TRACT

ON

COMETS;

AND PARTICULARLY ON THE

COMET THAT IS TO INTERSECT THE EARTH'S PATH

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TRACT ON COMETS.

THE public mind has been much occupied with the Comet which is to reappear in 1832. Many journals have even announced that it would strike the earth and break it in pieces. The Board of Longitude has therefore judged it proper to publish, in the *Annuaire*, all the exact and indisputable results which science has made known upon this subject. To this object I at first intended to restrict myself, but soon the field enlarged before me, and I was induced to speak not only of the alleged dangers to be feared from the approaching comet, but also of the part which, according to some distinguished philosophers, other bodies of the same nature have formerly played in the great physical revolutions of which the earth has been the theatre. In my humble opinion they have had no part or lot in the matter; I therefore apprize the reader beforehand, that he will find, in what I have to offer, nothing to countenance such doctrines.

This tract is divided into two parts. All the questions which are discussed in the first would belong properly to a treatise on Astronomy; the second is devoted to a detailed examination of certain hypotheses which I would gladly have left in oblivion, if the approaching return of the comet, and the fears occasioned by it, had not revived them.

The very elongated form of the orbit makes a marked distinction between a comet and a planet. Thus when Herschel discovered Uranus, it was for some time supposed to be a comet, although it had neither tail nor hairy appearance; for its proper motion among the constellations was manifest, and in order to explain why it had not before been seen and recognised, it was supposed that it had now made its appearance for the first time, and that its great distance had hitherto rendered it invisible. But when it was proved by careful and continued observation that it passed round the sun nearly in a circle, and was moreover visible at all seasons, in the absence of day-light, it was ranked among the planets.

3. *Nature of a Comet's Orbit; Elements of a Comet's Orbit.*

Comets were considered by most of the ancient philosophers as mere meteors formed in the earth's atmosphere; but they are now known to be celestial bodies. To ascertain this, it was only necessary to compare together several observations made at the same time in different parts of the earth very remote from each other.

From the time of Tycho Brahe, to whom we are indebted for this discovery, comets are known to move round the sun according to certain laws, similar to those which regulate the motion of the planets, *and that their orbits are very elongated ellipses.*

The sun is always in one of the foci of a comet's elliptical orbit.

The vertex of the ellipse nearest to the sun is called the *perihelion;* the other vertex takes the name of *aphelion.*

The distance between a comet and the sun, at the moment it passes the vertex of the ellipse nearest the sun, is called its *perihelion distance;* it is the smallest distance at which it can ever be from the sun.

Comets are never visible from the earth except when they are near their perihelion; but, as I have already remarked (page 6), a very elongated ellipse and a parabola, having the same vertex and focus, do not differ sensibly from each other for a great distance from their common vertex. Accordingly, to show the different positions of a comet during the short period that it is visible, we may generally substitute a parabola for an ellipse. If it should so happen, in any particular case, that the two curves do not coincide, we must conclude that it is an exception to the general rule, occasioned by the elliptical orbit of the comet not being very much elongated.

By a calculation which is very simple, but of which it would be impossible to give an exact idea in this place, it may be shown that three positions of a comet, seen from the earth, are sufficient to determine its parabolic orbit. The several particulars or *elements* which constitute this determination are as follows.

The plane, or basis to which every thing is referred, is that in which the earth moves, called the *ecliptic*. In this plane the nearly circular curve which the earth annually describes round the sun, is considered as divided into 360°. The point of commencement of this division is fixed by the help of certain astronomical phenomena, which it is unnecessary to speak of here.

The distance of any object reckoned round on the ecliptic from this point of commencement is called its *longitude*.

The plane of the orbit of a comet, the plane, in which the ellipse and its parabolic tangent are situated, passes through the sun, and must consequently meet the ecliptic in a straight line, of which we know the first point, that is, the centre of the sun. Another point is wanting in order to determine the line. It is universally agreed to take for this second point that in which the graduated circle of the ecliptic is cut by this straight line.

This point of intersection is called the *node.*

Thus, the node of a comet is found at 10° or 20° or 30°, according as the plane of the orbit cuts the ecliptic in a line which, drawn from the sun, terminates at 10°, 20°, or 30° of the graduated circle supposed. The position, or *place of the node,* is one of the elements of which the calculation gives the value. This position points out as it were the region of the heavens which the orbit faces; but this is not sufficient for determining the plane; it is necessary to know, besides, what angle it makes with the ecliptic, for it may pass through any number of planes in the same straight line.

This new element is called the *inclination.*

In the plane now wholly determined, the transverse axis of the ellipse, or, which is the same thing, the axis of the parabola, may be perpendicular to the line of the node, or it may form an angle with it of 10°, 20°, or 40°.

We get rid of all uncertainty in this respect by saying to what point of the graduated circle of the ecliptic, or to what longitude, the extremity of the transverse axis, that is, the perihelion, corresponds.

Thus, the *longitude of the perihelion* must necessarily make one of the elements of a comet's orbit.

If two parabolas, of which the common focus is the centre of the sun, have the same axis, they can differ from each other only with respect to the distance of this focus from the vertex of the curve, that is, the perihelion distance.

The *perihelion distance,* expressed in fractions of a unit that may be chosen at pleasure, is as necessary to be known, as any of the other elements of which I have spoken. It is agreed to take for the unit the medium distance of the earth from the sun.

An ellipse, or a parabola, may be traversed in two different directions. An observer ought therefore to note whether the motion of a comet is from west to east, or the reverse. As the moon, planets and satellites traverse the heavens from west to east, astronomers have agreed to call that motion *direct*. The motion of any heavenly body in the opposite direction, that is, from east to west, is called *retrograde*. Thus we can express in a single word the direction of a comet's course in its orbit, having only to describe it as *direct* or *retrograde*.

To sum up now the *parabolic elements of a comet*, we have;

The *inclination* and the *longitude of the node*, necessary to determine the *position* of the plane of the orbit.

The *longitude of the perihelion*, showing the direction of the *transverse axis* of the orbit, or the situation of that curve in its own plane.

The *perihelion distance*, which removes all doubt as to the form of the parabola, because the focus necessarily coincides with the centre of the sun.

Lastly, the *direction of the motion*, expressed by one or the other of these words: *direct*, *retrograde*.

To calculate the *parabolic elements*, is the first object of astronomers when a comet appears. In order to do this, three observations are necessary. If only two can be obtained, the form and the position of the orbit must remain unknown. If many observations can be had, they all tend to establish the final result, and it is the more exact.

4. *On the Means of ascertaining when a Comet appears, whether it is seen for the first time, or whether it has been before observed.*

After remarking how much the form of a comet's tail, the form of the envelope and nucleus, and the intensity of the light from all these parts vary in the course of two or three days, no one could expect to recognise such a body, on its second appearance, after a lapse of many years, by any description founded on those physical characteristics of size, form, or brightness. It is not therefore on any of these marks that astronomers rely. They leave them all out of the question, and confine their attention wholly to the course of the comet in the heavens.

When three observations have been made of a comet with sufficient exactness, the *parabolic elements* are calculated, and then search is diligently made in the *Catalogue of Comets*, which is always kept, and in which the elements are recorded, to ascertain whether it is like any of those already observed.

Let us first suppose that all the sets of elements contained in the catalogue, or table, differ from that of the new comet; we must still refrain from drawing any positive conclusion, because observation and theory prove that a comet, in passing near a planet, may be so perceptibly deranged in its course, that the curve it makes *after* that approach, cannot be considered as the continuation of the curve it was describing before.

Now let us suppose a contrary case, and that the parabolic elements of the new comet differ very little from a set of elements found in the table, and which belong to a comet seen at some former period. In this case there is *great probability* that they are one and the same, and that it is the reappearance of a comet returning to its perihelion. I say there is great probability only, because, mathematically speaking, it is not impossible that two comets should traverse the heavens, in two equal curves, and be similarly placed. But when we consider that the similitude must relate at the *same time*, to the inclination of the plane of the orbit, which may vary from 0° to 180°; to the longitude of the node, that is, to a number susceptible of taking all possible values from 0° to 360°; to the longitude of the perihelion, which, in like manner, may vary 360°; finally, to the perihelion distance, which, for comets already known, is comprehended between 0,206 and 4,043, the mean distance from the sun to the earth being 1; — when we take all these particulars into consideration, we can scarcely hesitate to conclude that two comets, which, at two different epochs, have appeared with all these elements nearly the same, are one and the same body. Hitherto, at least, we have been justified in this inference, by the event.

After having explained how the different circumstances in the proper motion of a comet are the only means of recognising it, when it reappears, I proceed to apply these principles to the only three comets whose periodical return has been satisfactorily determined.

5. *Comet of* 1759.

A comet having appeared in 1682, Halley determined its parabolic elements according to the observations of Lahire, Picard, Hevelius, and Flamstead, as follows;

Inclination.	Longitude of the node.	Longitude of the Perihelion.	Perihelion Distance.	Direction.
17° 42′	50° 48′	301° 36′	0,58	Retrograde.

The same mode of calculation being applied to the observations of a comet of 1607, made by Kepler and Longomontanus, gives the following.

Inclination.	Longitude of the node.	Longitude of the Perihelion.	Perihelion Distance.	Direction.
17° 2′	50° 21′	302° 16′	0,58	Retrograde.

Allowing for the inaccuracies that must necessarily occur in calculating the orbit, and for the errors which the ablest observers are liable to fall into, when using instruments so much less perfect than those of the present day, remembering also that the attraction of the planets must produce a real change in a comet's orbit at each successive revolution, Halley came to the conclusion, that from the great similarity in the elements, the comets of 1607 and of 1682 were identically the same.

From 1607 to 1682 there was an interval of 75 years. Therefore in going back from 1607, 74, or 75, or 76 years, (I say one or the other of these numbers, because the perturbations, already mentioned, may affect the period of a comet's revolution quite as much as the position of its orbit,) there ought to have been seen, if Halley's conjecture were founded in truth, a comet similar to that of 1607.

This was actually the case. In 1531, that is, 76 years before 1607, Apian observed, at Ingolstadt, a comet, the course of which through the constellations he watched very attentively. His observations, calculated by Halley, gave the following elements.

Inclination.	Longitude of the node.	Longitude of the Perihelion.	Perihelion Distance.	Direction.
17° 56′	49° 25′	301° 39′	0,57	Retrograde.

These elements, it will be seen, differ very little from those of 1607, and 1682.*

* The same comet had been remarked in 1456, as may be seen by the following elements, which Pingré obtained from the few precise observations which were to be found in the authors of that period.

Inclination.	Longitude of the node.	Longitude of the Perihelion.	Perihelion Distance.	Direction.
17° 56′	48° 30′	301° 0′	0,58	Retrograde.

Before the year 1456 we find no good observations. The chroniclers thought it enough to say that a comet was seen in such and such a constellation. Not a word do they give us as to its relative position to known stars, or the hour at which it was seen. Consequently the elements of the orbit cannot be calculated. When this infallible method of recognising a comet fails us, the period of its revolution is the only guide that remains. We have already seen how much this period varies, and consequently how uncertain the results must be. It is therefore, with some doubt, that I give the

The identity of these three appearances could not be any longer doubted, and accordingly Halley ventured to *predict* that a *comet* would be visible towards the end of 1758, or the beginning of 1759, having parabolic elements differing but little from those here recorded.

