

# PHILOSOPHICAL TRANSACTIONS.

For the Months of *August* and *September*.

*Septemb. 21. 1674.*

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*Microscopical Observations from M. Leeuwenhoeck, concerning Blood, Milk, Bones, the Brain, Spittle, and Cuticula, &c. communicated by the said Observer to the Publisher in a Letter, dated June 1. 1674.*

Sir,

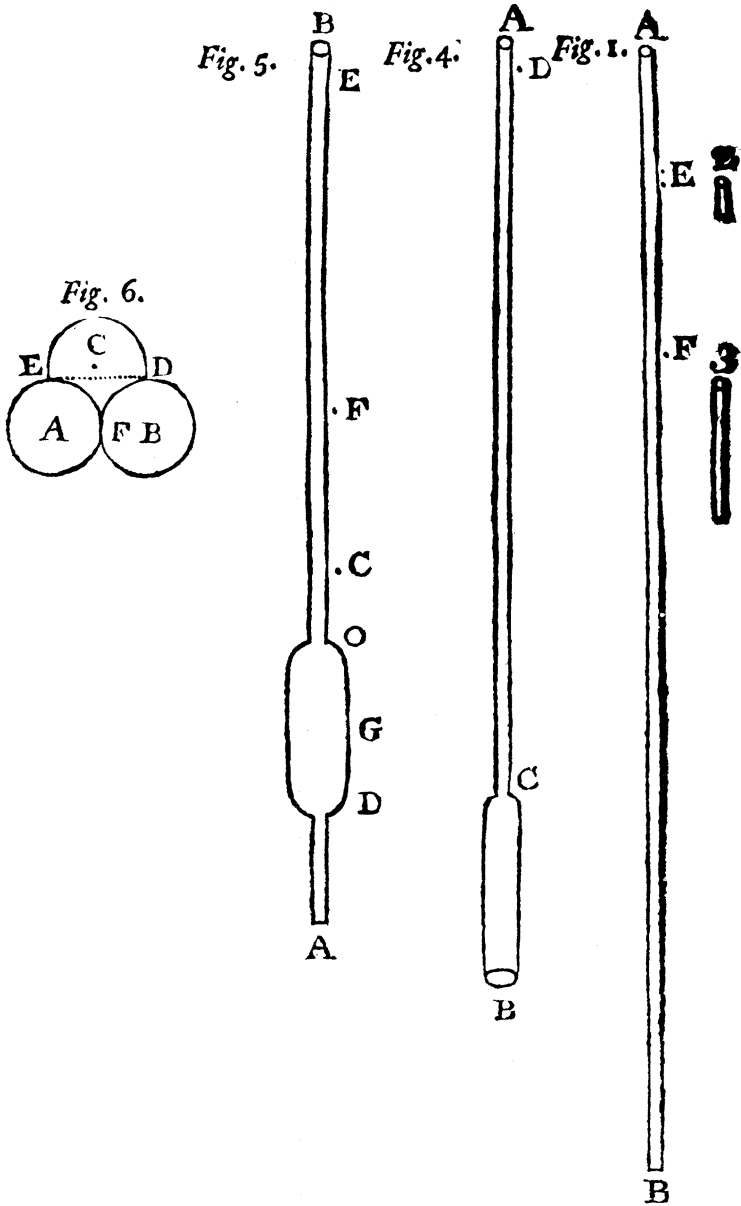
Yours of 24<sup>th</sup> of *April* last was very welcome to me; Whence I understood with great contentment, that my Microscopical Communications had not been unacceptable to you and your Philosophical Friends; which hath encouraged me

R. me

me to prosecute such Observations, concerning which I shall at present impart to you what follows :

1. The small Red Globuls in the Blood, formerly spoken of\*, are heavier than the CrySTALLINE liquor in  
 See *Numb.* 102. P. 23. which they are carried, because soon after that the Blood is let out of the Veins, those Globuls by little and little subside towards the bottom ; and being made up of soft fluid Corpuscles, and many lying upon one another, they do unite themselves close together, and by this close conjunction the Blood that is under the surface alters its colour, and becomes dark-red or blackish ; as I have observed several times : of which I take the reason to be, (with submission to better Judgments) that the Air cannot move every way round about the Globuls, and hits as 'twere against a close darkish body. Touching the *Florid* red colour of the surface of the Blood exposed to the Air, that comes, in my opinion, from hence, that the *uppermost* Globuls are not press'd, and therefore retain their nature, and the Globuls *subjacent* to the uppermost lye close together, by reason of which close conjunction the Air or Light cannot penetrate through them, but is reflected, and so gives a greater light to, and about, the uppermost Globuls, than they had before the union of the inferiour Globuls ; and this it is that makes them appear more florid.

