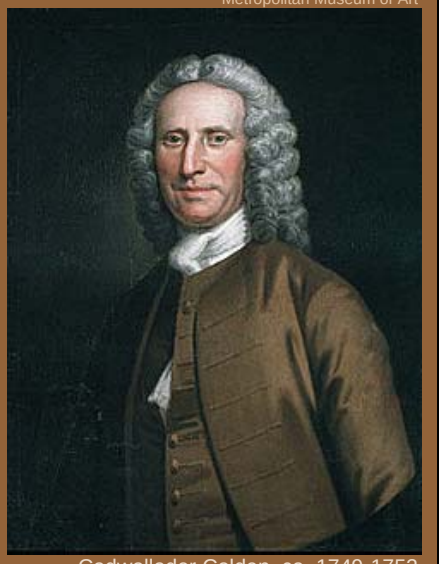
Harvard University Art Gallery

Benjamin Franklin, ca. 1738-1746
oil portrait by Robert Feke (detail)

The Science Correspondence of *BENJAMIN FRANKLIN* and *CADWALLADER COLDEN*

EXCERPTS
1750–1753

Metropolitan Museum of Art



Cadwallader Colden, ca. 1749-1752
oil portrait by John Wollaston

Franklin's kite-flying experiment is part of hallowed Americana, but it likely never occurred. He *did* write an article proposing the experiment, one of his voluminous writings on science and technology. He also maintained an extensive correspondence with like-minded Americans and Europeans, including Cadwallader Colden, a Scots-Irish physician and scientist who had moved to Philadelphia in 1710 (when Franklin was four) and who later became an influential government official in the colonies. Like Franklin, Cadwallader experimented with electricity and was captivated by the implications of Newtonian physics. Presented here are selections from their letters during a three-year period, 1750-1753, when Franklin was in Philadelphia and Colden in New York. They discuss electricity, light, gravity, magnetism, sound, astronomy, and medicine among other topics, and describe their own experiments on electricity. Read their interchange to understand the nature of their inquiry and friendship, how they bolster and question each other, and what they define as the scientific breakthroughs and mysteries of their day.

___Benjamin Franklin to Cadwallader Colden, 13 February 1750___

Sir

I receiv'd your very kind Letter relating to my Proposals for the Education of our Youth, and return you the Thanks of the Gentlemen concern'd for the useful Hints you have favour'd us with. It was long doubtful whether the Academy would be fix'd in the Town or Country, but a Majority of those from whose generous Subscriptions we expected to be able to carry the Scheme into Execution, being strongly for the Town, it was at last fix'd to be there. . . .[1]

I have no Observations of Jupiter's Satellites to send you, as I expected I should have. Being myself otherwise engag'd and not very skilful in those Matters, I depended on our Astronomer Mr. Godfrey and put the telescope into his Hands for that purpose. He had a fine Summer for it, but I am inform'd was so continually muddled with Drink, that our Surveyor General, Mr. Scull, who was his Neighbour, could never get him to assist in making the Meridian Line. He is now dead, and your Letter of Directions for making such a Line, which I put into his Hands, is lost. Mr. Scull desires me to write to you for a Repetition of those Directions, and when you have a little Leisure, I shall be oblig'd to you for them; but it will now be Midsummer before we shall have an Opportunity of observing Jupiter again.

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[1] The academy, soon the College of Philadelphia, become the University of Pennsylvania.

I have wrote some additional Papers on Electricity which I will get copied and send to you per next Post [mail]. They go on much slower in those Discoveries at home than might be expected.

I am glad you are about enlarging and explaining your Principles of Natural Philosophy. I believe the Work will be well receiv'd by the Learned World. I am, Sir, with great Respect, Your affectionate humble Servant.

___Benjamin Franklin to Cadwallader Colden, 28 June 1750___

Sir

I wrote a Line to you last Post and sent you some Electrical Observations and Experiments. You formerly had those Papers of mine out of which something has been taken by Mr. Watson, and inserted in the Transactions.[2] If you have forgot the Contents of those Papers, I am afraid some Things in that I last sent you will be hardly understood, as they depend on what went before. I send you herewith my Essay towards a new Hypothesis of the Cause and Effects of Lightning, &c. [etc.] of which you may remember some Hints in my first Electrical Minutes. I sent this Essay above a 12 month since to Dr. Mitchel in London and have since heard nothing of it, which makes me doubt of its getting to hand.

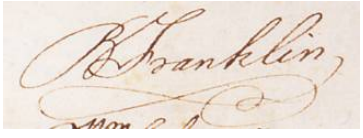
In some late Experiments, I have not only frequently fired unwarm'd Spirits by the Electrical Stroke, but have even melted small Quantities of Copper, Silver and Gold, and not only melted but vitrified them, so as to incorporate them with common Glass, and this without any sensible Heat, which strengthens my Supposition that the Melting of Metals by Lightning may be a cold Fusion. Of these Experiments I shall shortly write a particular Account.

