

Several essays towards discovering the laws of electricity. Communicated to the Royal Society / by John Ellicott, F.R.S. ; To which is prefixed, part of a letter from the Abbè Nollet, member of the Royal Academy of Sciences at Paris, and F.R.S. to Martin Folkes [Translated by T. Stack.] president of the same.

Contributors

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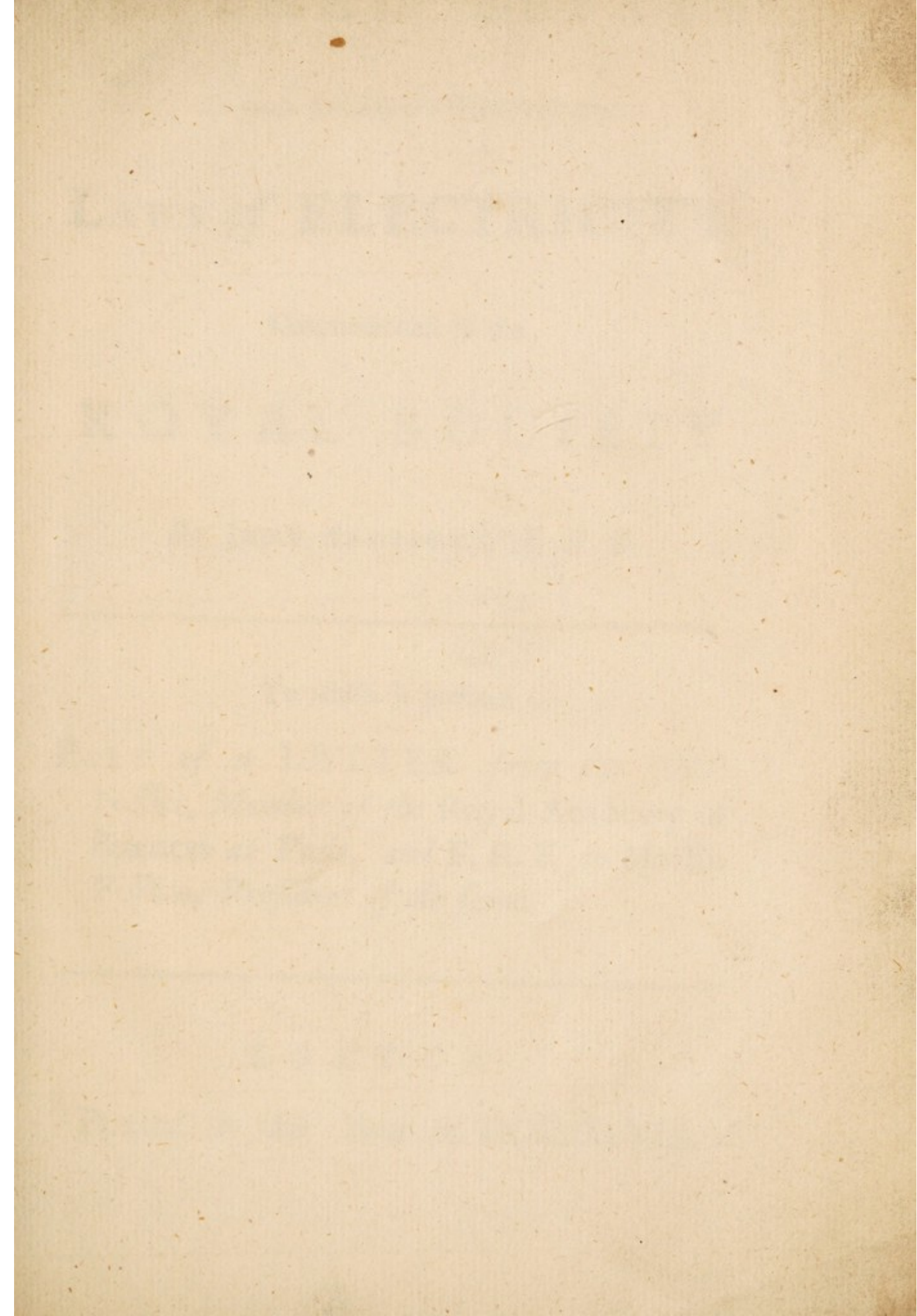


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SEVERAL ESSAYS

Towards DISCOVERING the

LAWs *of* ELECTRICITY.

Communicated to the

ROYAL SOCIETY

By JOHN ELLICOTT, F. R. S.

To which is prefixed

PART *of a* LETTER *from the* Abbè
Nollet, *Member of the* Royal Academy of
Sciences *at* Paris, *and* F. R. S. *to* Martin
Folkes, *President of the same.*

L O N D O N:

Printed in the Year M. DCC. XLVIII.

SEVERAL ESSAYS

TOWARDS DISCOVERING THE

LAW OF ELECTRICITY.

Communicated to the

ROYAL SOCIETY

By John Ellis Esq. R. S.



To which is prefixed

PART of a LETTER from the Abbe
Nollet, Member of the Royal Academy of
Sciences at Paris, and P. R. S. to Martin
Folkes, President of the same.

L O N D O N :

Printed in the Year M. DCC. XLVIII.

X. *Part of a Letter from Abbè Nollet, of the Royal Academy of Sciences at Paris, and F. R. S. to Martin Folkes Esq; President of the same, concerning Electricity.*

*Translated from the French, by T. Stack, M. D.
F. R. S.*

S I R,

*Read Feb. 11.
1747-8.*

FOR several Years past Electricity has been my chief Occupation. Last Summer I read three Memoirs at our weekly Meetings, which contained many Particulars on this Subject: But as these were Matters of mere Curiosity, and of no real Use, they almost tired out my Patience. I now send you some Experiments, which I made during the Vacation, which seem to promise at least the being of some Service; but of this you will be the best Judge. I will describe them in the same Order as I made them, and to which I was not led by mere Accident. You know, that when a Vessel full of Liquor, which runs out through a Pipe, is electrified, the electrified Jet or Stream is thrown farther than usual, and is diverged into several divergent Rays, much in the same manner as the Water poured out from a watering Pot. Every body at first Sight will judge, that the Stream is accelerated, and that the electrified Vessel will soon be empty. I was unwilling to rely on the first Appearances, and therefore resolved to ascertain the Fact, by measuring the Time, and the Quantity of the Liquor running out.

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And in order to know if the Acceleration, supposing there was any, was uniform, during the whole Time of the running out, I made use of Vessels of different Capacities, terminating in Pipes of different Bores, from three Lines Diameter to the smallest Capillaries: And I give you in gross the Result of upwards of an hundred Experiments, as it is not so easy a Task to draw a safe Conclusion, as may at first be imagined.