2. I shall herewith communicate the Manner *how* I have observ'd, among other things, *Blood* and *Milk*. I did my self  
 See Fig. I. prepare divers sorts of very slender hollow Glass-pipes, as A B, of which some were not thicker than a mans-hair ; and the slenderer they are, the clearer will they make the red Globuls of the Blood appear. But, for seeing the CrySTALLINE water in which those Globuls move, and for observing also how they subside, these Pipes may be made somewhat thicker. Having then made ready such a small Pipe, I tye about the uppermost joynt of (e. g.) my thumb a string, as is usual in opening a Vein of an Arm, and then I prick that part of my thumb with a pin, to make it bleed ; this blood I wipe off, if I intend to keep any for the Air. And then I look well to the place prick't, putting upon that point my Glass-pipe, and withal squeezing my thumb to press out  
 more



more blood; which being thus prefs'd out, will in part run up into the said pipe: This pipe with the blood in it, I lay upon a piece of white paper, and with my nail break a little piece

piece from it, as *Fig: 2<sup>d</sup> or 3<sup>d</sup>*; and set it to the pin of my Microscope, having first a little wetted the pin with my spittle, or a little turpentine, to make the pipe stick to it; or else I take the whole Glass-pipe, and with my hand hold it before the Microscope. Now in such a Glass-pipe, the blood on the surface, and that which is under it, is almost of the same colour, although it stand a pretty while in it, because the Globuls in the Glass-pipe are but few, nor lie they so close together. The slenderer the pipe is, the higher will the blood rise into it. And that the Curious in your parts might themselves see this, I have used the freedom of sending you some of the said hollow Pipes, by the means of which I hope my above-mention'd speculations will be verified.

The red Globuls of the Blood I reckon to be 25000 times smaller than a grain of sand; which perhaps will to many seem incredible: But the matter being about figured Bodies, 'tis known, that, two Globes being given, the Axis of one whereof is 1, and that of the other, 20, the proportion between their magnitudes is as 1 to 8000; Spheres being in a triplicat proportion to their Diameters. The same red Globuls, when they are single, and stick within to the sides of the Glass-pipes, will appear white and colourless.

3. Further, if your Curiosity shall lead you to observe the motion of those red Globuls thorow the Crystallin liquor, be pleased to take one of the thicker sort of these pipes: filling it with blood from E to F, and so putting the lower  
*See Fig. I.* end B. a little into the flame of a Candle, and closing it hermetically. Which done, set the pipe upright, with the end A upwards, that so the red Globuls may sink. And desiring to see the motion of those Globuls, apply a little warmth to the pipe between F, B, making use only of a warm hand; by which warmth the Air betwixt F, B, must expand itself into a greater space, and the blood in the pipe will be driven up higher; by which means the red Globuls will in part come to move above in the Crystallin humidity; yet if those Globuls come to joyn themselves too close together, this Observation will fail.

4. I have several times endeavoured to observe the parts of a *Bone*, and at first I imagin'd, I saw on the surface of the Shinbone of a *Cow* several small veins (which bone I still keep by me,) but I have not found it since in any other bone. I thought likewise, I saw then also, that that Bone consisted of united Globuls. Afterwards I viewed the Shinbone of a *Calf*, in which I found several little holes, passing from without inwards; and I then imagined, that this Bone had divers small pipes going longways: But I have since observed the *Tooth* of a *Cow* and I found it made up of transparent Globuls which I can see very perfectly. The same I have observed in *Ivory* or *Elephants-Teeth*. And having seen this several times, I doubt no longer but that all white Bones do consist of transparent Globuls. Which being so, I am of opinion, that all things that appear white to our eyes are made up of nothing but transparent particles lying one upon another: Such as are Snow, white Paper, Linnen, white Stones, white Wood, Scum, beaten Glais, beaten Rosin, Sugar, Salt, &c.