I wrote to Mr. Collinson, on Reading in the Transactions the Accounts from Italy and Germany, of giving Purges, transferring Odours, &c. with the Electrical Effluvia, that I was persuaded they were not true. He since informs me that Abbé Nolet of Paris, who had try'd the Experiments without Success, was lately at the Pains to make a Journey to Turin, Bologna and Venice [Italy] to inquire into the Facts and see the Experiments repeated, imagining they had there some Knacks of Operating that he was unacquainted with, but to his great Disappointment found little or no Satisfaction, the Gentlemen there having been too premature in Publishing their Imaginations and Expectations for real Experiments. Please to return me the Papers when you have perus'd them.

My good old Friend Mr. Logan, being about three Months since struck with a Palsy, continues Speechless, tho' he knows People and seems in some Degree to retain his Memory and Understanding. I fear he will not recover. Mr. Kalm[3] is gone towards Canada again, and Mr. Evans is about to take a Journey to Lake Erie, which he intends next Week. Mr. Bertram continues well and hearty.

I thank you for what you write concerning celestial Observations. We are going on with our Building for the Academy, and propose to have an Observatory on the Top; and as we shall have a mathematical Professor, I doubt not but we shall soon be able to send you some Observations accurately made. I am, with great Esteem and Respect, Sir, Your most obliged Humble Servant

p.s. If you think it would be agreeable to Mr. Alexander, or any other Friend in N York, to peruse these Electrical Papers, you may return them to me thro' his Hands.



[2] *Transactions of the American Philosophical Society*. The society for the discussion and promotion of science was founded by Franklin in 1743.
[3] Peter Kalm, a Swedish biologist travelling in the British and French North American colonies.

__Cadwallader Colden to Benjamin Franklin, 28 October 1751__

Sir

I had the pleasure of receiving yours with the favour of a copy of your Electrical experiments. My being in this place prevents my reading them with that attention which they deserve and which I intend to do as soon as I shall return home. My Notions on Electricity are confused and indigested. I know not wherein consists the difference between an Electric body per se and a non-electric or why one is an Electric and the other a Non electric. Without knowing this it will be very difficult if not impossible to account for the Phoenomena or to understand any reasoning on the Phoenomena. In the time I have been allowed amidst perpetual avocations to think on your experiments they seem to me to lead more directly to the discovery of the cause than any set of experiments which I have seen.

I know not wherein consists the difference between an Electric body per se and a non-electric, or why one is an Electric and the other a Non electric. Without knowing this, it will be very difficult if not impossible to account for the phoenomena [of electricity] . . . Colden

But I suspect that the air surrounding Electrics and Non electrics has not been sufficiently considered. May not many of the Phoenomena arise from the air on the opposite surfaces of electric and non electric bodies. I suspect that the Phoenomena of angular and pointed bodies arise likewise from the air which surrounds them. I am apt to conclude that electrical experiments made in Vacuo [in a vacuum] may be of use not only for discovering the true cause of Electricity but likewise the cause of the elasticity of the Air. For example what are the Phoenomena when the air is exhausted from the Water contained in the phial before it is charged. Whether the electrical atmosphere extends farther or less in Vacuo than in the air. Whether a point will draw it off at a greater distance or otherwise. Whether the electrical atmosphere extend in proportion to the density of the surrounding air or reciprocally to the density. I fancy that if experiments of this kind were well contrived they may lead us a great deal farther in discovering the cause of electricity and the laws of its action than we have as yet got. But it is probable you have already made experiments of this sort and that I only discover my ignorance in proposing them. However I shall be much obliged to you by your giving me your Sentiments on what I write that I may not indulge myself in a vain and fruitless speculation. We have no means in this place of making the experiments which I propose. If such have not been already made I am persuaded no man is more capable of contriving and executing proper experiments than your self to discover whether a thin plane or surface of air lying between an electric and Non electric or contained in them be not differently affected on the one side and the other. It is evident that the success of electrical experiments is different in different dispositions of the air and therefore it may be concluded that the air acts a considerable part in producing the Phoenomena.

___Benjamin Franklin to Cadwallader Colden, 31 October 1751___

Dear Sir

I enclose you Answers, such as my present Hurry of Business will permit me to make, to the principal Queries contain'd in your Favour [letter] of the 28th Instant [of this month], and beg Leave to refer you to the latter Piece in the printed Collection of my Papers for farther Explanation of the Difference between what are called Electrics per se and Non Electrics. When you have had Time to read and consider those Papers, I will endeavour to make any other new Experiments you shall propose, that you think may afford farther Light or Satisfaction to either of us, and shall be thankful for such Remarks, Objections, &c. as may occur to you.

I forget whether I wrote you that I have melted brass Pins and Steel Needles, inverted the Poles of the magnetic Needles, given Magnetism and polarity to Needles that had none, and fired dry Gunpowder, by the Electric Stroke. I have five Bottles that contain 8 or 9 Gallons each, two of which charg'd are sufficient for the above purposes; but I can charge and discharge them all together. There are no Bounds (but what Expense and Labour give) to the Force Man may raise and use in the Electric Way: For Bottle may be added to Bottle *in infinitum*, and all united and discharg'd together as One, the Force and Effect proportion'd to their Number and Size. The greatest known Effects of common Lightning, may, I think, without much Difficulty be exceeded in this way: Which a few Years since could not have been believed, and even now may seem to many a little extravagant to suppose. So we are got beyond the Skill of Rabelais's Devils of two Year old, who, he humourously says, had only learnt to thunder and lighten a little round the Head of a Cabbage. I am, with sincere respect, Dear Sir, Your most obliged humble Servant

[Enclosure]

Query 1. Wherein consists the Difference between an Electric and a Non electric Body.