1. The electrified Stream, tho' it divides, and carries the Liquid farther, is neither accelerated nor retarded sensibly, when the Pipe, thro' which it issues, is not less than a Line in Diameter.
2. Under this Diameter, if the Tube is wide enough to let the Liquid run in a continued Stream; the Electricity accelerates it a little, but less than a Person would believe, if he judged by the Number of Jets that are formed, and by the Distance to which it shoots.
3. If the Tube is a capillary one, from which the Water ought naturally to flow, but only Drop by Drop, the electrified Jet not only becomes continued and divided into several, but is also considerably accelerated; and the smaller the capillary Tube is, the greater in proportion is this Acceleration.
4. And so great is the Effect of the electrical Virtue, that it drives the Liquid out of a very small capillary Tube, thro' which it had not before the Force to pass, and enables it to run out in Cases, where there would not otherwise have been any Discharge.

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These last Facts have served as a Basis to my Inquiries. I consider'd all organized Bodies as Assemblages of capillary Tubes, filled with a Fluid that tends to run thro' them, and often to issue out of them. In consequence of this Idea, I imagined, that the electrical Virtue might possibly communicate some Motion to the Sap of Vegetables, and also augment the insensible Perspiration of Animals. I began, by some Experiments, the Result of which confirm'd my Notions. I electrified, for four or five Hours together, Fruits, green Plants, and Sponges dipp'd in Water, which I had carefully weigh'd; and I found, that, after this Experiment, all these Bodies were remarkably lighter than others of the same kind, weigh'd with them, both before and after the Experiment, and kept in the same Place and Temper. I also electrified Liquors of all sorts in open Vessels; and I remarked, that the Electrification augmented their Evaporation, in some more, in others less, according to their different Natures. Wherefore I took two Garden-Pots, filled with the same Earth, and sowed with the same Seeds; I kept them constantly in the same Place, and took the same Care of them, except that one of the two was electrified for fifteen Days running, for two or three, and sometimes four Hours a Day. This Pot always shewed its Seeds raised two or three Days sooner than the other, a greater Number of Shoots, and those longer, in a given Time: Which makes me believe, that the electrical Virtue helps to open and display the Germs, and facilitates the Growth of Plants. I advance this, however, only as a Con-

jecture, which deserves further Confirmation; as the Season was already too far advanced, to allow me to make as many Experiments as I could have wish'd: But here are yet other Facts, of which I have a greater Certainty, and which are not less interesting.

I chose several Pairs of Animals of different kinds, Cats, Pigeons, Chaffinches, Sparrows, &c. I put them all into separate wooden Cages, and then weighed them. I electrified one of each Pair for five or six Hours together: Then I weighed them again. The Cat was commonly 65 or 70 Grains lighter than the other; the Pigeon from 35 to 38 Grains; the Chaffinch and Sparrow 6 or 7 Grains: And in order to have nothing to charge upon the Difference that might arise from the Temperament of the Individual, I again repeated the same Experiments, by electrifying that Animal of each Pair, which had not been electrified before; and notwithstanding some small Varieties which happen'd, the electrified Animal was constantly lighter than the other in proportion.

Electricity therefore increases the insensible Perspiration of Animals: But in what Proportion? In the *Ratio* of their Bulks, or in that of their Surfaces? Neither of the one or the other, strictly speaking, but in a *Ratio* much more approaching to the latter than to the former. So that there is no Room to apprehend that a human Person electrified would lose near a 50th Part of his Weight, as it appear'd to me that it happen'd to one sort of Bird; nor the 140th Part, as to the Pigeon, &c. All that I have been hitherto able to learn upon this Head,

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is, that a young Man or Woman, from 20 to 30, being electrified during five Hours, lost several Ounces of their Weight, more than they were wont to lose, when they were not electrified. These last Experiments are difficult to pursue with Exactness; because the Cloathing, which cannot strictly be compared to the Hair or Feathers of Animals, retains a good Share of the perspired Matter, and hinders one from forming a good Judgment of the whole Effect of the electrical Virtue.

This forced electric Perspiration is very naturally accounted for, if we consider, that the electrical Matter pervades the interior Parts of Bodies, and that it visibly darts from within outward: For it is very plain, that these electrical Emanations must carry with them whatever they find in the small Vessels, thro' which they are seen, or at least are known, to issue.

This Explanation will, in my Opinion, occur to every one, who has seen the principal *Phænomena* of Electricity. But how shall we account for all the following Effects? All those Animals, whose Perspiration is increased upon their being electrified, all those Seeds, which shoot and grow quicker; all those Liquors, which evaporate; all that Acceleration of Liquids flowing thro' Tubes; all those Particulars, I say, happen in the same manner, when, instead of electrifying those Bodies themselves, they are only held near electrical Bodies of a pretty large Bulk. The Notion which I have, for these three Years past, formed of Electricity, not only affords me an Explication of this, as simple as the former, but I venture to say, it was this same Notion, that
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led me to the Experiments, and made me even foresee their Success.

I am not only satisfied of the Existence of an *effluent* electric Matter, which all the World allows, and which shews itself a thousand Ways; but many convincing Reasons have also assured me, that there is, round every electrified Body, an *affluent* Matter, which comes to it not only from the ambient Air, but likewise from all the other Bodies, whether solid or fluid, that are round about, and within a certain Distance of it. If these surrounding Bodies are of a simple Nature, as a Stone, a Piece of Iron, &c. nothing issues from them but pure electrical Matter: But if they are Animals, Plants, or Fruits, or, in a Word, any organized Bodies, or such, in the Pores of which there is any Substance capable of giving way to the Impulses of the electric Matter; this Matter will, in issuing forth with the great Rapidity, which it is known to have, carry along with it whatever it finds moveable enough to be displaced by it; and by so much will the Weight of the Body be diminished; the same Effect being here produced by the *affluent* Matter, as is produced on electrified Bodies by the *effluent*. If you will please to read over my Essay, what I advance will be better understood. The Increase or Diminution of Perspiration is not a Matter of Indifference to the animal Oeconomy: This new Method of increasing it at Will may possibly prove of Use; it is neither inconvenient nor dangerous; and neither I myself, nor any body else of those on whom I made my Experiments, suffered even the least Inconveniency from it. One feels neither Motion nor Heat differing from that of the natural State.

State. Nor did the Animals give any Signs of Uneasiness, while they were electrifying: A little Weariness, and a better Appetite, were the only Effects we ever perceived.