The fulfilment of this prediction would of course form a new era in the astronomy of comets, and therefore it was thought advisable, in order to convince the most incredulous, to do away as far as was possible with the indefiniteness in which Halley had very properly left the date of its precise return; for, in his time, it was impossible to determine exactly the amount of disturbances or perturbations. This difficult problem was solved by Clairault. He found that the attraction of the planets would so retard the motion of the comet, that it would require, in returning to its perihelion, 618 days *more* than in its preceding revolution, that is, 100 days for the effect of Saturn, and 518 days for that of Jupiter. It might be expected therefore to reach its perihelion about the middle of April, 1759. Clairault also gave notice to the public, that being much hurried in his calculations, he had not time to consider many smaller causes which might together make a difference of 30 days, more or less, in the period of 76 years. The event justified all he had said; for the comet appeared according to the prediction, and passed its perihelion March 12th, 1759, within the assigned limits. Its parabolic elements, a little changed since its preceding appearance, were such as the calculations of Clairault had made them.

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comet of 1305, that of 1230, the comet mentioned by Haly-ben Rodoan in 1006, that of 855, and lastly a comet seen in the year 52, before the Christian era, as former appearances of that of 1759. As to the comet of 1006, the identity may be inferred from the similarity of their limits, if not from their elements.

The elements for the year 1759, are as follows.

Inclination.	Longitude of the node.	Longitude of the Perihelion	Perihelion Distance.	Direction.
17° 38′	53° 48′	303° 10′	0,58	Retrograde.

No doubt could now be entertained as to the periodical return of the comet of 1759, and it only remained to calculate its next appearance. M. Damoiseau of the Board of Longitude did not shrink from the immense labor. He carried his approximations much farther than those who preceded him; he even calculated the disturbing influence of the planet Uranus, the existence of which was unknown in the time of Clairault. The following is the result obtained by my colleague;

"The interval between the passage of the comet through its perihelion in 1759, and its approaching return to that point, will be 28007 days, which, reckoned from the 12th of March, 1759, the beginning of its period, will be accomplished on the 16th of November, 1835." *

We shall therefore see, in the middle of November, 1835, the return to the sun of the first comet whose period has been

* As the time of the reappearance of the comet of 1759 is now near at hand, it may be well to observe, that whilst it is following, without any deviation, the course prescribed to it by the universal laws of gravitation, it is nevertheless continually diminishing in its intensity; therefore we must not expect to see in 1835 the *cometa horrendæ magnitudinis* of the year 1305, nor the long tail which in 1456 measured two thirds of the space comprehended between the horizon and the zenith, nor even a body as brilliant as the comet of 1682 with its tail of 30°. It appears probable that in describing their immense orbits, comets at each revolution, dissipate in space all the matter which, when they are near the perihelion, is detached from the envelope, forming the tail; it is therefore very possible that in time some of them may be entirely dissipated, unless in traversing constantly, and in various directions, the luminous trains of a similar nature left by other comets, they recover from time to time as much matter as they have lost.

verified; that comet which in 1456, followed by a tail of 60° in length, produced the greatest consternation in Europe, partly on account of its great brilliancy, and partly because the public mind, being then enslaved by astrological superstitions, believed this phenomenon in the heavens was connected with the most important event of the times, the alarming success of the Mahometan arms.

6. *Comet of* 1770.

Messier discovered a comet in the month of June, 1770. As soon as three good observations could be obtained, the astronomers hastened, as usual, to compute its parabolic elements. These elements were found to be unlike those of any comet previously observed.

This comet continued to be visible for a long while, which gave an excellent opportunity for ascertaining how far its last positions agreed with the parabola formed by means of the early observations. Strange to say, the disagreement was enormous, and could not be got rid of by any possible combination of the parabolic elements. In this particular case, therefore, hitherto without example, the ellipse could not properly be assimilated to the parabola; hence the real ellipse must be supposed to have a very short transverse axis.

Accordingly, Lexell found that the comet of 1770 had described round the sun an *ellipse* of which the transverse axis was only three times the diameter of the earth's orbit, and which corresponds to a revolution of *five years and a half.* He represented also all the positions of this body, during the long time it was visible, with the exactness of the observations themselves.

There was, however, one great objection to this important result, with so short a revolution; it would seem that the comet of 1770 ought to have been frequently seen. Now there was no account of it to be found in any catalogue of comets before the time of Messier; nay, more, it has not been observed since, although it has been diligently sought in those places where, according to the elliptic orbit of Lexell, it ought to have appeared.

It may be easily imagined how many sarcasms and jokes, good or bad, were levelled at astronomers for their *lost comet*, and how much they were laughed at for having supposed that they had found out an infallible method of calculating the return of these bodies. There was to be sure something very mysterious in the non-appearance of the comet, a real problem to be solved; for the bright light with which it shone in 1770, forbade the supposition of its having returned several times without being observed. In our day, the whole difficulty has been cleared up; and the laws of universal attraction have derived from this circumstance, which seemed at first to invalidate them, new proof of their stability.

Why was not this comet visible every five years and a half before 1770? Because its orbit was then quite different from what it has been *since*.

Why has not this comet been seen since 1770? Because its passage through the perihelion in 1776 took place by daylight, and before another return, the form of its orbit was so changed, that, if the comet had been seen from the earth, it would not have been recognised.

Lexell had remarked, that, according to his calculation of the elements in 1770, the comet must have passed very near Jupiter in 1767, within a fifty-eighth part of its distance from the sun; that in 1779, when it was again returning to us, it was, towards the end of August, about 500 times nearer to that planet than to the sun. So that notwithstanding the immense size of the solar globe, its attractive force upon the comet was not a two-hundredth part of that of Jupiter. Thus it could not be doubted that the comet had experienced considerable perturbations in 1767 and in 1779; but it was still necessary to prove that those perturbations were *numerically* sufficient to account for its non-appearance both before and after 1770.

The formulas of the 4th volume of the *Mécanique Céleste* give the analytical solution of this problem : The *actual* elliptical orbit of a comet being known, what has it before been, and what will it be afterwards, in consequence of the disturbing influence of the planets?

Now it is found, by translating these formulas into numbers, and substituting the particular elements of the comet for the indeterminate letters, that, in 1767, before this comet had approached Jupiter, the elliptical orbit it described corresponded to a revolution about the sun, not of five years but of fifty years; and that in 1779, when it escaped from the sphere of that planet's attraction, the orbit was such as to require at least a period of twenty years. It results, moreover, from the same researches, that before 1767, during the whole of its revolution, the least distance of the comet from the sun was four hundred and eighty millions of miles; and that after 1779, this least distance became three hundred and fourteen millions of miles. This interval is too great for the comet to be visible from the earth.

With respect to the comet of 1770, therefore, however strange it may appear, we are nevertheless fully justified in saying, that the influence of Jupiter in 1767 brought it within our view, and that the same influence in 1779 produced a contrary effect, and carried it out of our sight.

7. *Comet of a short Period.*

The minute details into which I have been led, in speaking of the comet of 1759, will allow me to proceed more rapidly in what I have to say of the method which has been used to verify the periodical returns of that which we are next to consider.

This comet was discovered at Marseilles, November 26, 1818, by M. Pons.

M. Bouvard presented its parabolic elements to the Board of Longitude, the 13th of January, 1819. A member immediately remarked that the results of M. Bouvard's calculation resembled so much the elements of a comet observed in 1805, that he could not doubt they were one and the same comet.

The periodical return appeared, by this single comparison, to be determined beyond all doubt; but the length of its period remained unsettled, as it was possible, if not probable, that in thirteen years this comet might have returned several times.

It happened in this instance, as it often does in scientific researches, that what appears improbable turns out to be true; for M. Encke, of Berlin, proved, by indisputable calculations, that this comet required for its whole course round the sun but *twelve hundred days*, or three years and three tenths.

But, say those who believe that the time of a comet's revolution must *necessarily* be very long, How happens it that this body, which comes to its perihelion in less than three years and a half, was never observed before 1805? The answer is, It is a very small comet, its light is feeble, and it cannot be seen with the naked eye. This did not account satisfactorily for the want of observations in some of its returns; but it was not long before it was found that, among the collections of the Academy, there were observations of this comet made in 1786 and 1795. The table of comets contains, moreover, the elements of an orbit, at those two epochs, so much like those of 1818, that persons who have any knowledge of the disturbances to which these bodies are liable, can have no doubt of their identity. The points of difference, however, were sufficiently remarkable to prevent a hasty decision.

If doubts were entertained as to the length of the revolution of this singular body round the sun, on account of its performing its elongated orbit in less time than some of the planets employ in their circular orbits, it is needless now to discuss them. The short period of the comet of 1818 is now an undisputed fact, for its reappearance in the southern hemisphere in June 1822, took place in the parts of the heavens which the calculations had pointed out beforehand; the agreement was not less remarkable in 1825; and lastly in 1829, the epoch of its third predicted return, it appeared in the places which M. Encke assigned for it a year before, with only very slight variations, the cause of which will be the subject of a future discussion.

The comet of a short period was to return to its perihelion on the 4th of May, 1832, but not in a favorable position for observations. The astronomers at the Cape of Good Hope and in New Holland are better situated than those of Europe for observing its course with exactness.

8. *Comet of Six Years and Three Quarters.*

We have now come in our account of comets to another periodical one, which is to reappear, like that just described, in 1832, and whose near approach, we are told, will be attended with fatal consequences to the earth and its inhabitants.

This comet was discovered at Johannisburg on the 27th of February, 1826, by M. Biela, and ten days afterwards at Marseilles by Mr. Gambart. The latter calculated the parabolic elements without delay, by means of his own observations, and immediately perceived, on consulting the table of the elements of comets, that this was not its first appearance, but that it had been already observed in 1805 and in 1772.

The comet of 1826 is therefore periodical.

It was accordingly necessary to change the parabolic elements into elliptical elements, in order to discover the length of the comet's orbit left undetermined by the former. Messrs. Clausen and Gambart undertook this calculation, and each found, in nearly the same time, that the new comet made a revolution round the sun in about seven years.

This curious result was adopted without dispute; for, in 1826 astronomers were cured of their old notion that the revolution of a comet must *necessarily* be very long; while, from the example of the comet of 1770, it was deemed imprudent to venture to determine the time of the future re-appearance of a new comet, before all the derangements and perturbations to which it was liable in its whole course, had been thoroughly studied. My colleague, M. Damoiseau, undertook this long and minute calculation, the result of which is as follows;

The comet of six years and three quarters will cross the plane of the ecliptic, that is, the plane in which the earth moves, on *the 29th of October*, 1832, *before midnight.*

The earth, during its annual course round the sun, never leaves the plane of the ecliptic; therefore it is only somewhere in this plane that a comet could strike it; of course, if we had any thing to fear from the comet of 1832, the danger would be on the 29th of October, before midnight.