Answ. The Terms *Electric per se* and *Non Electric* were first used to distinguish Bodies on a mistaken Supposition that those alone called Electric, per se, contained electric Matter in their Substance which was capable of being excited by Friction and of being produc'd or drawn from them and communicated to those called Non Electrics suppos'd to be destitute of it: For Glass, &c. being rubbed discover'd Signs of having it, by snapping to the Finger, attracting, repelling, &c. and could communicate those Signs to Metals and Water. Afterwards it was found that rubbing of Glass would not produce the Electric Matter, unless a Communication was preserv'd between the Rubber and the Floor; and subsequent Experiments prov'd that the Electric Matter was really drawn from those Bodies that at first were thought to have none in them.

Then it was doubted whether Glass and other Bodies called Electrics per se had really any Electric Matter in them, since they apparently afforded none but what they first extracted from those which had been called Non Electrics. But some of my Experiments show that Glass contains it in great Quantity, and I now suspect it to be pretty equally diffus'd in all the Matter of this terraqueous Globe. If so, the Terms *Electric per se* and *Non Electric* should be laid aside as improper, and (the only Difference being this, that some Bodies will *conduct* Electric Matter, and others will not) the Terms *Conductors* and *Non Conductors* may supply their Place. If any Portion of Electric Matter is apply'd to a Piece of Conducting Matter, it penetrates and flows thro' it, or spreads equally on its Surface according as situated or circumstanc'd. If apply'd to a Piece of Non Conducting Matter, it will do neither. Perfect Conductors of Electric Matter are only Metals and Water, other Bodies conducting only as they contain a Mixture of those, without more or less of which they will not conduct at all. This (by the way) shows a new Relation between Metals and Water heretofore unknown; and seems to favour some [*torn*] Opinions of the Formation [*torn*] Water.

But some of my Experiments show that Glass contains it ["Electric 'matter'"] *in great Quantity, and I now suspect it to be pretty equally diffus'd in all the Matter of this terraqueous Globe. If so, the Terms Electric per se and Non Electric should be laid aside as improper, and (the only Difference being this, that some Bodies will conduct Electric Matter, and others will not) the Terms Conductors and Non Conductors may supply their Place.*

Franklin

To illustrate this by a Comparison, which however, can [give?] but a faint Resemblance — Electric Matter passes thro' Conductors as Water passes thro' a *porous* Stone, or spreads on their Surfaces as Water spreads on a *wet* Stone; but when apply'd to Non Conductors 'tis like Water dropt on a *greasy* Stone, it neither penetrates, passes thro', nor spreads on the Surface, but remains in Drops where it falls. See farther on this Head in my last printed Piece.

Query 2. What are the Effects of Air in Electric Experiments?

Answ. All I have hitherto observ'd are these. Moist Air receives and conducts the electric Matter in proportion to its Moisture, quite dry Air not at all. Air is therefore to be rank'd with the Non Conductors. Dry Air assists in confining the Electrical Atmosphere to the Body it surrounds and prevents its dissipating, for in Vacuo it quits easily and Points operate stronger, i.e. they throw off or attract the Electrical Matter more freely and at greater Distances, so that Air intervening obstructs its passing from Body to Body in some Degree. A clean Electric Phial and Wire containing dry Air instead of Water will not be charg'd nor give a Shock, no more than if it was fill'd with Powder of Glass, but exhausted of Air it operates as well as if fill'd with Water.

Yet an Electric Atmosphere and Air do not seem to exclude each other, for we breathe freely in such an Atmosphere; and dry Air will blow through it without displacing or driving it away. I question whether the Strongest dry Northwester would dissipate it. I once electrify'd a large Cork Ball at the End of a Silk Thread 3 feet long, the other End of which I held in my Fingers, and whirl'd it round like a Sling 100 Times in the Air with the swiftest Motion I could possibly give it, yet it retain'd its Electrical Atmosphere, tho' it must have pass'd thro' 800 Yards of Air, allowing my Arm in giving the Motion to add a foot to the Semidiameter of the Circle. By quite dry Air, I mean the driest we have, perhaps we never have any perfectly free from Moisture. An Electric Atmosphere rais'd round a thick Wire inserted in a Phial of Air drives out none of the Air, nor on withdrawing that Atmosphere will any Air rush in, as I have found by a very curious Experiment accurately made, whence one would think the Air's Elasticity not affected thereby.

___Cadwallader Colden, to Benjamin Franklin, 16 March 1752___

Dear Sir

Last fall I acknowledged from New York the favour you did me in sending me a copy of your Electrical Experiments. The oftener I read them over the more I am pleased with them and every time discover something new which I had not taken notice of at the first reading. In my opinion no set of experiments which I have read lead so directly towards discovering the cause of Electricity as yours do. However I find it difficult to form any conception of this cause which in any degree satisfies my mind. I conceive it to be a most subtle elastic fluid like our air but incomparibly more subtle and more elastic. Vinegar and Vinous spirits are both parts or productions of Fermented Liquors. High rectified Spirit is an electric per se. Vinegar is a non Electric or a Conductor. Now I can easily Imagine that Wine or fermented Liquor contains a considerable quantity of this Electrical fluid [and] that Vinegar has lost it all or a great part of it but that the whole or greatest part is separated with the high spirit and remains with it. But I cannot conceive how or from what cause it proceeds, that in proportion as one side of the glass is filled with this elastic fluid the other side is emptied of it and, without understanding this, no satisfactory account can be given of the Phoenomena of Electricity.