As to the Facility of applying this Method, 'tis well known that the electrical Virtue is easily transmitted a good way off by Chains, &c. ; and one may easily imagine, that an easy Chair, or even a Bed, suspended or supported in a proper manner, will put the most infirm Persons in a Situation to be very commodiously electrified. But as there is no Necessity to electrify them actually, it will become easier still; for nothing more will be requisite, than to place near them a Basket of old Iron render'd electrical. The commonest Degree of Sagacity will suffice to put this Method in Practice, whenever it is found to be useful.

I shall observe further, that, when I electrify an Animal, I render his Perspiration more copious; and this Effect is universal thro' every Part of it. When I only place it near an electrified Body, it perspires as much. But is its whole Body equally sensible of this Effect? I mean, what exhales in consequence of the Electricity, does it issue from every Part of his Surface? I believe it does not; and that for these Reasons.

If it be the electrical Matter of the Skin that drives out the Matter of Perspiration, by rushing towards the electrified Body, it is natural to think, that this Effect takes place only in the Part out of which the electrical Matter issues: Thus the Perspiration, which is electrically forced out, ought to issue from those Parts only, which are the most directly applied toward the electrical Body. Let us confirm this by Experiments.

To

To an electrified Body I apply a Vessel full of Liquor, which issues Drop by Drop thro' several little Tubes placed in different Parts of its Circumference: These Drops become continued Streams, and are accelerated, as if the Vessel had been electrified: But this Effect is observable on that Side only which faces the electrified Body.

I moisten a thick Sponge with Water, and cut it in two: I weigh these two Halves separately; I join them again, and place the whole near a large electrified Body, so as to make one Half of the Sponge face the Body directly, and the other the contrary Way. After an Electrification of five or six Hours, that Half, which faced the electric Body, was found to be lighter than the other, &c.

Wherefore I think I have good Grounds to believe, that a Man, who presents a Shoulder, or one Side of his Head, to a large electrified Body, perspires more thro' that Part than thro' any other. Add to this, that since these Animals, which I caused to perspire in this last manner, and which had but one Side of their Bodies exposed to the Electricity, lost as much of their Weight, as the others which were thoroughly electrified; it follows, that they perspired as plentifully thro' the exposed Part, as the others thro' the whole Body. Whence we may infer, that, of the two Methods, which I propose for augmenting insensible Perspiration, the latter is the most powerful, and most proper to remove Obstructions from the Pores, or to scour them of any noxious Humours which they may happen to contain. I have the Honour to be, with the greatest, Respect, Sir,

Your most humble and most obedient Servant,

The Abbè Nollet.

II. *Several Essays towards discovering the Laws of Electricity, communicated to the Royal Society by Mr. John Ellicott F.R.S. and read on the 25th of Feb. 1747. and at two Meetings soon after.*

I. *A Letter to Martin Folkes Esq; Pr. R. S.*
S I R,

Read Feb. 25. 1747-8. **I**N the * Letter lately read before the *Royal Society* from the Abbè Nolet, containing his Observations on the Increase of the Transpiration of Animals, and the Growth of Vegetables, by means of the electrical *Effluvia*, he takes notice, that he was led to those Inquiries, from the Acceleration which (he found from a great Number of Experiments) was given to the Motion of Fluids thro' capillary Tubes, upon their being electrified. As I formerly made several Experiments on this Subject, I shall submit it to your Consideration, whether the following Observations on those Experiments may deserve the Notice of this illustrious *Society*. In which I have principally endeavoured to prove, that the Acceleration of the Motion of Fluids thro' capillary Tubes or Syphons is not barely owing to their being electrified, but that, in all Cases whatsoever, there are some other Circumstances necessary, in order to produce this Effect. And I doubt not but to make this fully appear, by shewing, that Water, being electrified, may either be made to run
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* See the preceding Paper.

in a constant Stream thro' a capillary Tube or Syphon, or only to drop, as if it had not been electrified at all: And likewise, that the Water may be made to run from the same Syphon in a constant Stream, without being made electrical, but cease to run, and only drop, the Moment it becomes electrical. Under the one or other of these Cases, I shall have an Opportunity of taking notice of the several Varieties observable in these Experiments; all of which I shall endeavour to account for from the following general Principles.

First, That the several electrical *Phænomena* are produced by means of *Effluvia*.

Secondly, That the Particles composing these *Effluvia* strongly repel each other.

Thirdly, That the said Particles are strongly attracted by most if not all other Bodies whatsoever.

That the electrical *Phænomena* are produced by means of *Effluvia*, is in general acknowledged by all the Authors who have wrote upon Electricity, however they may differ in Opinion with regard to the Bodies in which they are contained. The Properties I have mention'd of these *Effluvia* may be easily deduced from most of the Treatises lately published on this Subject. But to leave no Room for any Objection, I would beg Leave to observe, that the Existence of these *Effluvia* is proved by all those Experiments in which a Stream of Light is seen to issue from the electrified Body; particularly those Streams which are seen to issue in diverging Rays from the End of the original Conductor, when made of Metal, and reduced to a Point; from
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their being felt to strike against the Hand like a Blast of Wind, when it is brought near the Stream, and from that offensive Smell which generally accompanies these Experiments, and which is always more perceptible, the more strongly the Sphere is excited.

That the Particles composing these *Effluvia* repel each other, appears from those Experiments, in which two Bodies, how different soever they may be in kind, repel each other when they are sufficiently impregnated with these *Effluvia*. As a Feather, by the excited Tube; the several Fibres of the same Feather, or two Cork Balls, which will be found strongly to repel each other, so long as they retain any considerable Quantity of these *Effluvia*. Which Property will always decrease, as the Quantity they contain diminishes.

That these *Effluvia* are strongly attracted by most if not all other Bodies, is so evident from almost all the electrical Experiments, as to make any particular Examples of it needless here; especially as I shall have Occasion to take notice of the strong Attraction between the electrical *Effluvia* and Water, in accounting for these Experiments. And the first, I would take notice of, I shall now proceed to state as follows.

EXPERIMENT I.

If a Vessel of Water is hung to the prime Conductor, having a Syphon in it of so small a Bore that the Water will be discharged from it only in Drops, on the Water's becoming electrical by means of the Machine, it will immediately run in a Stream,

and continue to do so, till the Water is all discharged, provided the Sphere is continued in Motion.

That Water does not run in a constant Stream, but only in Drops, from a Syphon of a small Bore, is doubtless owing to the same Cause by which it is sustained above the Level in capillary Tubes. If therefore Water is made to run in a Stream barely by its being impregnated with the electrical *Effluvia*, it should follow, that if one or more capillary Tubes be placed in a Vessel of Water, that which is sustained in them would either sink down to a Level with the rest of the Water, on its being made electrical, or at least that it would not continue at the same Height as before; but if the Experiment is made, the Water will be found to continue exactly at the same Height, whether it is electrified or not.