Now let us inquire whether the point, at which the comet will cross the plane of the ecliptic, is near the path that the earth describes; for, in order that there may be a meeting between the two bodies, this is as necessary a condition as the other.

Upon this point it is proved, by calculation, that the passage of the comet through the plane of the ecliptic *will be a little within our orbit, and at a distance from it equal to two and a third of the earth's diameters, or* 18,500 *miles.* It is possible that this distance, already so small, may disappear entirely, if we suppose certain small variations in the elements, given by Damoiseau, which it is difficult to answer for.

Let us, however, take two diameters and a third, as the real distance; we must remember that this has reference to the centre of the comet, and we must ascertain whether its size is large enough for any part of it to extend to the earth's orbit.

When this body appeared in 1805, the observations made by the celebrated M. Olbers, of Bremen, gave for the semidiameter of the comet two diameters and two thirds of the earth. From this number, compared with the preceding, it plainly results, that on *the 29th of next October*, A PORTION OF THE EARTH'S ORBIT *will be comprehended within the nebulous atmosphere of the comet.*

There remains now but one more question to answer; it is this: At the time when the comet will be so very near our orbit, that the nebulous or hairy *atmosphere* will cover some part of it, *where will the earth itself be?*

I have already said that the passage of the comet very near to a certain part of the earth's orbit, will take place on the 29th of October, before midnight; well, the earth will not arrive *at that same point*, until the 30th of November in the morning, that is, *more than a month afterwards!* Now we have only to call to mind that the average rate at which the earth moves in its orbit is 1620 thousand miles per day, and a very simple calculation will show, that

THE COMET OF SIX YEARS AND THREE QUARTERS WILL, DURING ITS APPEARANCE IN 1832, BE ALWAYS MORE THAN FORTY-EIGHT MILLIONS OF MILES FROM THE EARTH.

In order to ascertain the least distance of the comet from the earth in its future returns, the same calculations must be made. If in this year, 1832, instead of passing the plane of the ecliptic on the night of the 29th of October, it reached that point on the morning of the 30th of November, it would certainly mingle its atmosphere with ours, and perhaps it would strike us. But I hasten to assure the public, that a mistake of a month, in determining the time when a comet reaches its node, is impossible. I have confined myself in this account to what relates to the body of the comet, because no trace of any tail has ever been seen to accompany it in its former visits.

The reader is now in possession of all that can interest him with respect to the course of the comet of October, 1832. The foregoing facts do not differ from those which M. Olbers published in a note, the meaning of which has been so strangely mistaken by the public and by several journalists. Shall I be more successful in my endeavours to explain myself? I hope so; but I cannot be very confident, so long as there are persons who, believing that the earth will not come in contact with the comet or receive any direct injury from it, yet think that the comet cannot cross the earth's orbit without altering its form, as if this orbit were a material substance; as if the parabolic line described by a bomb through the air, when discharged from a mortar, could be affected in its course by other bombs having formerly been projected through the same space.

9. *The Effect of the Resistance of Ether upon the Course of Comets.*

Until lately the proper motions of planets were calculated according to astronomical tables, constructed upon the supposition that they moved in empty space. From the course of the comet of a short period it is proved, that a new element must in future be taken into consideration, namely, the resistance which is offered to all bodies, by a very thin, gaseous substance, that fills all space, and is called by common consent *ether.*

This resistance does not produce any perceptible effect upon the planets, on account of their great density; but comets, being for the most part only a collection of light vapor, may be greatly retarded by it in their motion. To feel the truth of what I have just stated with regard to the different effect of resistance upon light and heavy bodies, we need only compare the very unequal distances to which three balls of the same size could be thrown, in the air, if one were made of lead, another of cork, and a third of eider down, supposing they were all projected by equal explosions of powder, and received, at starting, equal impulses.

In calculating the positions that the comet of a short period would successively occupy in 1822, 1825, and 1829, M. Encke kept an exact account of every possible disturbance occasioned by the influence of the planets. Nevertheless, each time it appeared, there was a discrepancy between the results of calculation and those of the observation. This was always of the same kind, and evidently greater than could arise from any error of measurement.

The cause of this discrepancy could be nothing but the resistance of the ether. Indeed, it appeared that the only two elements of the orbit, which from one revolution to another experienced no change, were the inclination and the position of the node; and we know very well, that the resistance of a gas, however much it might diminish the velocity of a body, could not turn it either to the right or left; this body would still continue to move in the same plane.

The effect of the resistance of the ether upon the whole duration of the revolution of the comet of a short period round the sun, amounted to about two days, according to th calculations of M. Encke. If this influence upon the comet of six years and three quarters were of the same nature, it could not materially affect the results we have obtained respecting the least distance of the comet from the earth in 1832. I might therefore have dispensed with noticing this new kind of perturbation; but I resolved to mention it, because some troubled spirits have seized upon the idea of this resistance of the ether, of which but little has been hitherto known, as a reason why the time of the comet's passing through the plane of the ecliptic, could not be properly ascertained, and also as a sufficient ground for not placing implicit confidence in the declaration of astronomers, that no danger need be apprehended from the comet of 1832. Here then I shall state the objection in all its force:

The comet, *moving in empty space*, would arrive at a certain point of the earth's orbit thirty-one days *before* our globe; but the natural effect of any resisting medium is to *retard* it; the comet therefore, *moving in ether*, will arrive at the point in question *later* than the time assigned; thus it may fairly be affirmed, that its least distance from the earth will be less than that given by the calculations. It is true, say these reasoners, we do not know how much less; but is it impossible, that in certain physical conditions of the comet, its course should be retarded one month in its whole revolution? Astronomers have told us only what is probable; it still remains to be proved, that in 1832 the earth will not receive a violent shock!

The difficulty here presented may appear to some a very serious one, and I should fail of the end proposed in this tract, if I did not clear it up. Happily a few words will suffice to show, that it is founded on an erroneous statement.

We will now consider the comet in its own orbit, and allow that the position assigned to it by the calculations, founded on the supposition that it moves in empty space, and that in which it is actually seen, do not coincide. Now, let me ask, in what way does this difference show itself? According to the objection, the real position ought to be less advanced than the calculated one. Instead of that it is exactly the reverse. At each return of the comet of a short period in 1822, 1825, and 1829, the real appearance of that body has always occurred *sooner* than the calculated appearance.

There is, then, no reason to suppose that the passage of the comet of 1832, through the plane of the ecliptic, will occur *later* than the first calculations fixed it. If its action is analogous to that of the comet of a short period, its passage through the node must take place sooner, and its least possible distance from the earth will be proportionably increased.

This single remark is sufficient to do away with the objection I proposed to combat. It only remains to be shown, how the accelerated motion of the comet can be the effect of a resisting medium.

I allow that, at the first glance, such an acceleration appears strange enough; for what resists generally retards; but this difficulty will vanish as soon as we consider, that the immediate effect of a resisting medium, upon a body travelling in it, is to diminish its velocity in the direction of a tangent, or, what is the same thing, it lessens what is called its centrifugal force, which is exactly the same thing as if the attraction of the sun were increased. The effect of this force is to bring the body nearer to the sun and to lessen the dimensions of its original orbit. Now it is well known, for it is equally proved by observation and theory, that the heavenly bodies move quicker according as they approach nearer the sun. Their velocities and distances are found to be intimately connected together by one of the three great astronomical principles, known by the name of the *laws of Kepler*.

On reflection it will be perceived, that the difficulty under consideration arises from the belief, which every one seems to have, that the orbit of a comet must be unchangeable. It is true, that a body restricted to a certain curve by an original impulse, would move faster in empty space, than in a gaseous medium. But such a body cannot be compared to a comet; for this no sooner experiences a resistance than it changes its course; no wonder therefore that it arrives sooner. We are here reminded of a remark of Fontenelle, that when a thing can happen in two ways, it generally occurs in that which at first sight appears the least probable.

10. *Will the expected Comet sensibly affect the Course of the Seasons in the Year* 1832?

This question brings to our recollection the beautiful comet of 1811, the high temperature of that year, the abundant harvest which it produced, and, above all, the superior quality of the *comet wines*. I am well aware how much prejudice I may have to encounter in maintaining, that neither the comet of 1811, nor any other comet yet known, has been the occasion of the slightest change in the seasons on our globe. This opinion is founded on a scrupulous examination and attentive consideration of all the circumstances of the case; whilst the opposite belief, however general it may be, is the result of vague conjectures, and destitute of any solid basis. I will first state the facts, and then consider the theory founded upon them.

It is said that comets heat our globe by their presence. If it be so, nothing is easier than to prove it. Are not the thermometers in all the observatories of Europe consulted several times a day? Are there not kept in the same places exact accounts of every comet that appears? Let us see then whether the *average temperature* of Paris, for instance, during the years in which there have been the greatest number of comets, exceeds the average temperature of those periods in which none of these bodies have approached us.

In the following table the comets are classed, as belonging to the year in which the passage through the perihelion occurred.

The temperature is given in degrees and tenths, of the centigrade thermometer.

Years.	Average Temperature.	Number of Comets.	Remarks.
1803	10°,6	0	
1804	11,1	1	
1805	9,7	2	
1806	12,1	1	
1807	10,8	1	
1808	10,4	4	Small. One only was calculated.
1809	10,6	0	
1810	10,6	1	
1811	12,0	2	The comet of 1811 was seen again in July, 1812.
1812	9,9	1	
1813	10,2	2	
1814	9,8	0	The comet of a short period was not observed; so 1815 counts 2.
1815	10,5	1	
1816	9,4	0	
1817	10,4	0	
1818	11,4	2	
1819	11,1	3	One was the comet of a short period.
1820	9,8	0	
1821	11,1	1	
1822	12,1	3	One was the comet of a short period.
1823	10,4	1	Bright.
1824	11,2	2	
1825	11,7	4	One was the comet of a short period.
1826	11,4	5	
1827	10,8	3	
1828	11,5	0	
1829	9,1	1	The comet of a short period.
1830	10,1	2	
1831	11,7	0	

Now the reader has before him the means of judging, and may clearly see, that the year 1805, with its two comets, is one in which the temperature was lowest; that 1808 must be considered a cold year, though there have rarely been seen so many comets in so few days; that the coldest year in the table is 1829, notwithstanding the appearance of a comet; that 1831, during which no such body was seen, was much warmer than 1819, when there were three comets, one of which was very bright. Now, with these facts before us, how is it possible to believe that comets raise the temperature of the earth. One thing more should be here noticed, and that is, the circumstance of cold years being generally cloudy ones, and, that when the heavens are overcast, the most brilliant comets may pass without being perceived.

Let us now put aside these results of observation, for they are still too few for the consequences deduced from them to be beyond the reach of objection, and look at the problem in another point of view.

A comet can act from a distance upon the earth in three several ways only; by means of attraction, by the rays of light and heat which it radiates or reflects in all directions, and by the gaseous matter that composes its envelope or its tail, which in certain positions may mix with the earth's atmosphere.