You say that Salt is an electric per se. Several pieces of West India Salt will draw the electrical fluid from the electrified viol [vial] and some others will not do it. Some will draw off the Electricity from the viol even when they are fixed in sealing wax. Salts never communicate the Shock but seem to retain the Electrical fluid in themselves and become saturated with it. For by some experiment made in my house, a piece of Salt that at first drew of the Electricity would by repeated applications to the Electrical viol

become an electric per se. But all Electrical experiments depend so much on particular circumstances that any not so much conversant in them as you are may be easily deceived.

We have observed that Women's flannel under petticoats are sometimes deeply charged with the Electrical fluid so as in the Winter time after they are thrown off and a non-electric draw slowly over them make a snapping noise as the excited tube does on the approach of a non electric.

I inclined to have made experiments by filling the viol at several times with the strong acid spirits such as strong spirit or oil of Vitriol, Sp. of Niter, Aqua fortis and Aq[ua]. Regia and at other times with the Alcaline sp. as sp. of Sal Armen [Ammoniac], Hartshorn &c. but I have not sufficient quantities for such purposes.

I would incline likewise to make experiments on several kinds of Salts as common salt, Niter, Borax, and Ammoniac, of Earths as Bole, Chalk, Clay, Sand, Lime, &c. I am strongly inclined to think that from such like experiments we may learn many useful things in Medicine and Agriculture. For I suspect that all Fermentations, Vegetation, and Animal Motion is principally produced by this subtle elastic fluid which I imagine to be the cause of Electricity and is more or less to be found in all bodies strongly, retained by some, and separating easily from others. When the Viol has been repeatedly charged we find Water raised along the Wine to the outside of the Cork and may not the similar nourishment in plants be raised in such like manner.

I am so strongly possessed with the Principles of Action in Matter which you have seen that I amuse myself at leisure hours in applying them to the explication of the most general phoenomena of nature and can not easily direct my thoughts to other speculatives. These favourite prepossessions probably may be of advantage to our gaining of knowledge more, perhaps, than if you and I were both solely attached to one kind of pursuit, because one may receive hints from the other which do not naturally arise in the pursuit which only one singly follows. Some gentlemen distinguished by their knowledge in Physical matters in London, Oxford, Leipzig, and Paris have given so favourable an opinion of that little treatise that I have been induced to revise what was before wrote and to make considerable additions which I expect Mr. Dodsley has by this time printed a Specimen of the sheet I have received this spring. The printer has done his part to recommend it by a good letter and paper. I have endeavoured to explain my thoughts more clearly and fully than I did at first. A few copies of it will be printed as it is not adapted to amuse common readers. I cannot expect that my sentiments so contrary to the commonly received notions should suddenly prevail. A French Gent. writes *il a bien donné la torture à nos Metaphysiciens* [4] but I am confident they will at last.

I have mentioned this book on account of a proposition advanced in it which perhaps may be of use or serve as a hint for explaining the electrical fire. I propose to add to this a copy of an illustration of that proposition because the illustration will not be found in the printed book.

No doubt you have seen the Cure of Cancers by the Poke weed published in the Gentns. Magazine.[5] I have lately had a confirmation of this by a Cancer last year cured in a Woman's breast. I make no doubt it will generally make a perfect cure of a genuine Cancer from many Accounts. I have heard though not obtained in such an authentic manner as fit to be published and as no cure before this was known but by the cruel method of extirpation and that not always a certain cure publication in the Magazine may be of use to many miserable persons. Though this juice gives much pain in the application it is not a caustic but rather such kind of pain as Arum gives without destroying the substance of the flesh. I never heard of any ill consequence from the external use of it where the sick had patience to endure the pain tho it has been frequently used in external applications.

[4] "It has tortured [truly given torture to] our metaphysicians," i.e., scientists.
[5] *Gentleman's Magazine* of London.

___Benjamin Franklin to Cadwallader Colden, 23 April 1752___

(copy to American Philosophical Society)

Sir

In considering your Favour of the 16th. past, I recollected my having wrote you Answers to some Queries concerning the Difference between Electrics per se, and Non Electrics, and the Effects of Air in Electrical Experiments, which I apprehend you may not have received. The Date I have forgot.

We have been us'd to call those Bodies Electrics per se, which would not conduct the Electric Fluid. We once imagin'd that only such Bodies contain'd that Fluid; afterwards, that they contain'd none of it. But farther Experiments show'd our Mistakes. It is to be found in all Matter we know of; And the Distinction of Electrics per se and Non Electrics should now be dropt as improper, and that of Conductors and Nonconductors assum'd in its Place, as I mention'd in those Answers.