Again, if the bare electrifying the Water was the Cause of its running in a Stream, it would continue to run in the same manner, so long as the Water continued electrical, which it will not do: For, on stopping the Motion of the Machine, the Stream will immediately cease, and the Water will only drop from the Syphon, notwithstanding its being strongly impregnated with the electrical *Effluvia*. To account then for the Water's being made to run in a Stream in this Experiment, I would observe, that so long as the Machine is in Motion, there is a constant Succession of the electric *Effluvia* excited, and which visibly run off from the End of the prime Conductor in a Stream, and as they are in like manner carried off from all Bodies hung to it, those *Effluvia* which run off from the End of the Syphon, being strongly attracted by the Water,

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carry so much of it along with them, as to make it run in a constant Stream.

That the Attraction between the Water and electric *Effluvia* is sufficient to produce this Effect, might be proved by a Variety of Experiments; but I shall only observe, that to this Attraction it is owing that silk Lines and glass Tubes (which, from their imbibing so very small a Quantity of these *Effluvia*, are generally made use of as Supports in many of the electrical Experiments) on only being wetted become strong Conductors: And that if an excited Tube is held over a Vessel of Water, the Water is found to imbibe a very considerable Quantity of this electric Matter; and, on the Approach of a Finger, or any other non-electric Body, the Water will be perceived to rise towards it; and if the Finger is brought so near the Surface as to draw off the *Effluvia*, they will carry several Particles of the Water along with them towards the Finger, in a Direction directly contrary to that of Gravity; and therefore may well be supposed, when acting in the same Direction, to have an Influence sufficient to produce a Stream, as in the Experiment.

And that this Current of the electric *Effluvia* is the true Cause why the Water runs in a Stream from the End of the Syphon, is farther evident, in that whatever tends to increase or diminish the Current of the *Effluvia*, produces the same Effect upon the Water. I have already observed, that when the *Effluvia* are strongly excited, they will be seen to pass off from the End of the prime Conductor in luminous Rays; and the same may be observed with respect to those which pass with the Water

Water from the End of the Syphon; but if any non-electric Body is brought under the Syphon, as, by its Attraction, the Current of the *Effluvia* will be increased, so these luminous Rays will likewise extend to a greater Length. Again, if the Motion of the Machine is stopped, the Current of the electric *Effluvia* will thereby be stopped, and the Water will immediately cease to run in a Stream, notwithstanding its being strongly impregnated with the electrical *Effluvia*.

And that the Water is strongly impregnated will not only appear from the Drops being sooner divided into small Particles than they would be if they had not been electrified, but from those Particles being separated to a greater Distance from each other, by the repulsive Property of the electric *Effluvia*; and if any of the Water is received into a dry glass Vessel, on the Approach of a Finger towards its Surface, there will be seen a Spark to issue from it in the same manner as from Water electrified by an excited Tube; or if any non-electrical Body is brought under the Syphon, by whose Attraction the *Effluvia* may be drawn off, the Water will immediately be found to accompany it in a Stream.

EXP. II.

If the Vessel of Water with the Syphon in it is suspended by any non-electric Body over another strongly electrified, the Water will immediately run from the Syphon in a Stream; but if supported by a Piece of Silk, or any other electrical Body, the Water will immediately cease running, and only be discharged

discharged in Drops. These *Phænomena* may, from what has been already said under the former Experiment, be easily accounted for.

That the Water is made to run in a Stream, is plainly owing to the mutual Attraction between the electrified Body and the Water; which Attraction will continue, so long as the Vessel which contains the Water, by being supported by a Non-electric, is prevented from retaining any of the electrical *Effluvia*; these *Effluvia* being drawn off by the non-electric Body, to which the Vessel is suspended: But on the contrary, when the Vessel is suspended by an Original Electric, the *Effluvia*, not being attracted thereby, will be prevented from running off, and the Water will soon be found to have imbibed a Quantity of them, sufficient, by their repelling Property, to greatly weaken, or wholly to destroy, the former Attraction, when the Water will cease to run in a Stream, and only drop, as if it had not been held near any electrified Body. Mons. *L'Abbe Nolet* has endeavoured to account for the former Part of this Experiment, by supposing there is, what he calls, both an affluent and an effluent electric Matter; but he takes no notice of the latter Part, which is not easily solved upon his Supposition. But if what I have observed on these Experiments is satisfactory, I apprehend I have accounted for the several *Phænomena* on much more solid Principles, and that thereby any less certain Hypothesis is render'd useless.

I intended to have taken some notice of the different Acceleration of the Fluids thro' Tubes of different Bores; but as this Acceleration will always
vary

vary with the Current of the electrical *Effluvia*, unless some Method could be found out to render this Current uniform throughout the whole Series of Experiments, the Prosecution of this Inquiry will be rendered extremely difficult, and the Result will at best be very uncertain. I am Sir, with the greatest Respect,

Your most obedient humble Servant,

John Ellicott.

When the foregoing curious Letter was read at the Meeting of the *Royal Society* on *Thursday* the 25th of *February* last, 1747. I acquainted the Gentlemen present, that the same ingenious Author had communicated to me a Paper several Months before, in which he had more fully and particularly delivered his Thoughts on the surprizing *Phænomena* of Electricity, and as several Persons expressed their Desire of seeing that Paper, I requested of him either a Copy, or an Abstract of the same; in Compliance with which he, some Days after, gave me the two following Papers, containing the Substance of what he had before shewn me; and I immediately put them into the Hands of Dr. *Mortimer*, one of the Secretaries of the *Society*, who read them at the two Meetings of the *Society*, on the several Days noted at the Head of those Papers.

M. Folkes.

2. *An Essay towards discovering the Laws of Electricity, addressed to the Royal Society.*

Read March 24.
1747-8.

THE great Difference I observed in the Sentiments of those ingenious Gentlemen who have favoured us with their Discoveries in Electricity, made me very desirous of finding out some general Principles, by means of which I might be able to form a Judgment of the several Hypotheses whereby they have endeavoured to account for the principal *Phænomena* observable in those Experiments. In order to this I took a general Survey of all the more remarkable Experiments, and out of them made Choice of such as I judged were most proper for my Purpose; and from these I deduced the general Principles hereafter mentioned. The Advantage I promised myself from this Method was, that the plainer and more simple the Experiments were, which I made choice of, the less liable I should be to mistake in any Conclusions drawn from them; and that every fresh Experiment, I could account for by them, would be an additional Proof in their Favour; and if my Attempt in explaining the following Experiments from those Principles should prove satisfactory, the Truth of them would be thereby so fully confirmed, that we might safely rely on them in forming a Judgment of any of the Discoveries already made; and (how general soever they may seem to be) I doubt not but they will be found of Service in prosecuting our future Inquiries on this Subject.

