

II. *Several Experiments touching the seeming Spontaneous Ascent of Water.* By Mr. Fr. Hauksbee, F. R. S.

EXPERIMENT I.

THE several Experiments, which already hath been made in relation to the Spontaneous Ascent of Water in small Tubes, not only by my self, but several others, with much the same success, gave me the occasion of thinking, whether the Figure of the Vessel might, or might not, contribute to the oddness of the Appearance. And to give my self that Satisfaction, (an Account of which I thought would not be unacceptable to the Society) I proceeded as follows.

I procured a Couple of Glas Plates, about seven Inches long, and one and a half broad; these Plates were part of a broken Looking Glass; and notwithstanding when clapt together, they seem'd to touch one another in so many parts, yet when they came to be immerfed in a Liquid, the Liquid would ascend between them; but so thin and colourless it was, that it could not without difficulty be discerned, but upon the separation of them, when they would be found wet on all their parts: therefore to make it more obvious, I put a small piece of thin Paper on each corner; by which means, when laid one on the other, they became separated by such a distance, as is equal to the thickness of the Paper. In this manner I plung'd one end under some strongly ting'd Liquor; where it no sooner arriv'd, but the Water run
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(but not with that Velocity as in a small Tube) gradually, sometimes higher in one part than in another, shooting it self very pleasingly into Branches divers ways, and so would continue till it had arriv'd to its greatest height; but that would be according to the distance the Planes were plac'd asunder: for if, instead of one, two pieces of Paper were laid on each corner of the Planes, the Water then would not ascend so high between them, as when they were separated only by a single one. And then, if the Planes were any ways declin'd, the Water would still spread it self farther and farther, agreeable to the degree of Declination: and this on several tryals succeeded much the same.

E X P E R I M E N T II.

Having seen the success of the former Experiment in the open Air, I was willing to try what appearance it would afford in *Vacuo*; accordingly I fixt the two Planes so to a Brass Wire, (which pass thro' the Cover of a Receiver) that I could make them descend at pleasure. In this manner, with a Dish of ting'd Liquor, I convey'd them within the Receiver; which having plac'd on my Pump, I proceeded to exhaust its contain'd Air, which the Gage, in a little time, discover'd to be pretty nicely done. Then I plung'd the Planes (separated by Pieces of thin Paper as before) into the Water, where, as in the open Air, it arose between them; only with this difference, that there appear'd more Intervals, or Spaces, between the Branches of the ascending Liquid, than in the former Experiment; but when I came to let in the Air, those Intervals vanish'd, and an entire Body of the Liquid succeeded; yet the exact form of the upper parts of it remain'd unalter'd.

E X P E R I M E N T III.

By the foregoing Experiments I found, that neither the Figure of the Vessel, nor the Presence of the Air, did any ways assist in the Production of the forementioned Appearance. To try therefore whether a quantity of Matter would help to unriddle the Mystery; I produc'd two Tubes of an equal Bore, as near as I could, but of very unequal Substances, one of them being at least ten times the thickness of the other; yet when I came to plunge them into the prementioned Liquid, the Ascent of it seem'd to be alike in both. Now since the form of the Vessel, the presence of the Air, or the quantity of Matter that composes the Vessel, do not any thing contribute to the Production of the Phænomenon, it may not be amiss, to inquire a little into the Nature and Property of some other Body, that operates with equal Vigour, under the prementioned Circumstances; and by a Comparison of one with the other, we may at length arrive nearer to account for the same.

What I shall now use to compare with these Experiments, is the Magnet.

First, A Magnet of any form will attract Iron.

So by the first Experiment, the Figure of the Vessel seems no ways to contribute to the Ascent of the Water.

Secondly, The Magnet is no ways lessen'd in its vigour of Attraction, even in so thin a Medium as a *Vacuum*.

So by the second Experiment we find the presence of the Air to be no ways necessary to assist in the Ascent of the Water, in small Tubes, or between the Planes.

Thirdly,

Thirdly, The Magnet, as suppose one of a Pound weight, that will take up or suspend a piece of Iron of the like weight, and no more, (supposing it to be in every part of equal vertue) when separated and broke into a number of small parts, (imagining them not to weigh above half a Grain each) and these dress, and Arm'd according to Art, will then be capable to suspend fifty, nay perhaps a hundred times more the weight of Iron amongst them now separate, than they could when all of one Mass; which appears to me, that the Attractive Quality of the Stone seems to be increas'd in Proportion as its Superficies is to its Bulk of Matter.