This third mode of action may be left out of the question entirely, so far as the comet of 1832 is concerned; for it is wholly without a tail, and its small nebulous head, as we have already seen, will be, during the whole time of its appearance, at an immense distance from our globe.

It will be remembered, that the comet of 1811 had a very brilliant tail, the extent of which was variable. Its greatest length was found, by calculation, to be one hundred millions of miles. Without taking the trouble to examine whether this tail was ever directed towards the earth, we may declare that it never touched it; for on the fifteenth of October, when it was nearest to us, it was at least one hundred and fourteen millions of miles from us.

At the time of its greatest brilliancy, the comet of 1811 did not certainly afford a light equal to a tenth part of that of the full moon; and the light of the full moon, even when concentrated by the focus of the largest mirrors and lenses, and acting upon the blackened bulb of an air thermometer, has never produced any sensible effect, although from the manner in which this experiment has been conducted, a hundredth part of a degree [centigrade] would have been readily appreciated. We must reject the use of reason, if, with such a result before us, we could entertain the idea, that a comet, even ten times more brilliant than that of 1811, could, by its light, produce upon the earth such variations of temperature as would affect the quantity or quality of its crops, or even such minute changes as are capable of affecting our most delicate meteorological instruments.

It must then be in the comet's power of attraction that we are to look for the efficient cause of its meterological influence. Here the moon will serve as a standard of comparison.

This planet causes the tides of the ocean. Mathematically speaking, the comet of 1811 ought to have produced similar tides; but none such were perceived, and therefore it must be admitted that they were inappreciable.

The height of the tide varies in proportion to the intensity of the attractive force. We have just found that the lunar tide is very great, and the cometary tide imperceptible; therefore the action of the comet upon the earth is but a very small part of that of the moon. This important result is deduced still more clearly from an examination of the disturbance which takes place among the planets, in their elliptical orbits, and which are known by the name of *perturbations*. For the sake of brevity, I shall confine myself to the first demonstration.

The attractive force of the moon cannot fail to produce an atmospherical tide, the variations of which would be indicated by the barometer. But in this case, amid so many accidental causes of disturbance, the only way of ascertaining the effects of the constant action of the moon is to bring together several thousand observations. This laborious and minute calculation has been made, with the greatest care, upon observations collected from various places; and the effect of the moon upon the atmosphere has scarcely been sufficient to produce a perceptible variation in the barometer. I need hardly add, after this, that it has never entered any body's head to try the effect of a comet upon this aërial tide.

I repeat, that the direct action of the tail and the nebulous head of the great comet of 1811, on the earth's atmosphere, was insensible on account of the immense distance at which this comet has always been from the earth. As to its power of heating or attracting our globe, the most delicate instruments cannot detect its existence. I now leave the reader to judge, whether the little comet of 1832 is likely to justify the expectations of the farmers and vine-dressers.

11. *On the physical Constitution of Comets; Envelope, Nucleus, Tail.*

In giving, page 7, a short description of the common forms of comets, I have spoken of the *nucleus*, the *envelope*, and the *tail*.

I will now enter more fully into those particulars with which telescopic observations have made us acquainted, in regard to the nature of each of these parts of a comet.

Many comets have no perceptible tail; some have been seen in which no nucleus could be discovered; but none have ever been visible (since they have been attentively examined with the telescope), which had not that sort of foggy appearance or nebulous atmosphere, called by astronomers the *envelope* or *chevelure*.

Of the Envelope.

Among the comets that have no apparent nucleus, and which seem to be only globular masses of vapor, slightly condensed towards the centre, I shall notice those of 1795, 1797, and 1798, observed by Olbers, and the little comet of 1804, the envelope of which was 4800 miles in diameter.

Seneca remarks, that stars may be seen through comets. This assertion cannot be called in question, so far as comets without any proper nucleus are concerned. It may even be added, that the nebulous matter which forms the envelope is so thin and transparent, that the light of very small stars may pass through it to a great distance, without ceasing to be visible.

For instance, Herschel saw a star of the sixth magnitude in the very middle of the comet without a nucleus, of 1795; also, on the twenty-eighth of November, 1828, Struve plainly distinguished a star of the eleventh magnitude through the central part of the comet of a short period. Many more such examples might be given.

When there is a nucleus in the centre of a comet, it seldom happens that the nebulous envelope extends to it with a progressively increased intensity; on the contrary, that part of the envelope nearest the nucleus is faintly illuminated, and appears to be extremely rare and transparent. At some distance from the centre, the envelope becomes suddenly brighter, so that it looks like a luminous ring, more or less extended, surrounding the nucleus, and maintaining itself at a nearly equal distance from it on all sides. Sometimes there have been seen two and even three of these concentric rings, separated by spaces more feebly illuminated. It will be easily conceived, that what appears to the eye to be a ring is really a spherical envelope, and we shall have a good idea of this complicated structure of comets, if we imagine, at different heights in our atmosphere, three strata of clouds completely encircling the globe. To make the similitude more exact, we must suppose these three strata to be transparent, and yet possessed of optical properties different from the intervening portions of pure air.

In the comet of 1811, the envelope could not be less than twenty-four thousand miles thick, and its interior surface must have been twenty-nine thousand miles from the centre of the nucleus. The envelopes of the comets of 1807 and 1799 were respectively twenty-nine thousand and nineteen thousand miles thick.

When a comet has a tail, the ring is only defined on the side next the sun, and never extends beyond a semi-circle; the extremities of this semi-circle are the points whence the rays are prolonged which define the limits of the tail.

Of the Nucleus.

The nucleus of a comet generally resembles a planet in form and brilliancy. It is commonly very small, but sometimes it approaches the dimensions of the lesser planets. The following table gives the diameter of the nucleus of several comets.

Comet of 1798,	26 miles.
Comet of December, 1805,	29
Comet of 1799,	373
Comet of 1807,	537
Second Comet of 1811,	2617

Some astronomers maintain that the nucleus of a comet, even when from its brilliant light it most resembles a planet, is always transparent; that comets are, in short, nothing but masses of vapor. The observations on which this opinion is founded are specious enough, but they do not, I think, warrant such conclusions as have been drawn from them. The question is an important one. Its solution must decide, in a great measure, the degree of influence to be attributed to comets in the physical revolutions of the world. I shall therefore hope to be pardoned if I treat the subject somewhat in detail.

All comets pass successively in their proper motions through different constellations; but the regions in which these movements take place, are vastly nearer to us than to the stars. Now it would seem evident that, if the nucleus of a comet is interposed between the observer and a star, we can judge better of its intimate constitution than in any other position.

Unfortunately these conjunctions are extremely rare, and for the very simple reason, that the part of the firmament which is the most crowded with stars, contains incomparably more void than occupied space. Instances, however, are not wanting of such conjunctions.

On the 23d of October, 1774, Montaigne saw at Limages a star of the sixth magnitude (*g′* of Aquarius) through the nucleus of a little comet.

This observation would undoubtedly prove that the comet of 1774 had no solid or opaque part, if the star had been seen through the middle of it; but Montaigne does not mention this last circumstance; and indeed the feeble powers of his telescope would scarcely admit of his being thus explicit.

On the 1st of April, 1796, Olbers saw a star of the sixth or seventh magnitude; and though covered by a comet, its light was not sensibly diminished. But this celebrated astronomer protests against the conclusion which some drew from his observation as to the transparency of the nucleus. According to his conjectures the star was situated a little to the north of the centre of the envelope, and if the neuclus disappeared for a time, it might be only in consequence of the neighbourhood of the greater light of the fixed star.

The same doubts may be entertained with regard to the passage, without a real occultation, of a star of the seventh magnitude, behind the nucleus of the comet of Taureau, observed at Nismes in 1825, by M. Valz; also with regard to former observations of the same kind made at Paris, Palermo, Konigsberg, Altona, &c.

If I wished to maintain the opinion that there is a solid and opaque centre to the luminous nucleus of comets, the annals of astronomy would furnish me with sufficiently plausible arguments. I might fortify myself with a variety of observations which, though they have been neglected, are not the less worthy of note. Thus I should say that when Messier perceived, for the first time, the little comet of 1774, there was, very near its nucleus, one telescopic star only, and that, some hours after, a second star was seen near the first, that this second star was not less brilliant than the first, and that there is but one way of explaining why Messier did not see it before; we must admit with him that it was concealed behind the opaque part of the comet. I might also add, that on the 28th of November, 1828, at half past ten at night, the comet of a short period, which returns to its perehilion every three years and a third, was observed by M. Wartmann, at Geneva, to pass over a star of the eighth magnitude, which was entirely eclipsed. Now I should say that a positive fact, like this real disappearance, may always be opposed with advantage to a negative fact, to a non-disappearance, because the latter may be always explained without difficulty, by a supposition fairly admissible, that the small *nucleus, which is solid and opaque*, did not pass exactly over the star, however it might have appeared to do so; whilst a total eclipse cannot be subject to any such uncertainty.

As, however, I am free from the spirit of system-making, I will not deny that I think M. Wartmann used too small a telescope, and a magnifier not sufficiently powerful. I will also allow that Messier's observation would be much more convincing, if he had seen the star before it was eclipsed; if the Astronomer, aware of its existence, had looked for it, we might not then suppose that it had escaped him through inattention. Whatever may be deduced from these remarks, as to the constitution of the nucleus of *very small* comets, which I have spoken of as passing over stars, no general consequences can be inferred from them. We are acquainted with comets that have no apparent nucleus, and are equally bright throughout their whole extent, and which are beyond all doubt simple collections of gaseous matter. An increased degree of concentration in these vapors may form in the centre of the head a nucleus, remarkable for the intensity of its light; but this, being still liquid, may be very transparent. At a later period this liquid may cool down till it becomes surrounded by a solid crust, and then all transparency of the nucleus will have ceased. If, after this, it should pass between an observer and a star, it would cause an eclipse as real and as entire, as that which is produced by the moon and planets. Now nothing, absolutely nothing, is known, which goes to prove that there may not be comets of this third class with a solid nucleus. The great variety in appearance and in brightness which these bodies exhibit, will justify any supposition of the kind. Those who, since the observations of the last forty years, can believe that all comets are formed on one model, need only examine with me the archives of science, to perceive how little such an idea is founded on fact.

I shall set aside as fabulous numerous accounts of comets the light of which is described as rivalling that of the sun, and even of those in which it was only sufficient to render that of the moon obscure, and shall restrict myself to indisputable facts.

In the year 43, before Christ, we are told that a *hairy star* appeared, which could be seen *by day-light, with the naked eye.* This comet was considered by the Romans as the metamorphosis of the soul of Cæsar, who was assassinated a short time before.

In the year 1402, after Christ, we hear of two very remarkable comets. The first was so bright, that the light of the sun, towards the end of March, did not prevent its nucleus, or even its tail, from being seen at noon. The second was visible in the month of June, and could be seen long before sunset.

Cardan relates that in 1532, the curiosity of the inhabitants of Milan was greatly excited by a star which could be seen at mid-day. At the time (that of the death of Sforza II.), Venus was not in a position in which she could be seen by day-light; the star of Cardan must therefore have been a comet. This is the fourth, visible by day-light, recorded by historians.