The Experiments from which I deduced these Principles were these which follow.

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EXP.

EXPERIMENT I.

If a glass Tube is rubbed by a very dry Hand, and a Finger is brought near any Part of it, a Spark of Fire will seem to issue from it, and strike against the Finger; and if the Finger is carried at a like Distance from the End of the Tube towards the Hand in which it is held, a Number of Sparks at a small Distance from each other will be seen coming from it, and a snapping Noise will be heard. The Tube is then said to be excited, or to be electrical; and at some times, when it is strongly excited, Sparks will issue from the Tube in Streams, not only while it is rubbing, but will continue to dart out from it for a considerable time after the Rubbing has ceased, and a very strong offensive Smell will be perceived.

EXP. II.

If the Tube, when thus excited, is held over some Pieces of Leaf-Gold, or any light Bodies whatsoever, they will be attracted towards it; and the more strongly the Tube is excited, the greater Distance they will be attracted from; and when they come near the Tube (tho' without touching it) they will be repelled from it, and continue to be so, unless touched by some other Body, when they will be attracted by the Tube as before: But if the Tube is but weakly excited, they will be attracted quite to the Tube, to which they will sometimes adhere, without being repell'd from it.

EXP.

EXP. III.

If a Ball (of Cork suppose for Lightness) be hung by a silk Line, and the excited Tube is applied to it, it will not only be attracted, but will have an attractive Quality communicated to it from the Tube; and if any light Bodies are brought near the Ball, they will be attracted by it.

EXP. IV.

As the Tube, when strongly excited, will not only attract, but afterwards repel any light Bodies brought near it, in like manner the Cork-Ball will be endued with the same Property; so that a smaller Ball will first be attracted towards it, and then repelled from it, the same as the Leaf Gold in *Exp.* 2. and on touching any other Body it will be again attracted; and this may be repeated several times, provided the smaller Ball is much less than the larger one, tho' the Effect will constantly grow weaker and weaker, as every time the lesser Ball is attracted, it carries off with it some of the electric Virtue, and is likewise endued with the same Properties as the larger Ball.

Mr. *Gray*, Mr. *Dufay*, and others have observed, that this electrical Quality is not only to be excited in Glass, but in most solid Bodies capable of Friction (Metals excepted); tho' in some it will be scarcely sensible, and that it is found to be strongest in Wax, Resins, Gums, and Glass: And as Glass is the easiest procured of a proper Form, it has generally been used in making these Experiments. It has been fur-

ther observed, that those Bodies in which the electrical Quality is capable of being excited the strongest by Friction will receive the least Quantity of it from any other excited Body, and therefore are properly made use of to support any Body design'd to receive the electrical Virtue. The Truth of this will sufficiently appear from the following Experiment.

EXP. V.

Hang up two Lines, one of Silk, and the other of Thread; that of Thread will be attracted by the Tube at a much greater Distance than the Silk. Again; Fasten to each String a Feather, or other light Body; if the Tube is brought to the Feather fastened to the Silk, it will be first attracted, and afterwards repelled; and from the Virtue communicated to it from the Tube, the several Fibres of the Feather will strongly repel each other. But when the Tube is brought to the Feather fastened to the Thread, the Feather will be strongly attracted, and continue to be so, without ever being repell'd, the Virtue passing off by the Thread it is hung to. If a glass Ball is hung to the silk Line, it will be but weakly attracted by the Tube; but one of Cork or Metal much stronger.

EXP. VI.

Let a Rod of Iron be sustained by silk Lines, and by means of a glass Sphere (which can be more regularly and constantly excited than a Tube) be made electrical; it will be found to have all the Properties of the excited Tube mention'd in *Exp. 1.* A
Stream

Stream of Light will come from the End of it, if it is pointed; it will attract, repel, and communicate this Virtue to any other non electric Body: On the Approach of a Non-electric, a Spark of Fire, with a Snap attending it, will come from it; which Spark will be greater or less, as the Bodies approaching it have more or less of the electrical Quality residing in them; and there will likewise be the same offensive Smell as was observed of the Tube.

From these Experiments, which I think contain the principal *Phænomena* of Electricity, may justly be drawn the following Conclusions:

- 1st. That these remarkable *Phænomena* are produced by means of *Effluvia*; which, in exciting the electrical Body, are put into Motion, and separated from it.
- 2^{dly}. That the Particles composing these *Effluvia* strongly repel each other.
- 3^{dly}. That there is a mutual Attraction between these Particles, and all other Bodies whatsoever.

That there are *Effluvia* emitted from the Tube when rubbed, and which surround it as an Atmosphere, is evident, from that offensive Smell arising from them, from that Sensation on the Hands or Face, when the Tube is brought near either of them, and from those Sparks of Light, on a still nearer Approach of the Finger to it.

That the Particles of these *Effluvia* repel each other, is proved by the Cork-Balls (*Exp. 4.*) and the Fibres of the Feather (*Exp. 5.*) repelling each other, when impregnated with them; and by the Leaf-Gold (in *Exp. 2.*) being repelled by the Tube, and

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not returning to it again, until, by coming near, or touching, some non-electric Body, the *Effluvia* are drawn off from it.

From this Property it is, that these *Effluvia* expand themselves with so great a Velocity whenever they are separated from the electric Body; and as they are likewise capable of being greatly condensed, may we not from hence justly conclude they are elastic?

That there is a mutual Attraction between these *Effluvia* and most other Bodies, appears from their collecting from the Tube such Quantities thereof, as to endue them with the same Properties with the Tube itself, as was proved by the 3^d, 4th, and 5th but more particularly by the 6th Experiment.

These Principles being admitted, it will follow, that the greater Difference there is in the Quantity of electrical *Effluvia* in any two Bodies, the stronger will be their Attraction. For, if the *Effluvia* in each are equal, instead of attracting, they will repel each other; and in proportion as the Quantity of electric Matter is drawn from one of the Bodies, will the Attraction between them increase, and consequently be strongest, when any one of them has all the electrical Matter drawn from it.

The Particles of these *Effluvia* are so exceedingly small, as easily to pervade the Pores of Glass, as is evident, in that a Feather, or any light Bodies inclosed in a glass Ball hermetically sealed, will be put in Motion on the excited Tube being brought near the Outside of it; and it has been generally thought that they pass through the Pores of the densest Bodies; and there are several Experiments which

which render this Supposition not improbable; tho' I must acknowledge I have not yet met with any one that I think is quite conclusive.