So by the third Experiment, I found that the Quantity of Matter, that was us'd to compose one Vessel more than the other, signify'd nothing to the Ascent of the Water, which seem'd wholly to depend on the largeness, or the smallness of their Cavities, as to the height it would arise in them; and as their Cavities are lessen'd, so the Disproportions of their inward Surfaces to their Cavities are increas'd.

And as the Magnet, when separated into the prementioned number of small Parts, will attract more than when united in one, and is no more than separating or working the prementioned thick Body of Glass into a number of small Tubes, that is multiplying the Surfaces; the Water then would arise in each of them singly, as it would when all in one Body, its Cavity being the same with the others; by which means, the quantity of Water ascending in them is augmented from the same Quantity of Matter.

To conclude: There seems to be such an agreeableness of the Qualities or Dispositions of one with the other, that I see no reason why the Facts proceed not from one and the same Cause; for as the inward Surfaces of the Tubes are made smaller and smaller, so the Power of their Attraction (as is visible by the higher

Ascent of the Water in them) is greater and greater, and is most demonstrable by the Experiments of the Planes ; for their inward *Area* being always the same, so that as they are placed nearer and nearer to each other, the Cavity or Space between them becomes less and less, and consequently the Disproportions are increased, whereby the Power of their Attraction is augmented.

EXPERIMENT IV.

This Experiment I take to be very Analogous to those lately made on the seeming spontaneous Ascent of Water between Glass, Marble, and Brass Planes, as also with those made in Capillary Tubes ; since it seems to proceed from the same Principle, and subject to the same Laws, as appears by matter of Fact ; which take as follows. I took a Glass Tube about 32 Inches long, the Diameter of its Cavity near three quarters of an Inch : This, when I had ty'd a Piece of Linnen Cloth at one end, (to prevent the Ashes from falling out) I proceeded to fill with Ashes at the other: the Ashes were sifted thro' a pretty fine Searse. At every small Portion I put in, I ramm'd them strongly down with a Rammer, whose Basis was very little less than the Bore of the Tube ; by which means, I laid, or rather crouded them as close together as possible. When the Tube was become full, I ty'd over that end of it by the Neck a small and limber Bladder, having first exprest all the Air out of its Body, in order to receive that Air, which I expected would be forc'd thro' the Ashes upon the Ascent of the Water. In this manner I plung'd the end of the Tube, to which I had ty'd the Linnen, (as it was,) under the surface of Water in a Glass, and found the Water presently begin to Ascend in it : It arose a pretty pace at first ; for in 16 Minutes time it had ascended near an Inch and three quarters : but as it arose higher, so its Progress

Progress became slower; for at the end of 24 Hours, the Water had attain'd but to 16 Inches; the Bladder, at the top being near half fill'd with that Air which had deserted the Ashes as the Water ascended in them. At the same time I found the upper part of the Tube, to which the Bladder was ty'd, to be crack'd round, and soon after drop'd off. However I had the Satisfaction desir'd. And so continuing the Experiment, I found at 24 Hours distance from the last Observation, the Water had ascended in the Ashes 6 Inches higher, which was very discernible by the change of Colour it gave thrm, distinct from those that were dry.

Again, At the like distance of time from the last notice, the Water had arisen 4 Inches and a half, and something better. On the 4th day, at the usual time of Observation, it had ascended 3 Inches higher: and when the following 24 Hours were finish'd, the Water reach'd within half an Inch of the top, by its ascent of 2 Inches. About 10 Hours after, it had compleatly reach'd the Extremity of the Tube. Then desiring to know what Quantity of Water the Ashes had Absorb'd, I weigh'd a Glass of Water nicely, part of which I Pour'd into the Glass, in which the Tube had all along been kept, till it reach'd the Mark the Surface of the Water stood at, when the Tube was first plung'd into it; and found the Quantity to be equal to the weight of 1792 Grains, which is nearly the Bulk of 7 Cubical Inches; the Capacity of the whole Tube, in which it arose, was equal but to about 13 Inches of the same denomination. Now this Experiment to me seems surprizing enough from the following Observations.

First, That the Water not only ascended in the Ashes, as between the premention'd Planes, and in the small Tubes, contrary to its Natural Gravation; but with such a Power too, as to force, and put to flight pretty strongly imprison'd Air, which was contain'd in the Interstices of the Ramm'd Ashes.