I do not remember any Experiments by which it appear'd that high rectified Spirit will not conduct; perhaps you have made such. This I know, that Wax, Rosin, Brimstone, and even Glass, commonly reputed Electrics per se, will, when in a Fluid State, conduct pretty well; Glass will do it when only red hot. So that my former Position, that only Metals and Water were Conductors, and other Bodies more or less such as they partook of Metal or Moisture, was too general.

Your Conception of the Electric Fluid, that it is incomparably more subtle than Air, is undoubtedly just. It pervades dense Matter with the greatest Ease, but it does not seem to mix or incorporate willingly with mere Air, as it does with other Matter. It will not quit common Matter to join with Air. Air obstructs in some degree its Motion. An Electric Atmosphere cannot be communicated at so great a Distance thro' intervening Air, by far, as thro' a Vacuum. Who knows then but there may be, as the Ancients thought, a Region of this Fire above our Atmosphere, prevented by our Air and its own too great Distance for Attraction, from joining our Earth? Perhaps where the Atmosphere is rarest, this Fluid may be densest and nearer the Earth; where the Atmosphere grows denser, this Fluid may be rarer, yet some of it be low enough to attach itself to our highest Clouds, and thence they becoming electrified may be attracted by and descend towards the Earth and discharge their Watery Contents together with that Etherial Fire. Perhaps the Aurorae Boreales are Currents of this Fluid in its own Region above our Atmosphere, becoming from their Motion visible. There is no End to Conjectures. As yet we are but Novices in this Branch of Natural Knowledge.

There is no End to Conjectures. As yet we are but Novices in this Branch of Natural Knowledge. Franklin

You mention several Differences of Salts in your Electrical Experiments. Were they all equally dry? Salt is apt to acquire Moisture from a moist Air, and some Sorts more than others. When perfectly dry'd, by lying before a Fire, or on a Stove, none that I have try'd will conduct, any better than so much Glass.

New Flannel, if dry and warm, will draw the Electric Fluid from Non Electrics, as well as that which has been worn.

I wish you had the Convenience of trying the Experiments you seem to have such Expectations from, upon various kinds of Spirits, Salts, Earths, &c. Frequently, in a Variety of Experiments, tho' we miss what we expected to find, yet something valuable turns out, something surprizing, and instructing tho' unthought of.

I am glad your Piece on the Principles of Action in Matter, with the Explanations, is likely soon to appear. I hope it may be printed correctly. Tracts on uncommon Subjects, when the author is at a Distance, frequently suffer much in the Press, thro' the Ignorance of the Workmen. I think my Letters were almost as fairly wrote as Print itself, yet they were publish'd with several Errata that render particular Parts quite unintelligible.

I must own that I am much in the Dark about Light. . . May not all the Phaenomena of Light be more conveniently solved by supposing Universal Space filled with a subtle elastic Fluid . . . Franklin

I thank you for communicating the Illustration of the Theorem concerning Light. It is very curious. But I must own that I am much in the *Dark* about *Light.* I am not satisfy'd with the Doctrine that supposes Particles of Matter call'd Light continually driven off from the Sun's Surface, with a Swiftness so prodigious! Must not the smallest Particle conceivable have, with such a Motion, a Force exceeding that of a 24 pounder discharg'd from a Cannon? Must not the Sun diminish exceedingly by such a Waste of Matter, and the Planets instead of drawing nearer to him, as some have feared, recede to greater Distances thro' the lessened Attraction? Yet these Particles with this amazing Motion, will not drive before them or remove the least and lightest Dust they meet with; And the Sun, for aught we know, continues of his ancient Dimensions, and his Attendants [planets] move in their ancient Orbits.

May not all the Phaenomena of Light be more conveniently solved by supposing Universal Space filled with a subtle elastic Fluid, which when at rest is not visible, but whose Vibrations affect that fine Sense the Eye, as those of Air do the grosser Organs of the Ear? We do not, in the Case of Sound, imagine that any sonorous Particles are thrown off from a Bell, for Instance, and fly in strait Lines to the Ear; why must we believe that luminous Particles leave the Sun and proceed to the Eye? Some Diamonds, if rubbed, shine in the dark, without losing any Part of their Matter. I can make an electrical Spark as big as the Flame of a Candle, much brighter and therefore visible farther; yet this is Light without Fuel, and I am persuaded no Part of the Electric Fluid flies off in such Case to distant Places, but all goes directly and is to be found in the Place to which I destine it. May not different Degrees of Vibration of the above-suppos'd Universal Medium, occasion the Appearances of different Colours? I think the Electric Fluid is always the same, yet I find that weaker and stronger Sparks differ in Apparent Colour, some white, blue, purple, red; the strongest white, weak ones red. Thus different Degrees of Vibration given to the Air, produce the 7 different Sounds in Music, analogous to the 7 Colours, yet the Medium, Air, is the same.