The beautiful comet of 1577 was *discovered* the 13th of November, by Tycho Brahe, from his observatory in the island of Hwen, in the Sound, before sun-set.

Persons accustomed to make astronomical observations will know why I have underscored the word *discovered;* it is because there is a great difference between perceiving a heavenly body, whose existence and position we are acquainted with, and discovering one, as our eyes wander accidentally over the firmament. A discovery produces a great deal more excitement and interest than a simple observation.

I hasten now to a more modern comet, minute observations of which are to be found in a work expressly written upon it.

On the 1st of February the comet of 1744 was, according to Chézeaux, more conspicuous than the brightest star in the heavens, that is, than Sirius; on the 8th it equalled Jupiter; some days afterwards it was only surpassed by Venus; at the beginning of the next month, it was visible by day-light. On the 1st of March, several persons, conveniently situated, perceived this comet, without the aid of glasses, an hour after noon.

What ground, then, is there for comparing, as to physical structure, bodies of such brilliancy as those just mentioned, and the comets observed during the last fifty years, which are rendered almost entirely invisible by the feeble light which is brought into the field of the astronomical telescope, in order to show the cross-threads necessary to determine its position?

We may now conclude from this discussion that there are,

Comets without a nucleus;

Comets of which the nucleus *may be* transparent;

Comets more brilliant than the planets, the nucleus of which is *probably* solid and opaque.

Of the Tail.

The long luminous train by which comets are generally attended, has been distinguished, in all countries and in all ages, by the name of *tail.*

Peter Apian says, after attentively observing the comet of 1531, that the tail, whatever may be the situation or motion of the comet, is always in the prolongation of the line which joins the sun and the nucleus.

This statement is not strictly correct. It is true that the tail is generally behind the comet as viewed from the sun; but the line which joins the two bodies, hardly ever coincides exactly with the axis of the tail. Sometimes the difference in the two lines is considerable; cases might be mentioned, indeed, in which they form a right angle. It is found, moreover, that *the tail constantly inclines towards the region which the comet is leaving*, as if, in its motion through a gaseous medium, the matter of which the tail is composed, experienced more resistance than the nucleus. May we not even believe that there is, in what I have said of resistance, something more than a mere comparison, when we remark that the deviation increases in proportion to the distance from the head. This is sometimes so great as to produce a very perceptible curvature. The tail of the comet of 1744, for instance, formed nearly a quarter of a circle in an extent of only a small number of degrees.

If this be the real cause of the curvature of the tail, it follows, as a necessary consequence, that the convexity must always be turned towards that region to which the comet is tending. One or two exceptions to this rule may perhaps be found, but they are not well established facts.

According to the hypothesis under consideration, the nebulous matter of the tail must be more concentrated, more dense, and consequently more luminous, and the outline must be better defined, on the convex side than the other; all known observations tend to confirm the truth of this position.

The tail of a comet becomes larger the farther it is from the head; the middle often presents a dark space, which divides it longitudinally into two distinct and often nearly equal parts. Former observers considered this dark space as the shadow of the body of the comet. This explanation, however, is not applicable to tails that are not in a line with the nucleus and the sun. It is more accordant with all the particulars of this phenomenon to consider the tail as a hollow cone, the sides of which have a certain degree of thickness. If we draw this figure, we shall see directly that the line of sight, in passing through the edges of the cone, will strike a great many more nebulous particles, than a line through the middle; now whether these particles shine of themselves, or only reflect the rays of the sun, it is their whole number which must, in every direction, determine the intensity of the light. Thus the hypothesis of the hollow cone does away all the difficulty respecting the edges of the tail being the brightest, and respecting its division into two luminous portions by a comparatively dark space.

It is not uncommon for comets to have several separate tails. That of 1744, on the 7th and 8th of March, had no less than six, each about 4° broad, and from 30° to 44° long; their edges were well defined and bright; the middle portions emitted a very faint light; the space between these separate tails was as dark as the rest of the heavens.

The tails of comets have sometimes been of immense extent. The following are the results of various measurements, *as to their* angular dimensions.

Comet of 1811, length 23°;

Comet of 1689, length 68°. It was curved like a Turkish sabre, say contemporary observers.

Comet of 1680, length 90°;

Comet of 1769, length 97°.

Thus the comet of 1680 and that of 1769, might be in the horizon and setting, whilst a portion of the tail was still in the zenith.

I will add here the lengths of a few, expressed in miles.

Tail of the comet of 1680, more than ninety-six millions of miles in length.

Tail of the comet of 1769, more than thirty-eight millions of miles.

Tails of the comet of 1744, each seven millions of miles.

It may be matter of surprise that I should close this topic so suddenly. The public has, I allow, a right to expect some particulars as to the nature of the light of comets, some account of the causes which produce their tails, which modify them in so many different ways, which give rise to the system of concentric envelopes around the nucleus, &c. But I must frankly say, that, in the actual state of the science, I have nothing upon these subjects to lay before the reader but mere romances, gratuitous hypotheses and theories, having no real foundation. That branch of astronomy which treats of the motions of comets has made great progress during the last century and a half; but the physical constitution of these bodies is still wrapt in great obscurity, notwithstanding the zealous labors of observers.

What I am about to add must, therefore, be considered not as what is positively known, but as the plausible suppositions of philosophers.

Do comets shine by their own light, or do they, like the planets, only reflect the rays of the sun? It will be allowed that this is a most important question. It has, however, never been answered. Whenever a comet shows itself with a decided phase, all doubt will be removed. I am aware that it is pretended, on the faith of certain observations of Cassini, that the comet of 1744 exhibited such a phase; but to this I reply, that the words of that learned astronomer prove that the nucleus was very irregular, not that it had a proper phase. At any rate, Heinsius and Chézeaux say positively that no phase existed at the very time when it is *pretended* that Cassini observed it. If I am reminded of the observations of the English geometrician, Dunn, I reply, that they are contradicted by the contemporary observations of Messier. If an argument is drawn from the form of a cross, in which M. Cacciatore, of Palermo, saw the comet of 1819, let it be remembered, that, on the 5th of July, the line of the horns, instead of being, as must happen in a real phase, perpendicular to a line drawn from the comet to the sun, was, on the contrary, parallel. On the other hand, the absence of phases in a nucleus, surrounded as that of a comet is, with a thick atmosphere, capable of disseminating the light on every side, cannot lead to any certain conclusion. The recent labors of philosophers have given rise to a new mode of investigating this subject, which promises more valuable results. They have discovered, that when light is reflected under certain angles, it is distinguished by some peculiar properties from light that comes to us directly. Now some traces of these peculiar properties have been perceived, at the observatory in Paris, in the light from the tail of the comet of 1819, but not so distinctly as to warrant a positive conclusion, that these bodies shine only by a borrowed light; for bodies that become self-luminous do not lose the power of reflecting light received from other sources.

The nebulous envelopes of comets, when closely studied, present also inexplicable difficulties. It is very natural, to be sure, to suppose them masses of permanent gas, or collections of vapor disengaged from the nucleus, upon which the solar rays are constantly acting; but what becomes, upon this supposition, of the luminous, concentric envelopes of which I have spoken, page 33? Why should the nucleus be eccentric, generally towards the sun, but sometimes on the opposite side, &c.?

Wholly occupied with the motions of comets, and carried away perhaps by favorite theories, modern astronomers have neglected one observation, worthy of note, as to the manner in which the envelopes of comets vary in size. Hevelius, who was bound to no system, stated distinctly, that the real diameter of the envelope increased according as the comet became more distant from the sun. Pingré observed this also, but hardly dared to avow it; for in his work, Vol. II. p. 193, this important fact is thrown out, as if by chance, in a paragraph upon the variations of the tail.

I certainly should not undertake to justify such hesitation, if since the time of Pingré, experience had established the point beyond all doubt. But, considering that the measurements are rather difficult in their nature, one may surely be allowed to doubt whether a gaseous mass would dilate in proportion to its distance from the sun, when, advancing into colder regions, it ought, according to all we know of the properties of heat, to become considerably condensed.

Thanks to the comet of a short period, we may now place the observation of Hevelius among the best established facts of science. The following table shows the variations in the real diameter of the nebulous matter of this comet in 1828.

Dates.	Distances of the Comet from the Sun.	Real Diameter of the nebulous matter in semi-diameters of the Earth.
October 28	1,4617	79,4
November 7	1,3217	64,8
November 30	0,9668	29,8
December 7	0,8473	19,9
December 14	0,7285	11,3
December 24	0,5419	3,1

(To understand the figures in the second column of this table, it must be remembered, that the mean distance of the earth from the sun is considered as 1.)

It follows from the results before us, that, on the twenty-eighth of October, the comet was nearly three times as far from the sun as on the twenty-fourth of December, and that, nevertheless, at the former of these two periods the real diameter of the nebulous matter was about twenty-five times as great as at the latter! Or we may put the same thing into other words, by saying that, in the interim between the twenty-eighth of October and the twenty-fourth of December, the size or volume of the comet was reduced to a *sixteen thousandth* part of its former size; the least bulk thus corresponds to the least distance of the comet from the sun.

M. Valz supposes, in a memoir just published, that the ethereal matter forms a true atmosphere about the sun, in which the lower strata are so much the more compressed and so much the more dense (as in the case of the earth's atmosphere) according as there are a greater number of strata above them. He imagines therefore, that the comet, in traversing these strata, must undergo a pressure proportional to their density! There would be no objection to this, if it were proved that the exterior envelope of nebulous matter was not permeable to the ether. It is indeed well known, that a bladder filled with air, at the base of a mountain, expands as it is raised to higher positions, and that it finally bursts when carried to a sufficient height. But have we discovered about *the nebulous matter* any case or pellicle, which will allow us to make the comparison, which would prevent the ether from penetrating it in every direction? This difficulty appears at present insurmountable, and we cannot but regret it; for the ingenious hypothesis of M. Valz gives the law of variation for the magnitude of the nebulous matter, both for the comet of a short period and for that of 1618, with an exactness truly surprising.

It would require a volume, to give even a faint idea of the great variety of theories by which astronomers and philosophers have endeavoured to explain the tails of comets. The least objectionable of these theories is that which supposes the lightest particles of the nebulous matter to be detached and carried off by the force of the sun's rays. Accordingly the tail would always be directly opposite to the sun, as Apian would have it; but this rule does not apply universally, for the tail is sometimes perpendicular to the line drawn from the sun to the nucleus; it is also occasionally very much curved; there are sometimes six tails at once; these multiplied tails appear and disappear in a few days, and their direction is so various that, in certain positions of the earth, the comet of 1823 appeared for several days to have one tail extended towards the sun, and another in the opposite direction. There are indications in these multiplied tails of a very rapid rotatory motion, which must soon occasion their entire dispersion in space. There are comets too, the nebulous matter of which seems very light, and which nevertheless have no tails at all. The resistance of the ether which has hitherto been overlooked, may explain some of these difficulties; but it is to be feared that the complete solution of so intricate a problem will long remain a desideratum.