5. Again, I have observed the *Liver* of a *Sheep*, and that of a fat plethorick *Cow*; and they also consisted of very small Globuls, which appeared so little as those of Blood. The Liver of the *Cow* was of a Brown-red colour: yet viewing it in my Microscope, I found the particles, which I took from that Liver, to have but very little colour, only they were a little bright towards the red edge, and generally beset with very small Globuls of blood; and in some few places the blood lay vein-wise. Whence I cannot otherwise judge, but that these small particles of blood lay up and down dispersed through the Liver out of the veins. I caused part of those Livers to be boyled, esteeming, that by reason of their natural softness, all could not well be observ'd that might be remarkable in it; and I exposed it to dry somewhat hard; and thus in both of them I did see the Globuls: which I intend to observe yet further

6. The *Brains* of a Cow being viewed by me, I found the White substance thereof to be made up also of very fine Globuls. As for the Gray colour of the Brain, I have not as yet my self been able to observe any thing in it that is particular, by reason of its duskishness. Now that the Curious may be assisted to view the particles of the brain, I herewith send also some Glafs-pipes, by me contrived for that purpose. A B

is a hollow Glafs-pipe, A C is of the thickness of a course horse-hair. Its end from A to D, I thrust into the white of the Brain (having first open'd it with a Pen-knife,) and to the open end B, I apply my mouth, and there suck as strongly as I can, and during that suction I move the pipe by thrusting it inward and drawing it outward, so that the point A remains still moving in the white matter of the Brain: By which means I got a little of that part of the

*\* Perhaps it will be said, that the natural texture of the parts of the Brain, by being forced into these small pipes, is much altered and vitiated.*

Brain into my Glafs-pipe, which I view in the manner above-prescribed in the account of blood. But this I shall also observe again at my next conveniency\*.

7. As to the *Marrow* of the Back-bone, I found that also to consist of very subtil Globuls; yet some few Globuls *stood out*, of a bigger size: Whence I doubted whether these bigger Globuls might not be caused by the labor of my suction and motion, having used the same way in viewing this Marrow, as I did in observing the Brain.

8. Having divers times observed the *Flesh* of a Cow, I found it to consist of very slender filaments, lying one by the other as if moven into a film. I have also viewed several filaments, which were beset with Globuls. These Globuls I judged to be blood, and that, pricking our body with a pin without hitting a vein, the bloody Globuls did issue from between these filaments: But this I leave to further consideration. Mean time I have with a pins point sever'd these filaments from one another, and found the single ones so fine, that any of them seem'd to me some 25 times thinner and finer than a hair. Having exposed them to my Microscope, I saw to my wonder, that they were made up of very small conjoined Globuls, which in smallness seem'd to surpass all the rest. This I took notice

notice of frequently, being unwilling to take up any thing for truth, but what I have seen divers times, and in divers parts.

9. Having view'd *fasting Spittle*, I found in that fluid matter carried some few and those very small Globuls, of which I observ'd some to subside. I saw also therein several odd particles, some of which seem'd to consist of united Globuls. But looking upon the *Spittle* in the afternoon, I found those Globuls and odd Corpuscles in a greater number. I conclude hence, that all Bodies made out of Fluid matter do consist of Globuls; and am therefore of opinion, that if a drop of water could be placed in the free Air, it would be a perfectly round body and consequently, when out of any fluid matter in our body there are made consistent particles, that they also must be press'd together on all sides: Which pressure I esteem to be greater in our Body, than if the Water should press the Air, or the Air the Water. And by the same pressure the particles are likewise press'd together; whereupon must also ensue the roundness of their bodies.