If the Sun is not wasted by Expense of Light, I can easily conceive that he shall otherwise always retain the same Quantity of Matter, tho' we should suppose him made of Sulphur constantly flaming. The Action of Fire only *separates* the Particles of Matter, it does not *annihilate* them. Water by Heat rais'd in Vapour returns to the Earth in Rain. And if we could collect all the Particles of burning Matter that go off in Smoke, perhaps they might, with the Ashes, weigh as much as the Body before it was fired; and if we could put them into the same Position with regard to each other, the Mass would be the same as before and might be burnt over again. The Chemists have analys'd Sulphur and find it compos'd in certain Proportions of Oil, Salt, and Earth: And having by the Analysis discover'd those Proportions, they can of those Ingredients make Sulphur. So we have only to suppose that the Parts of the Sun's Sulphur, separated by Fire, rise into his Atmosphere, there being freed from the immediate Action of the Fire, they collect into cloudy Masses, and growing by Degrees too heavy to be longer supported, they descend to the Sun and are burnt over again. Hence the Spots appearing on his Face, which are observ'd to diminish daily in Size, their consuming Edges being of particular Brightness.

'Tis well we are not, as poor Galileo was, subject to the Inquisition for Philosophical Heresy. My Whispers against the orthodox Doctrine in private Letters would be dangerous. Your Writing and Printing would be highly criminal. As it is, you must expect some Censure, but one Heretic will surely excuse another.

I am heartily glad to hear more Instances of the Success of the Poke Weed in the Cure of that horrible Evil to the human Body, a Cancer. You will deserve highly of Mankind for the Communication. But I find in Boston they are at a Loss to know the right Plant, some asserting it is what they call *Mechoacan,* others other Things. In one of their late Papers, it is publickly requested that a perfect Description may be given of the Plant, its Places of Growth, &c. I have mislaid the Paper or would send it to you. I tho't you had describ'd it pretty fully.

With great Respect and Esteem, I am, Dear Sir, Your obliged humble Servant

___Cadwallader Colden to Benjamin Franklin, 20 May 1752___

Dear Sir

I received yours of the 23d of April as I was going on board the sloop in my return home from New York and could not take the pleasure of reading it before I left that place. . . .

Your conjecture of the Electric fluid's taking place in the superior regions of our atmosphere pleases my fancy, as it in some measure confirms what I have advanced in the Treatise now in the press viz. [namely] That all the Planets in a greater or less degree emit Light and indeed I think that all bodies do. It does not follow that because we do not see the light that none is emitted. Some men can see where others are entirely in the Dark and some Animals as Owls, Bats, &c. see in the Dark and cannot bear so great a degree of Light as is necessary for our Perceptions.

When you shall see that Tract you will have opportunity of Judging of the Validity of the reasons I advance for an opinion that Light is a substance or Being essentially distinct from what we commonly call Matter or Body, that they have nothing in common between them except that we consider or conceive both as consisting of Quantity, that is, that in the same space there may be a greater or less quantity of either and that a certain quantity of either may be confined within certain bounds and consequently have some shape or form. Light has no power of attraction though it be attracted by resisting matter.

The Vibrations of a Fluid will in no manner explain the Phoenomena of Light as is very expressly pointed out in Sir Isaac Newton's *Optics*.[6] For example, Light proceeds always [always] in straight lines unless diverted by some other thing. For this reason any opaque body placed between the eye and a luminous body intercepts all the light but it does not intercept the sound coming from a sonorous body because Sound is conveyed by the Vibrations of a fluid Medium, not by any emission of particles from the sounding body. Again the separation of the distinct parts of Light which excite in us the different and distinct sensations of colours and which, once separated, always remain the same prove that these sensations cannot be produced by the Vibrations of any Medium supposed to convey the Action of Light from the Luminous body. I am persuaded that a careful attention to the Phoenomena in Sir Isaac's *Optics* and to his reflections on them will remove all doubt on this head.

On this occasion I think it proper to observe to you that in the Treatise before mentioned what Sir Isaac has proved is generally taken for granted and supposed to be known.

It may be proper likewise to observe to you that pure Light without any other mixture makes no impression on any other sense except the Sight. That the sense of heat arises from the Action of Light united with the action of some resisting matter. So likewise we have no Idea of fire without the union of resisting matter with Light.

In considering all Quantities or Degrees of Action or Force, whether in ascending or descending, whether in considering them as continually increasing or continually decreasing, the ratio of comparison must at last come to that of infinity. We have no Idea of the absolute Force of anything, only of its comparative force — or ratio of its force — to that of some other thing. The force of Different quantities of Light does not arise from the different Velocities (for I suppose all light always moves in the same

[6] Published in England in 1704.

ratio of Velocity Compared with any velocity that can be distinguished by our senses) but from the greater quantity or density of Light in the same Space.

If the emission of Light be not continued but by distinct vibrations or pulses and an infinitely thin surface of Light be thrown off in any finite part of time, suppose in a fifth, then there cannot be any finite or determinable diminution of the Light of the Sun or of the Diameter of Light in the sun in any finite time. If the intervals of the vibrations or emissions of infinitely thin Surfaces of Light be in an infinitely small part of time, It may take a hundred of a thousand years to diminish the sun's Diameter one Inch. You will find something of these abstracted Speculations in the treatise I mention. . . .

I have received a Copy of the Translation of my first piece into High Dutch with Animadversions on it at the end of it printed at Hamburg and Leipzig [Germany] 1748 but I do not understand one word of them. I find my name often in company with those of very great ones — Newton, Leibnitz, and Wolfius and Leibnitz's Monades often mentioned a New Doctrine which perhaps you have seen and is of great repute in Germany. The animadversions end — *Magnis tamen excidit ausis* [7] — which being in Latin I understand.

