Hole in the Shutter of a Window, in such a Manner, that no Light can pass into the Room but through the aforesaid Tube. Fastened to the Frame by Hinges, on the Side that goes without the Window, is a Looking-glass, which, by means of a jointed brass Wire coming through the Frame, may be moved either vertically or horizontally, to throw the Sun's Rays through the brass Tube into the darkened Room.

Room. The End of the brass Tube without the Shutter has a convex Lens, to collect the Rays, and bring them to a Focus; and on the End within the Room, *Wilson's* Pocket-Microscope is screwed, with the Object to be examined applied to it in a Slider. The Sun's Rays being directed by the Looking-glass through the Tube upon the Object, the Image or Picture of the Object is thrown distinctly and beautifully upon a Screen of white Paper, and may be magnified beyond the Imagination of those who have not seen it.—I assisted lately in making some Experiments with Dr. *Alexander Stuart*, by means of this Instrument, and a particular Apparatus contrived, by him, for viewing the Circulation of the Blood in *Frogs, Mice, &c.* and had the Pleasure of beholding the Veins and Arteries in the Mesentery of a *Frog* magnified to near Two Inches Diameter, with the Globules of the Blood rolling through them as large almost as *Pepper-corns*. We examined also the Structure of the Muscles of the *Abdomen*, which were prodigiously magnified, and exhibited a most delightful Picture. But, as the Doctor intends himself to communicate to you an Account of these Experiments, I will not anticipate your Pleasure.

The Microscope for opaque Objects remedies the Inconvenience of having the dark Side of an Object next the Eye: For by means of a concave Speculum of Silver, highly polished, in whose Centre a magnifying Lens is placed, the Object is so strongly illuminated, that it may be examined with all imaginable Ease and Pleasure.—A convenient Apparatus of this kind, with Four different Specula, and Magnifiers of different Powers, has lately been brought
to

to Perfection by Mr. *Cuff*; whose Copper-plate and Description of it, as it will save much Trouble, and make me better understood, I take the Liberty, at his Desire, to present herewith, together with his printed Account of the Solar Microscope, the Pocket Microscope, and the Microscope before spoken of, with a Scroll, Pedestal, and Speculum, of which there are also Copper Plates. These, with the large double reflecting Microscope, are, I think, the chief, if not the only useful Sorts now made in *England*.

I must not omit taking notice, that Mr. *Leewwenhoek* says, (in his Second Volume, Part II. pag. 93.) that sometimes, to throw a greater Light upon his Objects, he used a small convex Metal Speculum. How he applied it, I will not pretend to guess; but it is highly probable our double reflecting Microscope may be owing to this Hint. I must also observe farther, that in the Fourth Volume of his Works, pag. 182. after describing his Apparatus for viewing *Eels* in glass Tubes, Mr. *Leewwenhoek* adds, that he had another Instrument, whereto he screwed a Microscope set in Brass; upon which Microscope, he tells us, he fastened a little Dish (of Brass also, I suppose), that his Eye might be thereby assisted to see Objects better: For he says, he had filed the Brass which was round his Microscope, as bright as he could, that the Light, while he was viewing Objects, might be reflected from it as much as possible. This Microscope, with its Dish, (which I give an exact Copy of from the Picture in his Works) seems so like our opaque Microscope with its silver Speculum, that, after considering his own Words, I submit to your better Judgment, whether he is not properly the

the Inventor of it. His Words are these,—“ Supra
 “ hoc Microscopium Catillum ferruminavi, ut oculus
 “ objecta tanto melius videret: nam cuprum circa
 “ Microscopium, quantum pote, lima abraferam, ut
 “ Lumen in conspicienda objecta, quantum pote,
 “ irradiaret.”

See the Figure of this Apparatus in TAB. IV. at G.

**X. An Inquiry into the Causes of a dry and
 wet Summer. By an anonymous Hand.**

THE wet Weather which we had in *March*
 1734. (the Year beginning with *January*) set
 me on considering what might be the Causes of it.
 The Wind was then, generally, South-west, the
 Weather rainy. Sometimes it veered to South-east,
 which, commonly, brought much Rain: But the
 Wind seldom stood at that Point 24 Hours, before it
 returned to South-west again. A strong Gale at
 South-west, with Rain, would be succeeded by as
 strong at North-west, still raining; but if the North-
 west continued 24 Hours, it cleared the Sky. The
 Summer following was cold and wet; the Wind on
 the same Points. The preceding Winter was mild,
 and especially *December*, in which Month, from the
 10th inclusive, the Wind blew, generally, South-west,
 sometimes strong, attended with much Rain. At
 the End of *December*, the Birds sang, and the Grass
 did grow as at other Years in the Spring.

The Winter of 1734. was as mild as that of 1733.
 the Birds as joyful, and the Grass as green at the End
 of