Those who take an interest in comets, only with a view to satisfying themselves whether, in striking the earth, they will produce great disasters, must find, in the telescopic observations of which I have now given some account, strong reasons for feeling secure. I may also add, that these observations are not the only means of ascertaining the ordinary smallness of the mass of these bodies; the same result is arrived at by studying attentively the motions of planets, near which comets have passed.

The comet of 1770 has come the nearest to us of any hitherto.* Laplace discovered that the action of the earth upon it increased the length of its revolution by more than two days. Mathematically speaking, the reaction of this comet upon the earth ought to have increased the length of the earth's revolution round the sun. If we suppose the mass of the comet to be equal to that of the earth, the time thus added to the year would be, by strict calculation, two hours and fifty-three minutes. Now it is well known that in 1770 the length of the year did not vary one second; we have taken, then, for the ground of our calculations a very exaggerated statement, in supposing the mass of this comet to be equal to that of the earth; and we may fairly infer from the above fact, that the mass or quantity of matter in the comet is not one five-thousandth part of that of the earth. This result explains how it was possible for the comet of 1770 to traverse twice the system of Jupiter's satellites without producing the slightest disturbance.

I shall conclude this section by a table, containing the smallest distances *from the earth's orbit* of the comets which have approached the nearest to it. It will be easily seen that the same numbers would also express the least distances from the earth, to which these bodies have ever been able to approach.

	Least distance from the Earth's orbit.
Comet of 1680,	112 semi-diameters of the earth.
Comet of 1684,	215 "
Comet of 1805,	260 "

* The shortest distance of the comet of 1770 from the earth, was 368 semi-diameters of the earth, or 1456840 miles; the mean distance of the moon is 60 semi-diameters of the earth, or 237160 miles; thus at the nearest approach of the comet of 1770, it was still six times as far from us as the moon.

Comet of 1742,	330	semi-diameters of the earth.
Comet of 1779,	346	"

Let us remember now, that the comet of six years and three quarters will pass within about four terrestrial semi-diameters or two diameters of the earth's path; and we shall perceive that such a circumstance, if it justifies none of the fears which have been excited, deserves at least to be noted.

SECTION SECOND.

1. *Is it possible for a Comet to strike the Earth or any other Planet?*

In virtue of first causes, the nature of which is unknown to us, and which have given rise to various theories, more or less plausible, the planets of our system make their revolutions round the sun all in the same direction, and in orbits nearly circular. Comets, on the contrary, travel in very elongated ellipses, and move in all possible directions. In coming from their aphelions, they continually traverse our solar system, passing within the orbits of the planets, sometimes even between Mercury and the Sun. *It is not, therefore, impossible for a comet to encounter the earth.*

After thus admitting the possibility of such a collision, let me hasten to add that the probability of such an event is extremely small. This will be evident at first sight, if we compare the immense space in which our globe and the comets move, with the very small size of these bodies. Mathematical calculation carries us much further; it gives us, in numbers, the chances for or against the event in question, founded on the relative magnitude of the comet and the earth.

Suppose, now, a comet of which we know nothing but that, at its perihelion, it will be nearer the sun than we are, and that its diameter is equal to a quarter of that of the earth; the doctrine of chances shows that, out of two hundred and eighty-one millions of cases, there is but one against us, but one in which the two bodies could meet.

Without wishing to disturb the tranquillity which the most timid ought to derive from the foregoing statement, I must add, that if, in calculating the chances of a collision between the earth and the *nucleus* of a comet, we have adopted a proper estimate of the size of the nucleus, we shall find the result, given by this calculation, too small for the chance of meeting, if we consider, not only the nucleus, properly so called, but the whole nebulous envelope which surrounds it. If we increase the number above given ten-fold, we shall not make it too large.

Just ideas on the calculation of chances are so little understood, and the public mistake so strangely the meaning of the numerical results of such calculations, that I at first thought of suppressing this short account of the matter. I might have done it with the less hesitation, as in whatever relates to the comet of 1832, all considerations of probability are superfluous; for, the orbit being known, we can say with certainty what will be, at its next appearance, the least distance of this body from the earth.

The problem, it will be seen, was entirely different in the calculation, of which I have given the results. Here the chances of a collision between the earth and the comet were given, *without any thing being known of the form or position of the comet's orbit.* It was then found that there was for the nucleus, properly so called, one chance of its striking the earth, one unhappy chance, to 280,999,999 chances of its escaping us; and for the nebulous head, according to its ordinary dimensions, about ten or twenty chances in favor of a contact, to the same number of 281,000,000 against it. Admitting, then, that the nucleus of a comet may strike the earth and annihilate the human race at once, the danger to each individual, on the appearance of an *unknown comet*, would be exactly equal to the chance he would run, if there were *one black ball* in a box with 281,000,000 balls of another color, and his condemnation to death were the inevitable consequence of his drawing, at the first trial, that one black ball.

Any reasonable being, however attached he may be to life, would smile at such a small risk as this; the appearance then of a comet that has never been observed, and whose course is unknown, may, as to the danger it portends to each inhabitant of this globe, be represented by the black ball in the box of which I have spoken.

2. *Is there any Reason to suppose, from all that is known of Astronomical Phenomena, that Comets have ever fallen into the Sun or into Stars?*

At the time of passing its perihelion, the comet of 1680 was separated from the sun by a space not greater than a sixth part of the diameter of that luminary. In a region thus near to that immense orb, the atmosphere by which it is surrounded may have an appreciable density, producing upon a body that passes through it such effects as ought to be taken into consideration, particularly in regard to comets, the swiftness of whose motion at their perihelion is very great, and whose density is generally very small. The inevitable effect of this atmospheric resistance upon the comet of 1680 must have been to diminish its tangential velocity. But when a heavenly body slackens its pace, whatever may be the cause, the centrifugal force lessens also; the centripetal force, which it counterbalanced, preponderates immediately, and that body quits the curve it was describing, to approach nearer to the centre of attraction. Thus the comet of which I have been speaking, must have passed nearer the sun's surface in 1680, than at its former appearance. This diminution in the dimensions of its orbit must occur at each return to the perihelion; *the comet of* 1680 *must therefore, in the end, fall into the sun.*

This reasoning is founded on incontestable mechanical principles; therefore the consequence hence deduced is not less certain. We must only bear in mind that our ignorance of the density of the several successive strata of the solar atmosphere, of that also of the comet of 1680, and of the length of its revolution, renders it impossible to *calculate* how many ages must elapse before this strange event is to take place. The annals of astronomy furnish us no reason for supposing that such a thing has ever happened within the period of authentic history.

Let us look back to the most ancient epochs, to those which are lost in the darkness of remote time, and see if there is any thing in the actual condition of our planetary system which requires to be explained on the supposition that a comet has already been precipitated into the sun.

All the planets move round the sun *from west to east*, and in planes forming with each other but very small angles.

The satellites move round their respective planets as the planets do round the sun, that is, from west to east. The planets, and those satellites whose rotatory motion can be observed, *turn on their centres* from west to east, and for the most part nearly in the plane of their progressive motions. It will be easier to appreciate all that is extraordinary in this phenomenon, if I here give a complete enumeration of the motions that I refer to.

Astronomers have observed *rotatory motions* in the Sun, in Mercury, Venus, Mars, the Earth, Jupiter, and Saturn; in the Moon; in the four satellites of Jupiter; in the ring of Saturn, and in the last satellite of that planet; making in all sixteen. By adding this number to that of the *progressive* motions of the same bodies, and of those which, from their smallness, have not been seen to revolve on their axes, we find a total of forty-three motions all in the same direction. Now by the calculation of probabilities, it appears that there are more than four thousand millions to one against this arrangement of the solar system being the effect of chance. We must therefore admit that an original physical cause governed all the motions of these heavenly bodies from the moment they were created.

Buffon is the first who, looking at the solar system from this elevated point of view, has tried to point out the origin of planets and satellites, and of what appears in their motions to be common to all these bodies.

He supposes that a comet fell obliquely into the sun; that it grazed the surface, or at least produced only an inconsiderable furrow. He says, that, in the torrent of liquid matter which the comet forced away before it, the portions which were the lightest, the size being the same, receiving the greatest impulse, would go the farthest from the sun, and there become, by concentration, immense planets, like Saturn and Jupiter, the density of which is comparatively small; that the most concentrated portions would, on the contrary, in regions less remote, produce masses like Mercury, Venus, the Earth, and Mars. Thus, according to Buffon, the planets were in their origin so heated as to be in a liquid state; and it was then they became regular bodies, and by cooling gradually produced the varied appearances which we now observe.

It has been objected to Buffon's theory, that the volume, the mass, and the velocity of a comet are not sufficient to drive off from the sun a quantity of matter equal to that which composes all the planets and satellites of our system; but objections of this nature are never without their answer; for there is nothing to prevent the striking comet from being considered of any size and weight that the theory requires. Besides, it may be well to observe here, that all the planets with their satellites do not make one eight-hundredth part of the mass of the sun.

Celestial bodies, produced as Buffon supposes, would no doubt have, in their *progressive motions*, that surprising agreement we remark in our planetary system. The same cannot be said of the *rotatory motions;* these might be in an opposite direction to the progressive motions. The Earth, for instance, in performing her annual course round the sun, from *west to east*, might turn on her axis from *east to west*. This objection is applicable also to the motions of the satellites, the direction of which would not *necessarily* be the same with the progressive motions of the planets. Thus Buffon's hypothesis does not adapt itself to all the circumstances of the phenomenon; it has not cleared up the mystery of the creation of planets, and therefore we cannot argue from it that our system originated from a comet's falling into the sun.

Besides the objections already mentioned, I may add another, founded on later observations, of which Buffon knew nothing.

Every solid body, every cannon ball, for example, which is thrown into space with sufficient force and in a right direction to become a satellite to the earth, must repass, at each revolution, through the point of departure, leaving out of consideration, of course, the resistance of the air. This is a fact founded on the first principles of mechanics.

If Buffon's comet, in striking the sun, had detached solid fragments from it, and if the planets of our system were originally such fragments, they must graze the surface of the sun in each revolution. Every one knows how far this is from the truth. But then our great naturalist did not believe that the matter, which composes our planets, came forth from the sun in distinct masses, and already formed. He imagined, as I have already said, that the comet drove off a real torrent of liquid matter, the different parts of which received various impulses, and experienced mutual attractions, thus rendering it impossible that they should be subject to the laws that govern solid bodies. The system therefore of Buffon leads *impliedly* to this conclusion, that the exterior matter of the sun is in a state of liquefaction. Now I must remark that the most careful observations of recent date do not confirm this idea.

The rapid changes which are constantly occurring in the bright as well as dark spots of the sun, and the immense spaces through which these changes take place in very short portions of time, have led, within a few years, to the very reasonable *supposition*, that such phenomena must belong to a gaseous medium; and now experiments of another kind, namely, those on the polarisation of light, made at the Observatory of Paris, establish this fact beyond dispute. Accordingly, if the exterior and incandescent part of the sun is a gas, the hypothesis of Buffon loses its chief support, and can no longer be defended.