The person in the Boston paper who wants a fuller description of the Poke weed or Phytolacca than that given in the Magazine must have but little skill in Botany, for I am confident the Description is sufficient for a Botanist to distinguish it from any other Plant whatsoever. I know that some people have thought that the Pokeweed is Mechoacan but they who think so know little of Plants.

___Benjamin Franklin, to Cadwallader Colden, 14 September 1752___

Dear Sir,

When I had read your Favour of May the 14th, I resolved to read and consider more carefully Sir Isaac Newton's *Optics*, which I have not look'd at these many Years. I delay'd answering, till I should have an Opportunity of doing this, but one thing or other has hitherto hindered. In the Winter I may possibly have more Leisure.

In the mean time I would just mention that the Interposition of a Hill between a Bell and the Ear does interrupt great Part of the Sound, tho' not all; and we cannot be certain that an opaque Body plac'd between the Eye and a luminous Body intercepts all the Light, since, as you observe, it does not follow that where we see no Light there is therefore none existing. What you say of the Separation of the distinct Parts of Light, which once separated remain always the same, has more Weight with me, and indeed seems conclusive; at least I see at present nothing to object.

I congratulate you on the Prospect you have of passing the Remainder of Life in philosophical Retirement. I wish for the same, but it seems too distant. Franklin

I congratulate you on the Prospect you have of passing the Remainder of Life in philosophical Retirement. I wish for the same, but it seems too distant. I might then more punctually perform my Part in the Correspondence you honour me with, than which I have none more instructive or agreeable.

Send me, if you please, the Translation of your Piece into High Dutch. I understand a little of the German Language and will peruse and return it. At present, I cannot guess the Meaning of the Passage you mention. Unless perhaps, as your 20th Section speaks of "a Power that neither resists nor moves and

[7] "It was, however, in great undertakings that he failed." Ovid, *Metamorphosis*.

exerts no kind of Action of itself without the Concurrence of some other Power, so that in the Absence of other Powers it must be in perfect Inaction, &c." It may be some kind of Dutch Wit and intended to joke that Quietism which in Germany is supposed to be very prevalent in Pensilvania, many of their Quietists having removed hither.

I see by Cave's May Magazine they have translated my Electrical Papers into French and printed them in Paris. I hope our Friend Collinson will procure and send me a Copy of the Translation. Such Things should be done by Men skilled in the Subject as well as in the Language, otherwise great Mistakes are easily made, and the clearest Matters rendered obscure and unintelligible.

I am sorry you could not see Mr. Kinnersley's Lectures; they would have pleas'd you. I send you Mr. Wilson's Book, which I just receiv'd from London, and think it contains the best Directions for the Use of the Machine that are extant. When you have done with it, please to return it to Dear Sir Your most humble Servant

___Cadwallader Colden to Benjamin Franklin, 24 October 1752___

Dear Sir

I now send back to you Wilson on Electricity[8] for the use of which I am much obliged. My youngest son, the only one I have with me, hopes to be able to make Electrical experiments tolerably well. Mr. Wilson, I think, is on the true scent of the cause of Electricity, though it be plain he is not sufficiently informed of the nature of that elastic fluid which he calls Aether to be able sufficiently to account for the Phaenomena.

In my Opinion some more perfect knowledge of the Air than we have is likewise necessary, and the cause of the cohesion of the parts of bodies which last has been lately the subject of my Meditations. No tolerable account of this, so far as I know, has been given by any Philosopher, and if this can be accounted for from my Principles it will go a great way to confirm them. I hope to let you see something on this head. At present I shall only mention one Theorem viz. [namely] That the parts or particles of Bodies are at a great distance from each other in the ratio of their bulk. To prove this it is supposed that the solid particles of inert Matter are impenetrable by light or that Light cannot be in the same space with matter. Then, since light freely passes through pellucid bodies in straight lines and in all directions with a very small diminution of its quantity, the distance between the particles of pellucid bodies must be very great in proportion to their bulk if the prodigious number of those particles be considered which must be in a pellucid body of any bulk.

This may be easily conceived by placing a number of points in any order and considering how they must stop the progress of light in many directions. Again the number of particles in the same quantity of space in several bodies is as their Specific Gravities. Now considering the difference of Specific Gravity of pellucid bodies and of any other opaque body that it does not arise to a great degree, the parts of all bodies must be at a great distance from each other in proportion to their bulk. Sir Isaac Newton accounts for the cohesion of the parts of bodies from the stronger attraction in little bodies than in great bodies, but if this were the cause, the parts of bodies must run together into mutual contact if some other power do not keep them separated. What I call Aether is essentially different from Mr. Wilson's Aether and from that Elastic fluid which I think produces Electrical phaenomena. Sir Isaac Newton was far from having clear conceptions of what I call Aether though he perceived from the Phaenomena that some such medium must necessarily exist between the several bodies in the Universe and within them between their component parts.

[8] Benjamin Wilson, English portraitist and researcher in electricity.

I have at last got the remarks on the First causes of Action in Matter well translated by Mr. Hartwick, a Lutheran Minister who is well acquainted with the German systems of Philosophy and thereby more capable of making a good Translation. I have likewise drawn up an answer to the remarks which I expect may assist you to form a better conception of my principles and of the truth of them than what you have already seen. I now send both the remarks and Answer to Mr. Alexander and I shall desire him to transmit them to you if he do not think it necessary to alter anything in the Answer. In the mean time I send you the original remarks in the German language that you may the better judge of the Translation when you shall see it.