Secondly, That the removal of this Imprison'd Air could not be done without a Power surmounting its Resistance, which must be great, since upon endeavouring to force Air thro' the Body of Ashes by the strength of my Breath, when the Tube was not above half fill'd, it prov'd unsuccessful. Not but that I believe, if the same force had been continu'd for some time, it would have found its way through.

That the Water ascends fastest at first, when there is a larger quantity of Interstitial Air to remove, (if I may call it so,) than when the Column of the dry Ashes grows shorter, by the higher Ascent of the Water in them.

Fourthly, That notwithstanding the Tube was rammed as full as it could with Ashes, yet their Interstices were so many, as to receive, or imbibe another Body, equal in bulk to above half the Content of the whole.

Fifthly, That the Water arose, not only in the Ashes adjoining to the inward Surface of the Tube, but equally in the whole Body of it, as I found upon Examination.

Sixthly, That the Air lodg'd in the Interstices of the Ashes, was protruded thro' them as the Water ascended, was manifest by the Intumescence of the Bladder: And notwithstanding the Accident of the Bladders falling off, I cannot but conclude, that the Quantity of it must be equal to the like bulk of Water which supplied its place.

I repeated the same Experiment in *Vacuo*, in a Tube much about the same Diameter of the other, but not above 10 Inches in length: This Tube, being fill'd with Ashes as before, was plac'd in *Vacuo*, where it remain'd some time, to give liberty for the Air contain'd in them to get away. Then Plunging the lower end of the Tube under some Water, I found (as I expected,) that the Water arose faster in the Ashes in that Medium, than in
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Common Air ; for in about 4 Hours time, it had reach'd the Extream of its height ; which plainly shews, that the Presence of the Air is so far from being necessary in the Production of this old Phænomenon, that it is a manifest Impediment to it.

A Continuation of Experiments, touching the seeming Spontaneous Ascent of Water, or other Liquids.
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THE Ascent of Water in Capillary Tubes has been taken notice of some Years ago, but that it should arise between two Glass Planes, whose Sides lie open to the Air, I had not so much as received a hint of it before I first discover'd it. And I find that this *Phænomenon* is not to be ty'd up to Glass Bodies alone ; for Stone, or Brass, and, for ought I know, most other Bodies that have smooth Surfaces, or that their Surfaces may become nearly Contiguous to one another, may give the like Appearance ; as is plain by the following Experiments. I procur'd a pair of Marble Planes, that were Ground as true as the Workman could make them : These when I had joyn'd together dry, without any thing between, I plung'd the Edge of them about a quarter of an Inch under the Surface of the Water, and continued them so for some Minutes of time : then taking them out, I found I could not easily part them without sliding them one from off the other ; which when I had done, 'twas easily discoverable how far the Water had made its way between them, which, upon divers tryals, I have found different ; but at all times, when I had newly rubb'd over the Planes with Wood Ashes, the Water would ascend highett. Now whether the small Duff of the Ashes adhering to the Planes may contribute any thing towards

towards it; or that they better clear them from an Oily or Viscous Matter, that may be communicated to them from our Hands, I cannot yet determine: However, whatever the occasion is, the Matter of Fact is true. Then I took a pair of round Brass Planes, and ordered them as before; the Success of which was very agreeable with the former.

There is one thing I forgot to take notice of in a former Experiment; which is the Ascent of Spirit of Wine, or Oyl of Turpentine between two Glass Planes, without any thing to separate them. It cannot be imagined but that these Planes must touch each other in a multitude of Parts; yet for all that, and notwithstanding they are held forcibly together, the Spirit of Wine will insinuate, and ascend seemingly in an intire Body, between all the contiguous Parts of them, as before and after their Separation nothing appears to the contrary,

To the prementioned Experiments give me leave to add what I have since observed, in plunging the Planes in Spirit of Wine, Oyl of Turpentine, and common Oyl: That all these different Fluids arose between as the tinged Water; only with this difference, the common Oyl very sluggishly; it was near an Hour arising so high between them, as the other Liquids would in less than half a Minute. They all arose in an intire Body from side to side of the Planes, without those Intervals or Spaces, which generally happen on the Ascent of the Water. I likewise too a couple of round Glass Planes, and having laid them one on another, without Paper, or any thing else between to keep them separate; In this manner I plung'd one edge just under the Surface of the tinged Liquor, and found the Water almost Instantly had reach'd the Extrems of them in all Parts: By which we find, that the Water not only ascends directly upwards, but runs sideways, obliquely, or in any direction.