It may, to be sure, be said, that the opaque body to which this luminous atmosphere serves as an envelope, and which we are able to distinguish through apertures in the atmosphere, is liquid; but this would be an hypothesis wholly gratuitous, and not founded on any precise observation.

However weighty these objections are to the theory of Buffon, if there were no other by which to explain the wonderful coincidence in the progressive and rotatory motions of the planets, it would be well to suspend our judgment; but this is not the case; the ingenious hypotheses of Laplace, whatever doubts they may still give rise to, prove at least that the great mystery of creation which we have been considering, may be referred to causes very different from those alleged by our French Pliny.

To conclude, then, there is nothing to prove, whatever Buffon may say, "that the planets once formed a part of the sun, from which they were driven off by a force common to them all, by which force they are still moved." Nothing therefore obliges us to suppose, that a comet has had any thing to do with the formation of our planetary system; nothing indicates that a body of this sort did, at the beginning of things, fall into the sun.

Pliny mentions a star, which, in the time of Hipparchus (that is, two thousand years ago), appeared suddenly in the heavens, and suggested to this great astronomer the idea of that catalogue of stars, for which science is so much indebted to him, and which was preserved by Ptolemy.

A similar phenomenon occurred in 1572 and in 1604.

The *new star* of 1572 appeared on the 8th of November, in the north, in the constellation Cassiopeia. It was more conspicuous than the brightest star in the heavens, that is, than Sirius; it gave almost as much light as the planet Venus, and was visible for nearly a year and a half. That of 1604, when seen by the disciples of Kepler, on the 30th of September, at noon, in the constellation Serpentarius, surpassed Jupiter in splendor, though the night before it appeared very small. At the end of sixteen months, there was no trace of it to be seen.

Fixed stars are real suns, around which, in all probability, planets and comets revolve. The facts just stated prove that there are, besides the common stars, exhausted or extinguished stars, that are ordinarily invisible. Newton believed that this kind of stars again become conspicuous, and suddenly recover their former brilliancy, when comets, by falling into them, furnish them with fresh combustible matter.

If this explanation were adopted, it would follow, that within the period of authentic history, comets had, in three instances, fallen, if not into the still brilliant sun of our system, at least into the extinct suns of other systems.

The great name of Newton must not prevent my remarking, that in comparing the fires of the heavenly bodies with those of our own kindling, and considering comets like the billets of wood, which must be constantly renewed upon our hearths, we carry the laws of analogy much too far. It is now generally known, that under certain specific conditions, and particularly in certain electrical states, all bodies may become luminous, without any thing combining with their substance, and without any thing being disengaged from them. This is the case with two pieces of charcoal, *placed in a vacuum*, one of which touches a wire connected with one end of a powerful galvanic battery, whilst the other communicates with the opposite end; as soon as the surfaces of the two coals are brought near each other, they become more resplendent than any other known terrestrial fire, so much so, that it is agreed to distinguish the light, thus produced, by the name of *solar light*.

This is a most important experiment. It does not, however, necessarily follow, that the light of the sun and stars is electric; though it must be granted that the contrary is not proved, which is sufficient to justify our classing among simple hypotheses, the reasoning of Newton, by which he endeavoured to prove that comets have fallen into stars; and this is the only view to be taken of it here.

3. *Can the Earth pass into the Tail of a Comet? What would be the Consequences of such an Event to our Globe? Were the dry Fogs of* 1783 *and of* 1831 *occasioned by the Tail of a Comet?*

Newton thought that the matter, the *exhalation*, of which the tails of comets are composed, might fall by its gravity into the atmosphere of any planet, but more especially into that of the Earth, be condensed there, and give rise to all sorts of chemical reactions and a thousand new combinations.

A few words will suffice to prove, not only that the diffusive substance of comets *may* fall into our atmosphere, but even that this phenomenon is of a nature to occur often.

Comets appear to be, for the most part, mere collections of vapor. Now since it is an incontestable principle that attraction is in proportion to the mass or quantity of matter, each particle of the tail of a comet must be feebly attracted towards the body. The attraction lessens as the distance increases; not merely in a simple ratio, but according to the squares of the distance. Thus at the distances 2, 3, 4, — 10, the attraction, exerted by any body, is 4, 9, 16, — 100 times less than at the distance 1.

We have seen that a comet, in consequence of the small quantity of matter it contains, exerts upon what is near it but a feeble attraction; and upon particles far removed from its head, the attraction must be hardly perceptible. Now have we not seen comets with very long tails? In the comet of 1680, the extreme visible particles were, in a right line, about 100,000,000 of miles from the nucleus.

It will now be seen that a planet like the Earth, the mass of which, for the most part, is much greater than that of a comet, must have the power of attracting and of drawing in and appropriating to itself the extreme particles in the tail of a comet, even when in its annual course it may be very distant from it.

The introduction of some new gaseous element into the terrestrial atmosphere might, as it was more or less abundant, occasion the death of all animals, or produce epidemics; such, indeed, has been, according to various authors, the origin of most of these scourges which are mentioned in history.

In a much esteemed work on Astronomy, published at Oxford in 1702, Gregory says, that among all nations and in all ages, *it has been observed*, that the appearance of a comet has always been followed by great calamities; and he adds, "It does not become philosophers lightly to set down these things as fables."

I have just shown what is not a fable; it is, that the earth *may* occasionally appropriate some of the matter which is in a comet's tail; but Gregory has not confined himself within the strict limits of truth, when he gives, as *observations* worthy of confidence, the careless remarks of historians concerning a pretended influence of these bodies over the events of the world at the time of their appearance.

An English physician, whose name is not unknown to philosophers, Mr. T. Forster, has lately treated particularly of this subject. According to him, "*It is certain*, that ever since the Christian era, the most unhealthy periods are precisely those in which some great comet has appeared; that the approach of these bodies to our earth has always been accompanied by earthquakes, eruptions of volcanoes, and atmospheric commotions; whereas no comet has ever been seen during the salubrious periods."

Those who will take the pains to examine critically the long catalogue, given by Mr. Forster, will not, I am sure, be led to the same conclusions.

The whole number of comets mentioned by historians, reckoning from the beginning of the Christian era to the present time, is about five hundred. At the present time, when the heavens are examined attentively and skilfully, when comets that can be seen only by the aid of the telescope are no longer overlooked, the average number of these bodies is more than two for each year. If we agree with Mr. Forster, that their influence begins before they are visible, and continues some time after, we shall never be without a comet to account for every phenomenon, misfortune, or epidemic that can occur. This remark is applicable also to the Memoirs of the celebrated Sydenham, who was an advocate for the influence of comets; to the dissertations of Lubinietski, &c. Mr. Forster has moreover, I ought to say, so extended, in his learned catalogue, the influences of comets, that it would seem there is scarcely a phenomenon which is not to be ascribed to them.

Hot or cold seasons, tempests, hurricanes, earthquakes, volcanic eruptions, violent hail-storms, great falls of snow, heavy rains, overflowings of rivers, droughts, famines, thick fogs, flies, grasshoppers, plague, dysentery, contagious diseases among animals, &c., are all registered by Mr. Forster, as consequences of the appearance of some comet, whatever may be the continent, the kingdom, the town, or the village so visited. By thus making out for each year a complete catalogue of all the miseries of this lower world, any one might foresee that a comet would never approach the earth, without finding a part of its inhabitants suffering under some calamity or other.

By a strange accident, well worthy of remark, the year 1680, the year of the most brilliant of modern comets, the year of its passage so near the earth, is that which has furnished our author with the fewest phenomena. Let us see what is to be found under this date? "*A cold winter, followed by a hot and dry summer; meteors in Germany.*" As to maladies, we find no record whatever! How then, with such a fact as this before us, can we attach any importance to the accidental coincidences noted in other parts of this table? How are we to regard this celebrated comet of 1680, which, blowing now hot and now cold, increased the frosts of winter, and the heat of summer?

In 1665, the city of London was ravaged by the plague. If, with Mr. Forster, we attribute this to the remarkable comet which appeared the same year, in the month of April, how are we to explain why the same pestilence did not extend to Paris, to Holland, to any of the numerous towns in England except the capital? This difficulty must be met; and until it is done away, we shall expose ourselves to the ridicule of every man of sense, if we attempt to make comets the messengers of evil.

Let us now see which are the comets whose tails may have mingled with the earth's atmosphere; and then search the histories and chronicles of the same period, to discover whether, at the same time, there were not manifested, *in all parts of the earth at once*, unusual phenomena. Science may take note of such researches; though, to tell the truth, the extreme rarity of the matter which composes the tail, would lead one to expect nothing but negative results; but when an author appends to the date of a comet, like that of 1668, the remark that *all the cats in Westphalia were sick*; and to the date of another, that of 1746, the circumstance, very little analogous to the former, to be sure, that an *earthquake* destroyed in *Peru* the towns of Lima and Callao; when he adds that, during the appearance of a third comet, a *meteoric stone* fell, in *Scotland*, into a high tower and broke the wheels of a clock; that, during the winter, wild pigeons appeared in large flocks in *America*; or still more, that *Ætna* or *Vesuvius* threw out torrents of lava,— we must consider him as displaying his learning to little purpose. If, in thus registering contemporary events, he thinks he has established some new relations between them, he is as much mistaken as the old woman, mentioned by Bayle, who, never having put her head out of her window without seeing coaches in the Rue St. Honoré, imagined herself to be the cause of their passing.

I wish, for the honor of science, that I could have dispensed with taking any serious notice of the ridiculous ideas I have just adverted to; but I am satisfied that this exposition will not be without its use, for Gregory, Sydenham, and Lubinietski have many followers among us.*

Moreover, if you will only listen, in those circles which are called fashionable, to the long discourses of which the approaching comet is the theme, you may decide whether there is any room to congratulate ourselves upon the pretended diffusion of knowledge, which so many *perfectionists* are pleased to consider as the distinguishing feature of our age. For myself, I have long been cured of these illusions. Under the brilliant but superficial gloss, with which the purely literary studies of our colleges cover all classes of society, we almost always find, to speak plainly, a profound ignorance of those beautiful phenomena, those grand laws of nature, which are our best safeguard from prejudice.

When, in 1456, the splendid comet appeared, which will return in November, 1835, Pope Calixtus was so terrified at it, that he ordered public prayers to be offered up in all the churches; and, in the middle of each day, the comet and the Turks were excommunicated. That no one need fail in this duty, he established the practice, which has been continued to this day, of ringing the church bells at noon.

We are not quite so bad now, I admit; and, with a few exceptions, among which I could place a person whose name here would excite very just surprise, since he has astonished the world as much by his courage, as by his genius, no one at the present day would dare *publicly* to avow, that he considered comets as signs and precursors of *moral* revolutions.