I shall now proceed to shew, how, from these Principles, the *Phænomena* of some of the more remarkable Experiments of Electricity may be accounted for.

EXP. VII.

Let a Rod of Iron, pointed at one End, be suspended on silk Lines, as in *Exp.* the 6th, and by the Sphere be made electrical. When the Rod is strongly electrified, a Stream of Light in diverging Rays will be seen to issue from its Point; and if any non-electric Body is held a few Inches from the Point, the Light will become visible to a greater Distance, and if the non-electric Body is likewise pointed, a Light will seem to issue from that in diverging Rays in the same manner as from the electrified Rod. But if the non electrical Body is flat, and held at the same Distance from the Rod as the pointed one was, no Light will be seen to come from it.

The principal *Phænomena* to be accounted for in this Experiment are; Why a Light is only seen at the Point of the Rod, and not through the whole Length of it? Why this Light is visible to a greater Length, when the Point is approached by a Non-electric? And, Why a Light is seen to issue from the Non-electric when it is pointed, and not when it is flat.

Upon which I observe, that whenever the Sphere is excited, the electrical *Effluvia* are thereby put into Motion, and made to form an Atmosphere round

round about it, from whence, by their repulsive Property, they endeavour to expand themselves on all Sides equally; but being strongly attracted by the Iron, a great Part of them are drawn off along the Rod, about whose Surface they likewise form an Atmosphere, which will be denser or rarer, in proportion as the Attraction of the Rod is greater or less; and as the repulsive Power of these *Effluvia* will always increase in proportion with their Density, it will follow, that whenever the Sphere is so strongly excited, that the *Effluvia* surrounding it are denser than those surrounding the Rod, they will, by their repulsive Property, drive the *Effluvia* off from the End of it in a Stream, and that with a very great Velocity; as is evident, from their striking against the Hand like a Blast of Wind when brought near the End of the Rod: And as this Velocity is partly owing to the Attraction of the Rod, so this Attraction continuing quite to the End of it, the Velocity of the Particles will there be greatest; and as they approach towards the Point, they will be brought nearer together, and therefore become denser there than in any other Part of the Rod; and therefore if the Light is owing to the Density and Velocity of the *Effluvia*, it will be visible at the Point, and no-where else.

And that the Light is thus produced, will appear, in that whatever increases or diminishes either the Velocity or Density of the Particles will increase or diminish the Light. For, let the Motion of the Wheel which turns the Sphere be stopped, the Current of the *Effluvia* will likewise be stopped, and the Rays of Light will no longer be seen to issue from the Point;

Point, and yet the whole Rod will continue to be electrical ; but, on putting the Sphere again into Motion, the *Effluvia* will become visible as before, and will increase, as the Sphere is more strongly excited. Again, the Light will be visible to a greater or less Distance, as the Point is more or less acute; and as this Light is always brightest next the Point, and grows fainter, as the Rays diverge, this is plainly owing to the different Density of the Rays at equal Distances ; for, when the Point is more acute, the Rays will diverge less, and therefore will be denser to a greater Distance than when it is less acute.

When a Non electric, whose End is flat, is brought within a few Inches of the Point of the electrified Rod, the electric Stream will be attracted by it, and the Rays made to diverge less than before ; and the Effect will be the same as if the Point was more acute ; *viz.* a Continuation of the Light to a greater Distance, and which will be farther increased by the additional Velocity the Particles will acquire from the Attraction of the Non-electric. What will follow on a nearer Approach of the Non-electric to the Rod, will be consider'd under the next Experiment.

If the Non-electric is pointed, and held in the same Place as the former, a Light will appear from it the same as from the electrical Body : For, as the Points of the two Rods are the Parts which approach nearest each other, the Attraction there will be strongest : The Rays therefore, which diverged from the electrical Rod, will be attracted by, and made to converge towards, the Point of the non-electrical Rod, and will consequently be nearly of the same Density at the one as the other ; and the

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Velocity being accelerated by the additional Attraction, the Rays will become luminous at the Point of the Non-electric, the same as at the Point of the electrified Rod. If this Experiment is made with a Tube, instead of a Sphere, as it cannot be so uniformly excited as the Sphere, the Light will issue from the Rod in Flashes, as the Tube is more or less excited.

Several very ingenious Gentlemen, and in particular the Abbé *Nollet* have imagined, that the Light seen at the Point of the Non-electric was produced by means of *Effluvia* issuing from it in diverging Rays towards the electrified Rod, and which Current of *Effluvia* is therefore supposed to be the Cause of the attractive, as a like Current issuing at the same time from the electrified Rod is supposed to be the Cause of the repulsive Property of Electricity.

This Conjecture being directly contrary to the Account I have given of this *Phænomenon*, I shall offer some Considerations in Support of what I have advanced, and which I think will make it appear highly improbable, that any such Current of *Effluvia* issues out of the Non-electric; but as what I have to offer on this Subject would trespass too much on the *Society's* Time at present, I shall defer it to my next Paper. I am,

Gentlemen,

Your obliged humble Servant,

John Ellicott.

3. *A Continuation of the foregoing Essay.*

Read May 19 1748. **I**N a Paper I had the Honour to communicate to this *Society*, *March 24*, I endeavour'd, from the Principles therein laid down, to account for some of the most remarkable *Phænomena* of Electricity; and in particular for that Appearance of a Light issuing from the End of an iron Rod, when pointed, and made electrical; Why this Light was visible only at the Point, and in no other Part of the Rod: Why the Light was visible to a greater Length when the Point was approached by a Non-electric: And why a Light will be seen as issuing from the Non-electric when it is pointed, but not when it is flat.

I shall now endeavour, from the same Principles, to account for those *Phænomena*, which will be produced on a nearer Approach of the Non-electric to the electrified Rod.

EXP. VIII.

If the non-electric Body, whether flat or pointed, is brought nearer to the End of the Rod, than in the last Experiment, there will be a small Stream of Light produced, reaching quite from the electric to the non-electric Body; and if brought still nearer, there will issue a Spark attended with a small snapping Noise, which will be succeeded by others at equal Intervals; and if the Non-electric is held at some Distance from the Side of the Rod, the Point of it will frequently appear luminous, but no Part

of the electrified Rod will be so. If it is brought nearer, there will likewise be Sparks produced at nearly equal Intervals from each other, which will sometimes appear as issuing from the Side of the electrified Rod, at others, as coming from the Non-electric.

If a Finger is used as the Non-electric, it will receive a smart Stroke; and if Spirit of Wine, heated so as to emit an inflammable Vapour, is made use of, it will be kindled by the Spark.