10. The *Cuticula* or uppermost Skin of our Body consists of round parts or small scales, (as far as I have been hitherto able to judge :) And I fancy, that the continual growth of this *Cuticula* is made in this manner: If, *for example*, you let fall upon a white paper a little drop of Gum-water, the water will in a little time steam away, and the Gum will keep the surface of the drop. Now I imagine this Gum-water to be the humors, that are continually emitted out of our Body, whence the humidity issues forth from between all those round particles or scales lying close upon another, and not through *pores*, as many have taught. Like a close and well-twisted Cable, upon which powring continually some water, this water will pass through the whole Cable and issue out at the end; not passing through any pores, but making its way about and between the filaments of the Cable, and so getting out beneath. And the courser or more consistent matter, which I compare to Gum, cleaves to the body, and so maketh the uppermost skin, which skin thus grows on from beneath and is worn off from above: And the more transparent these particles are, the whiter is our skin. Which yet are but our conjectures and suspicions. And the  
like

like manner of growing I have formerly said to have place in *Plants*; only with this difference, that, when the superface of a moist Globul, which is given out of the Plant, is become somewhat stiff, the moisture is then propelled out of the upper end of the plant, and that by a continual succession. Which kind of progress of growing I apprehend may in some manner be seen in the Pith of *Wood*, in *Cork*, in the Pith of *Membranes*, as also in the White of a *Quill*; of which three last I have sent you and your curious Friends some small particles, cut off with a sharp Pen-knife, thinking it well worth their observation. Only I would here advertise, that when any of these particles is applied to the pin of such a kind of Microscope as mine is, the instrument may be held within doors and in the shade, yet held to the free Air, as if with a Telescope you would look upon the Stars in the Firmament.

*Other Observations made by Mr. Leeuwenhocck, about Sweat, Fatt, Teares; imparted to the Publisher in a Letter of July the 6th 1674.*

1. I Have often viewed the *Sweat* of my face, which consisted of a Crystallin moisture, in which I saw some, but very few, transparent Globuls, as also a very few, but bigger and odd particles of different forms, which latter I esteem to be particles scaled off from the *Cuticula* or uppermost skin.

2. I have also observ'd the *Sweat* of several Horses; first in such, as sweat but a little, yet so that I could wipe off some drops of Sweat from their heads: In which I saw likewise some Globuls swimming in the Crystallin humidity, as also some odd bigger parts: But then in Horses that had labour'd harder, or run more violently, and sweat so as that white sweat-drops run from their body, I saw in them a great abundance of Globuls moving in the Crystallin moisture, together with some of those odd bigger parts, which I likewise judged to be scalings off from the *Cuticular*.

3. Heretofore I acquainted you, that I imagined to have seen *Hair* as made up of united Globuls, and to have also observ'd *Elephant's hair* to consist of the like. I cannot omit

now



now to communicate unto you, that since that time I have seen such Globuls not only in *Mans* and *Horse-hair*, but also frequently in the *Wool of Sheep*; and further, that the *Root* of the hair pull'd out of my *Eye-brows* consists altogether of the like Globuls.

4. Having pull'd out of an *Elephants-tayl* a black Hair, and cut tranſverſly from it a thin ſcale, I expoſed it to my Microſcope, which repreſented in the thick of that Hair about an hundred little ſpecks ſomewhat whitish, and in each ſpeck a black point, and in ſome few of thoſe black points, a little hole; and this hair conſiſted withal of united Globuls, which yet I thought I ſhould have found bigger in this thick hair of ſo bulky a Beaſt, than indeed they were. This Scale I keep ſtill by me becauſe of its curious and elegant appearance, not unlike (excepting the Colours) a *Peacocks-tayl*.

5. I have formerly ſent you my way of ſeeing the motion of the Globuls in the Cryſtallin liquor of the *Blood*: Having ſince contriv'd a more convenient Glaſs-pipe for that purpoſe, I cannot but give you and your Curious Friends notice thereof; *viz.* A B is a hollow Glaſs-pipe from B to O, about the thickneſs of a courſe horſe-hair; from O See Fig. V. to D, about the thickneſs of a Pigeons-quil, and the thickneſs from D to A ſomewhat ſlenderer, *ad placitum*. 'Tis open on both its ends, A and B: Into this pipe I brought ſome Blood from E to F, or from E to C, and then ſeal'd the end A hermetically: Or elſe, I leave the pipe cloſed at A, and by the application of my hand or breath bring a little warmth to the thickeſt part of the Glaſs G, holding the pipe with my two fingers at F, and ſo conveying its open end B to the Blood, &c. Whereupon ſome of the Air in the pipe, being by the ſaid warmth driven out at the open end B, it will immediately endeavour to have its former ſtate, and ſo attract a little blood into the ſlenderer part of the pipe: which pipe I then put from A to G into a ſmall Copper-pipe, which I had cauſed to be fitted to one of my Microſcopes, and which I can move at pleaſure, nearer or further off, higher or lower.