The Remarks and Answer are chiefly on the Metaphysical parts of my System. The same subject is treated in Dr. Johnson's Noetica but in a very different manner. I hope from your Friendship that you will give me your sentiments without reserve and I beg that you will take some pains because I have some distant prospect of being able to explain the phaenomena of Electricity from my Principles with your assistance. If this can be done I am persuaded that the greatest improvement will thereby be made in the most useful parts of Physics. I conceive that Fermentations of all sorts arise from Electricity and that the life and vegetation of Animals and Vegetables arise from Fermentation. If so the knowledge of Electricity must give great light in Medicine and Agriculture. For this reason I will gladly take pains to remove any difficulties you may have in receiving or conceiving these Principles. I have not as yet heard that the Principles of Action in Matter is published though I had the first sheet sent me in January last.

[Y]ou have such sagacity in contriving proper experiments for any purpose you have in view.

Cadwallader

p.s. This having lain by me some days for an Opportunity to send it I have in that time seen in the News papers the Account of the Electrical Kite. I hope a more perfect and particular account of it will be published in a manner to preserve it better and to give it more Credit than it can obtain from a common News paper. I wish you would attempt some experiments to know whether the Electrical fluid can be drawn from fermenting liquors or Mixtures. I propose to try but what may fail with me may succeed with you, you have such sagacity in contriving proper experiments for any purpose you have in view. The Clouds before a Thundergust and after in the time of it appear to be in a violent intestine motion or fermentation.

___Benjamin Franklin to Cadwallader Colden, 28 February 1753___

Dear Sir

I return you herewith Professor Kanster's Remarks. As far as I am able to judge, the Translation is just, and your Answer a good one. I am pleas'd with the Omission of that part of a Paragraph relating to the German and Pensilvanian Electricians, and have corrected the Copy as you direct. I have but one other Alteration to propose, which is, to omit some Part of the last Paragraph, and read the rest thus: — "After all, Mr. Colden must think himself obliged to the Professor for exposing the Difficulties his Treatise lies under in the Opinion of others, as thereby an Opportunity is given of explaining his Doctrine more fully to their Satisfaction." For it seems to me not so proper to make Acknowledgement for his Translating your Piece, as if it were a Favour, when he tells the World he did it by Command. And I apprehend it unnecessary, and that it may look like too great a Fondness for Compliment, to draw one from him by Consequence; viz. *That he did not think it a trifling Performance or he would not have taken the Trouble, &c.* since he himself freely says, *that the many new, good and just Thoughts contain'd in it, made him willingly undertake the Task enjoin'd him.* Besides that it is not clear he could have refus'd to obey the Command he received, whatever might have been his private Sentiments.

The Ship I intended to forward these Papers by to Mr. Collinson has stay'd much longer than I expected, and now I am told will not sail before the End of next Month, so that I may possibly receive your Directions concerning this propos'd Alteration before she sails.

I find I was not wrong in my Apprehensions that your Book would be incorrectly printed. I hope however that the Errata will be in England time enough to be published with the Work, and I thank you for sending them to me. I have corrected the Book accordingly and given it one Reading, but it is not a Piece to make sudden Remarks on, as one might of a Poem or other Performance on common Subjects. I must read and consider it yet more attentively. At present I can only tell you that some Things in it please me exceedingly, some I do not yet clearly understand, and one or two Positions I think wrong, of all which you shall hear more fully in my next. On the whole it gives me great Satisfaction, when I consider it as a Work that will not only improve Philosophy, but do Honour to America.

I am sorry I have not, as you expect, anything new to communicate to you on the Subject of Electricity. My Time and Thoughts have of late been much engag'd in other Matters, and ever since I heard of your being furnish'd with an Apparatus, I have hoped rather to receive Information of new Discoveries from you than expected to send you any. If your other philosophical Pursuits do not prevent your Application to the Experiments you propos'd to make on various Salts, &c. I shall still hope it. Your Skill and Expertness in Mathematical Computations will afford you an Advantage in these Disquisitions, that I lament the want of, who am like a Man searching for something in a dark Room, where I can only grope and guess, while you proceed with a Candle in your Hand.[9]

We are preparing here to make accurate Observations on the approaching Transit of Mercury over the Sun. You will oblige us much by sending the Account you have received from Lord Macclesfield of his great mural Quadrant. I congratulate you on your Discovery of a new Motion in the Earth's Axis. You will, I see, render your Name immortal.

I believe I have not before told you that I have procur'd a Subscription here of £1500 to fit out a Vessel in Search of a N[orth]West Passage. She sails in a few Days and is called the *Argo*, commanded by Mr. Swaine, who was in the last Expedition in the *California*, Author of a Journal of that Voyage in two Volumes. We think the Attempt laudable, whatever may be the Success: if he fails, *Magnis tamen excidit ausis.*

With great Esteem, I am, Dear Sir, Your most humble Servant

[9] Franklin is being considerate of Colden in his comments here, for Franklin was the superior thinker and researcher.