These *Phænomena* may, on the afore-mention'd Principles, be thus accounted for.

If the non-electric Rod is pointed, and brought so near, as, by its Attraction, to prevent the Rays issuing from the Point of the electrified Rod from diverging, they will be drawn off parallel to each other, and consequently be equally luminous throughout the whole Distance between the two Rods.

If the Non-electric be brought still nearer, the attractive Force will be so much increased, as not only to affect the *Effluvia*, when they are driven off from the Point of the electrified Rod, but to be capable of drawing them off from a considerable Part of the Rod beyond the Point; and that with a Velocity, and in a Quantity, sufficient to occasion both the Spark and Blow, as well as the Noise that is heard.

The same is the Case, when the non-electric Rod, or a Finger, is held against the Side of that which is made electrical: At a greater Distance a Light will appear as issuing from the Non-electric, the Particles attracted from a large Surface of the Rod (and therefore not visible as coming from it) being made to converge to a Point, are thereby rendered

dered luminous, and, if brought nearer, there will issue Sparks in the same manner as when held to the End: And that this is owing to the Increase of the attractive Force, seems plain; for it was observed in the last Experiment, the Attraction was capable of changing the Direction of the Rays at the Distance of several Inches; whereas a Snap or Spark is seldom produced, when the Non-electric is held more than an Inch and half distant. If therefore the Attraction decreases, as the Squares of the Distances increases, as it probably does, the attractive Force will be many times greater in one Case than in the other, and if where the attractive Power was weaker, as in the former Experiment, there were so many Rays of the electric Matter collected, as to be sufficient to produce a Light, it cannot be thought extraordinary, when the Attraction is so greatly increased on the nearer Approach of the Non-electric, that both the Density and Velocity of the Particles should be thereby increased, so as to produce Heat sufficient to fire the Vapour arising from Spirit of Wine, or any other inflammable Vapour.

And that the Quantity of the electric Particles is greatly increased, as well as their Velocity, is evident from that large Surface of the Rod, which, by the Approach of a Finger, is in one Spark divested of them; and which requiring some time before it can be again sufficiently recruited, I apprehend is the Reason of that Interval between the Sparks. And here it must be observed, that the Distance the Point of the Non-electric is held at from the Rod, in order to produce the greatest Spark, must be varied, in proportion as the Rod is electrified in a greater or less Degree; the more strongly the Rod

is impregnated the greater will be the Distance; and if then the Non-electric is brought nearer, the Sparks will be smaller, but succeed each other quicker; so that when it is brought almost to touch the Rod, they will appear like a small Stream. The Reason of which I take to be, that as the electric Atmosphere surrounding the Rod is denser nearer it than farther off, when the Non-electric is brought into so very dense a Part of the Atmosphere, it will from thence become nearly as electrical as the Rod itself; and therefore lose great Part of its attractive Force, and consequently will only be able to draw off those Particles from the Rod which are nearest to it.

I would farther take notice, that the Sparks are always produced in the Space between the Non-electric and the Rod, and often appear as issuing from the Non electric. This Appearance is probably owing to those Particles, which, by their Elasticity, are reflected back again from the Non-electric towards the Rod, and which, by striking against those coming from it, produce both the Sparks and Noise that is heard; and as I have already shewn, that the Particles often appear in luminous Rays at the Point of the Non-electric, it thence happens, that the Spark is frequently kindled so near to the Non-electric, as to appear as issuing from it.

I observed, in my former Paper, that several ingenious Gentlemen, from this Appearance of a Light at the Point of the Non-electric, have imagined there was a Current of electrical *Effluvia* continually issuing out of it, and which, setting in towards the electrified Rod, was the Cause of the Attraction of the Electricity: And this Conjecture of theirs will

will seem to be greatly favoured by the following Experiment.

If some of the Fibres of a Down-Feather be fastened to the End of a small Skewer or Wire, and made electrical, they will strongly repel each other, and will expand themselves on all Sides to the greatest Distance possible from each other; but if a non-electric Person bring the Point of a Pair of Compasses, or any other small-pointed Body near them, they will be repell'd from it, and driven up together as with a Blast of Wind, and, in the dark, a Light will be seen as issuing from the Point; from whence it might be concluded, that the Fibres are repell'd by *Effluvia* issuing out of the Point of the Non-electric.

As the Abbé *Nollet* endeavours to account for the Attraction of Electricity on this Principle, I shall offer some Considerations, which, notwithstanding these Appearances, have induced me to be of a different Opinion; and they are founded on the following Observations.

First, That however replete any Bodies may be with the electric Matter, none of these *Phænomena* are ever produced, unless the *Effluvia* are first excited in some particular Body, and put in Motion, either by rubbing, or some such-like Operation.

Secondly, That the *Effluvia* are not to be equally excited in all Bodies, but much stronger in some than in others; and that, in particular, they are not capable of being at all excited in Metals by Friction.

Thirdly, The attractive and repulsive Property will be stronger or weaker in any Body, in proportion to the Quantity of excited *Effluvia* wherewith it is impregnated.

Fourthly, That those Bodies which are most easily excited by Friction, will receive the least Quantity of the electrical *Effluvia* from any other excited Body; and, on the contrary, Metals, or those Bodies in which they cannot be excited by Friction, will receive the most.

From these Observations I think it may be shewn, that this Appearance of Light is so far from proving that the *Effluvia* come out of the Non-electric, at whose Point they are visible; that from thence it cannot be concluded the Body has any of the electrical Matter residing in it, but is rather a Proof to the contrary. For I have already shewn, that the same Appearance would be produced from the setting in of the *Effluvia* into the Non-electric; and this might be confirmed, if necessary, by a Variety of Experiments. And as those Bodies, at whose Point this Light appears the strongest, afford us no Signs of their having any of the electrical *Effluvia* residing in them, either by their attracting or repelling other Bodies, or by their being capable of being excited in them by Friction, as in Glafs, &c. nor in short any sort of Evidence whatsoever, but what arises from this Appearance; may we not expect some better Proof of their being possessed of these *Effluvia*, before we admit of their issuing out of them?

Again, it appears very extraordinary, that those Bodies, in which the *Effluvia* cannot be excited by
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any other Method, should send forth such Streams of them, only on their being brought within a few Inches of the electrified Rod, and that these Streams should increase as the Rod is more strongly electrified ; and yet that few or none of these Streams should issue from those Bodies in which the *Effluvia* can be excited : And if the first-mention'd Bodies are themselves strongly impregnated, the Streams will disappear, and they will be so far from parting with any of their *Effluvia*, that, on the contrary, they will be strongly repelled by the Rod.