6. I did lately view † ſome Blood, in which † In one of the new-  
there was much of that Cryſtallin liquor, and by diſcribed pipes.

going into the open Air, at a time when there were pretty strong gusts of wind, I saw, to my great delight, continually, and without any other motion but that of the wind, the red Globuls agitated pefle-mefle, and as if each Globul had yet a fecond motion, and that about its axe.

7. I fhew'd to Mr. C. H. and couched in writing, how I had obferv'd the Blood, &c. furnifhing him alfo fome of thofe fmall Glafs-pipes; which together with my Letter being fent by him to his Son at *Paris*, he had this return from him, that they had feen no Globuls at all in the blood, but other particles. This may happen alfo to others, who are therefore hereby advertifed that thofe red Globuls, ftanding ftill, do foon come to ftick to one another, (as I have obferv'd my felf more than once,) and being thus carried thorow the Cryftallin humidity, exhibit odd and mifhapen particles: Which doubtlefs is the reafon, why the faid Globuls were not feen by the above mention'd perfon, and why indeed they cannot be feen in that cafe.

8. Thofe fmall Glafs-pipes, which I am wont to obferve any fluid matter with, are clos'd by me on both ends; and when I come to make ufe of them, I break off with my nail the clos'd ends, that fo the Earthy particles, that fwim continually in the Air, may not get into the pipes, having frequently found, that when thofe pipes have been open a while in the Air, they are in many places befet with earthy particles and filaments, which, without this precaution, might be taken for parts of the matter itfelf that is under obfervation.

9. I have heretofore view'd the *Fatt* of Mutton and Cows, and fhew'd to feveral of the Curious, that it is made up of Globuls joyn'd together, which appear'd to my eye, as big as ordinary hail-ftones: Yet are we not to fancy, as if thefe Globuls, and thofe that conftitute a Bone and other folid parts, did confift of Globuls perfectly round: For, if that were fo, it muft follow, that the interfices betwixt fuch Globuls would be triangular, or they be fill'd up with other Corpufcles. But you are to know, that they are round but on one fide; as, for example, See *Fig. VI.* A and B are two Globuls of Fat, that are formed firft, and the third being a forming, and to be plac'd between and above A and B, it will take the form of C, and fo

so make up the triangular body FDE, as in the Fig. annext. And thus I think I see the grosser parts of Fat, not perfectly round. And if any of the Curious desire to see the Globuls, of which the greatest parts of Fat are made up, they may be pleas'd to take care, that there be taken a piece of the coursest Fat, and that with the hand it be broken afunder; which way being observ'd, there will then (yet not always) some small particles of fat, in the midst of the fat, be sever'd, which being dextrously applied to the pin of the Microscope, you will be able to see its form: For if you break off a piece of fat with a pin, you will tear the Globuls.

10. I have lately observ'd, that each buble or globul of Fat consists of more than a thousand small Globuls. Yet I am apt to believe, that those that have not seen the Globuls in Blood, Hair, Bone, &c. will not satisfie themselves about seeing the Globuls in the Globuls of Fat, because of their extraordinary minuteness.

11. The Fat of some *Water-fowl* and *Fish*, though it have been view'd by me, yet shall I endeavor to observe it again before communication.

12. Having view'd the *Tears* of two infants, I found therein very few round Globuls, but much more other odd and misshapen particles, of divers forms; some of which seem'd to consist of united Globuls. I was thinking, because those Tears had run down the Cheeks, whether all these particles might not be scallings off of the Cuticle. For I presume, if the Tears of a grown person, and such as are caused from much grief, and are shed copiously, were well viewed, there would in all appearance be much more seen in them.

*An Account of a notable Case of a Dropsy mistaken for Gravitation in a young Woman; communicated by a Learned and Inquisitive Physician in Holland, considerably enlarging the Observation made of the same Case by the famous Dr. Tulpius, lib. 4. Obj. c. 48.*

Some years since, there came to Dr. D. a young Woman of about 17 years of age, unmarried and reputed a Maid, of a florid countenance, and strong body, having a good stomach, *periodicè menstruata*, and wanting none of other due evacuati-