I farther apprehend, on this Supposition, it will be extremely difficult, if not impossible, to account for the ceasing of the Stream from the Point of the Non-electric on stopping the Machine ; as likewise that the Rod should so soon be divested of its *Effluvia*, on such a Non-electric's being held near it, which it would otherwise retain for several Hours, and which I think is a strong Proof of the *Effluvia*'s passing from the Rod into the Non-electric. And that it certainly does so, may be confirmed by the Person who holds the Non-electric stepping upon a Cake of Wax, when he will soon become electrical, from the *Effluvia* he will receive (thro' the Point of the Non-electric) from the Rod ; but so long as he continues to se so, there will not be seen any Light to issue from the Point ; which I apprehend cannot be accounted for on any other Principle, but that of the setting in of the *Effluvia* at the Point of the Non-electric. And as I have already shewn, that all the *Phænomena* are naturally to be accounted for on this Principle, without being liable to any of the above-mention'd Objections, I must remain of the Opinion (till I can see

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these Objections answer'd) that this Appearance of Light is no Proof that the *Effluvia* issue out of the Non-electric, but of the direct contrary.

The above-mention'd Objections might be brought, with equal Force, against the Fibres of the Feather being repelled by *Effluvia* issuing out of the Point of the Non-electric that is held near it, and in particular, that this Effect would cease to be produced, either when the Machine was stopped, or the Person who held the Point became electrical. And to these I would add, that if this was really the Case, the Fibres would continue to be repell'd, notwithstanding any Alteration in the Shape of the Non-electric; whereas, on the contrary, if the Joint of a Pair of Compasses was held towards them, instead of the Point, they would be strongly attracted to it: And the same will always happen, whenever an obtuse Body is brought near them instead of a pointed one.

The true Cause of this remarkable *Phænomenon* I apprehend to be the different Density of the *Effluvia* at the Extremities of the two Bodies; for I have already shewn the *Effluvia* will be much denser at the Extremity of a pointed Body than at an obtuse one: And as the Force by which the Particles endeavour to expand themselves, increases in proportion to their Density, it follows, that the Particles will be reflected back with greater Violence from the pointed Body than the other; and this Force exceeding the attractive Power of that particular Part of the Feather, to which it is directed, the Fibres will be repelled by it; whereas the Force, with which the Particles endeavour to expand themselves from the obtuse Body, being less than the attractive Power,

it follows, that the Fibres of the Feather will continue to be attracted by it.

EXP. IX.

Take two Plates of Metal, very clean and dry, whose Surfaces are nearly equal; hang one of them horizontally to the electrified Rod, and bring under it upon the other any thin light Body, as Leaf-Silver, &c. when the upper Plate is made electrical, the Silver will be attracted by it; and if the under Plate is held at a proper Distance, will be perfectly suspended at right Angles to the Plates, without touching either of them; but if they are either brought nearer together, or carried farther asunder, the Leaf-Silver will cease to be suspended, and will jump up and down between them. The same Effect will be produced, if you reverse the Experiment, by electrifying the bottom Plate, and suspending the other over it.

If the upper Plate is electrified when the Leaf-Silver is brought near, it will be attracted upwards by it, and thereby become electrical; and so long as it continues to be electrical, it will likewise be attracted downwards by the non-electrical Plate. Whenever therefore this last Attraction added to the Gravity of the Silver, which acts in the same Direction, is equal to the contrary Attraction upwards, the Leaf-Silver will, by means of these two opposite Forces, be kept suspended between the Plates, and will continue to be so, as long as the Equality of these Forces is preserved.

I have already shewn, that the Attraction between any two Bodies will always be in proportion to the different Quantity of electric *Effluvia* they are possessed of; the greater that Difference is, the greater will be the Attraction. In order therefore to obtain this equal Attraction at first, the Leaf-Silver must be imbued with a greater or lesser Quantity, in proportion as the Plate is more strongly or weakly electrified; but always with a much less Quantity than the Plate; and likewise the lower Plate will require to be placed at different Distances, in proportion to the Quantity of electric Matter the upper Plate is possessed of. As therefore the Suspension of the Silver depends upon the exact Proportion of Attraction (arising from the different Quantities of electric Matter) in the two Plates and Leaf-Silver, it follows, that whatever alters the Quantity contained in any one of them would prevent the Suspension.

It is well known, that, by the Attraction between any two Bodies, the electric *Effluvia* are continually drawn off from that which has the greatest Quantity of them, till the other being sufficiently impregnated, the Attraction ceases. In order therefore to preserve these Proportions, it is necessary, that, as fast as the non-electric Plate draws off any of the *Effluvia* from the Leaf-Silver, it should part with it again; and so, by continuing to be a Non-electric, an equal Degree of Attraction be preserved; and again, that the Leaf-Silver should receive a fresh Supply from the electrical Plate, equal to what it constantly parts with; and the electrical Plate must likewise receive an equal Supply from the Globe;
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and that there is such a constant Current of the electrical *Effluvia*, is evident, from those small Streams of Light, visible at the two Corners of the Silver next the Plates. If therefore the Globe should be stopped, or the under Plate by any means become electrical, these Proportions would be thereby destroy'd, and the Leaf-Silver would cease to be suspended.

That the Leaf-Silver is always nearer to the non-electrical than to the electrified Plate, is owing to its receiving its Supply of *Effluvia* from the Atmosphere surrounding the electrified Plate: For as the Plate is more strongly electrified than the Silver, its Atmosphere of *Effluvia* will be denser to a greater Distance than that surrounding the Leaf-Silver, and therefore can supply an equal Quantity at a greater Distance than what the lower Plate can receive from the Silver, whose Atmosphere is rarer; and therefore, as the Silver will always be suspended in that Part where the two Currents are equal, without which I have already shewn the Proportion would be destroy'd, it will consequently be always nearer to the non-electrical than to the electrified Plate. If the Experiment is reversed, by electrifying the under Plate, and making the upper one the Non-electric, the only Difference will be, that the Gravity of the Silver must then be added to the Attraction of the electrified Plate, and will therefore cause the Silver either to be nearer the non-electrical one, or the Plates to be moved a little farther asunder, or perhaps both.

I shall not at present presume to take up any more of the Time of this illustrious *Society*; hoping
that

that I have already shewn how the principal *Phænomena* of Electricity may be accounted for, upon the few Principles I have laid down; and however in different Experiments the Effects produced may either be varied, or increased, I doubt not but they may all be easily accounted for from the same Principles; as I shall willingly attempt to make appear at some more convenient Time, should it be thought necessary. In the mean time I have the Pleasure to subscribe myself,

Gentlemen,

Your most obedient humble Servant,

John Ellicott.

F I N I S.