* The celebrated traveller, Rüppell, wrote from Cairo, on the 8th of October, 1825;—"The Egyptians think that the comet now visible, is the cause of the great shocks of an earthquake, felt here on the 21st of August, and that it is the same malign influence which kills the horses and asses. The truth is, that they die of hunger, fodder being scarce on account of the imperfect inundation of the Nile." If I dared take the liberty here, I could easily prove to the reader, that, as regards comets, all Egyptians do not live on the banks of the Nile.

Nevertheless, as the approach of the comet of 1832 has caused a great deal of uneasiness (though no one has hitherto spoken of any but its *physical effects*), I should not wish Pope Gregory XVI., even as a mere experiment, to renew the brief of his predecessor Calixtus; the honor of the nineteenth century would be tarnished by it.

The fog of 1783 began nearly on the same day (the 18th of June) in places very distant from each other, as Paris, Avignon, Turin, Padua;

It extended from the northern coast of Africa to Sweden; it was also observed in a great part of North America;

It lasted more than a month;

The air, at least that of the lower regions, did not appear to be its vehicle, because in some places it came on with a north wind, and in others with a south or east wind;

Travellers found it on the highest summits of the Alps;

The abundant rains which fell in June and July, and the highest winds, did not disperse it;

In Languedoc, its density was occasionally so great that the sun did not become visible, in the morning, till it was 12° above the horizon; it was very red the rest of the day, and might be looked at with the naked eye.

This fog or smoke, as some meteorologists have called it, had a disagreeable odor.

The property by which it was particularly distinguished from common fogs, was its being, by all accounts, very dry, whereas most fogs are moist. At Geneva, Sénebier found that the hair hygrometer of Saussure, which in real fogs stands at 100°, ranged in the midst of this, as low as 68°, 67°, 65°, and even 57°.

Besides all this, there was one very remarkable quality in the fog or smoke of 1783; it appeared to possess a phosphoric property, a light of its own. I find, at least in the accounts of some observers, that it afforded, even at midnight, a light which they compare to that of the full moon, and which was sufficient to enable one to see objects distinctly at a distance of two hundred yards. To remove all doubts as to the source of this light, it is recorded that at the time there was a new moon.

Such is the state of the facts; let us now see whether, in order to explain them, it will be necessary to admit, that in 1783 the earth was immersed in the tail of a comet.

The fog of 1783 was neither so constant, nor so thick, as to prevent the stars being seen every night, in all the places where it occurred. Admitting therefore that the earth was in the tail of a comet, there is but one way of explaining why the head of that comet was never seen, and that is, by supposing, that it rose and set almost at the same time with the sun; that the superior light of that luminary rendered it invisible; and that this conjunction of the sun and comet lasted more than a month.

At a time when the proper motions of comets appeared subject to no rule, when every one disposed of them as he pleased, considering them as mere meteors, the supposition we have just made might be admitted; but now that comets are known to all astronomers to be heavenly bodies, as obedient as the planets to the laws of Kepler; now that the mutual dependence of distance and velocity is known; now that observation and theory combine to prove that all these bodies *necessarily* move in their orbits with a rapidity that increases as they approach the sun, it would be contrary to all established principles to admit that a comet, interposed between the sun and earth, could revolve about the sun in such a manner as to appear constantly near it for more than a month, to a spectator on the earth! It is in vain to attempt to explain the difficulty attending an exact conjunction, by supposing the tail very large. If it were as large as that of 1744, the objection would remain in all its force. The dry fog of 1783, then, whatever may have been said of it, was not the tail of a comet.

The remarkable fog of 1831, which so excited the public mind in all quarters of the globe, resembled too much that of 1783 for me to dispense with proving that this also could not be attributed to the tail of a comet.

This fog was remarked, for the first time,

On the coast of Africa, -	August 3d;
At Odessa, - - -	9th;
In the South of France, - -	10th;
At Paris, - - - -	10th;
At New York (U. S.), - -	15th;
&c.	&c.

We can learn nothing from these observations as to the rate at which it spread, or the direction it took.

This fog so dimmed the light passing through it, that the sun might be looked at all day long with the naked eye, without any colored glass, or any of the precautions usually employed by astronomers to guard their sight.

On the coast of Africa, the sun was not visible till it had risen 15° or 20° above the horizon. At night, the heavens sometimes became clear, so that the stars could be seen. I was informed of this circumstance, which is well worthy of note, by M. Bérard, one of the best educated officers of the French Marine.

M. Rozet, who had a command at Algiers, and the observers at Annapolis in the United States, and those in the South of France, saw the solar disc of an azure blue color, or greenish, or of emerald green.

It certainly is not impossible, theoretically speaking, that a gaseous substance, that a vapor, like so many of the liquids or solids discovered by modern chemistry, should tinge white light, passing through it, with blue, green, or violet; but hitherto there had been no well established example of it, and the tints *transmitted* by clouds or fogs had always been different shades of purple or red. This circumstance may perhaps be considered sufficient to prove, that the fog of 1831 was not of terrestrial origin; but it should be observed, that the unusual blue or green color of the sun's disc may not have been real; that if the fog or clouds near the sun were, as we may suppose, red *by reflection*, the direct light of this body, enfeebled but not colored in its passage *through* the atmospheric vapors, could not, at least in appearance, but assume the tint *complementary* to red, that is, a blue verging towards green. The phenomenon would thus belong to the class of accidental colors, with which philosophers have of late been so much occupied; it would be simply the effect of contrast.

Whilst this fog lasted, there was really no night in those places where the atmosphere was strongly impregnated with it. In Siberia, at Berlin, and at Genoa, in the month of August, the smallest writing could sometimes be read even *at midnight*.

Twilight, under the most favorable circumstances, begins in the morning and ceases in the evening, when the sun is not more than 18° below the horizon; now at midnight, on the 3d of August, the date of the Berlin observation, the sun was more than 19° below. There could not therefore have been any twilight; and yet there is abundant evidence to prove that there was light enough to enable one to read the finest print.

If the fog reflected this light, it must necessarily have occupied, in the atmosphere or beyond it, very elevated regions; still not so elevated, that we may apply to it the common calculations relating to twilight. These calculations are founded upon the hypothesis of one *simple reflection*, while it can be shown by recent experiments, of which it is impossible to give a correct idea here, that *multiple reflections* have the most important influence in all the phenomena of atmospheric light.

If we are allowed to consider this fog as placed high enough thus to account for the nocturnal light observed at Berlin, in Italy, &c., its being tinged with red, however deeply it may have been supposed to be or really was colored, is attended with no. difficulty, philosophically considered; and I shall therefore not stop to notice it.

There is, then, nothing in the preceding statement, which leads us to believe, that the fog of 1831 was introduced into our atmosphere by the tail of a comet. At this time, moreover, the phenomenon was not general in Europe, or at least was perceived but faintly at Paris and some other places, and for a few days only; there could not, therefore, be any reason why the body of the comet should not have been seen. This circumstance is alone sufficient to destroy the hypothesis.

When we wish to overthrow a scientific theory, it is not sufficient, I know, to attack it with powerful arguments; we must also show that we have another theory to substitute in its stead. It remains for me to do this, in order to accomplish the end proposed in this section.

The year 1783, the year of the dry fog that we have heard so much of, was rendered remarkable at the two extremities of Europe by great physical commotions. It was in 1783, in the month of February, that Calabria was visited with those terrible and continual earthquakes which changed the whole face of the country, forty thousand inhabitants being buried under hills that were overturned, or beneath the ruins of churches and houses, or in the deep fissures with which such violent and repeated shocks furrowed the ground. Later in the same year, Mount Hecla, in Iceland, exhibited one of the greatest eruptions ever known. New volcanoes rose up from the bottom of the sea, at a considerable distance from the island.

Can it then be matter of surprise, if, amidst such convulsions of nature, new gaseous substances should issue from the bowels of the earth through the numerous fissures made in its crust, and be diffused through the air? Is not this idea of terrestrial emanations confirmed by the circumstance, already noticed, that out at sea these fogs were not seen? Will it not add to its probability, also, to observe, that fogs of this kind are sometimes found within very circumscribed limits? On the 11th of September, 1812, for instance, Mr. Gasparin, in ascending Mount Ventoux, in Provence, passed through a thick cloud, which did not wet his clothes, or tarnish metals, or affect the hygrometer, and which seemed, in every respect, just like the fog of 1783. But it is needless to say more upon this subject here, for all I now wish to establish is, that the mode of explaining the phenomenon here suggested is entitled to consideration, quite as much as that to which our attention was first called.

In the absence of terrestrial effluvia, we might suppose, with Franklin, that the fog of 1783 was simply the result of the general diffusion of the thick columns of smoke, emitted all summer by Mount Hecla, and carried about by the winds; or we might avail ourselves of another suggestion of the illustrious American Philosopher, for there is no reason against believing it, viz. that an immense fire-ball, in penetrating our atmosphere, was there but partially inflamed or ignited, and that torrents of smoke, occasioned by this imperfect combustion, were deposited in the higher regions of the air, and were afterwards carried into all the atmospheric strata by the action of common winds, and by the currents ascending and descending vertically, which exert so important an influence in meteorological phenomena.

Meteoric stones, which fall from time to time upon the earth, are sometimes *very compact* metallic masses. In general they can only be distinguished from common stones, by the slight coating of vitrified matter that surrounds them. Occasionally they have been found of a *spongy* texture. The showers of dust that fall, either alone or mingled with rain, are another state of these meteoric substances. Attenuate these clouds of dust a little more, reduce them in idea to impalpable molecules, so that they can fall to the earth only very slowly, and we shall have another way of explaining the phenomena of dry fogs.

The interest which the public has taken in the extraordinary fog of this year, is not the only reason I have for entering into these minute details on the subject. The passing of the earth through the tail of a comet is an event that must happen several times in a century. If it did not occur in 1819 and in 1823, it could only be on account of a purely accidental circumstance, that of the tail not being long enough to reach the earth; for in each case it was for several hours directed exactly towards us. It is therefore important to prove, that there is really no danger to be apprehended on this score, and that we even pass through these immense trains without being in the least aware of it. Now this may be considered as a fact clearly proved, if it be granted, as I think it must be, that the tail of a comet does not serve to explain all the circumstances attendant on the dry fogs of 1783 and 1831.

Many authors have chosen to see some connexion between the extraordinary fog of 1831 and the entrance of the *cholera morbus* into Europe. This opinion reminds me of what an old English traveller, Matthew Dobson, says of the effects of a periodical wind on the west coast of the continent of Africa, which is called the *Harmattan*. On reading over the original narrative just as I was about to send these pages to the press, I was so struck with several points of resemblance between the properties of the air, where this wind prevails, and that which is filled by the dry fogs of Europe, that I determined to give here a short analysis of that memoir. The reader will observe, that out at sea, some distance from the shore, the Harmattan loses its peculiar qualities; and he will remember, that in 1783 the dry fog was not perceived in the middle of the Atlantic, although it darkened at the same time the atmosphere of Europe and America. He will see also, that all fogs of this description are not fatal.

A wind that blows three times each season from the interior of Africa to the Atlantic Ocean, is called the *Harmattan*. On that part of the coast which lies between Cape Verd (Lat. 15° N.) and Cape Lopez (Lat. 1° S.), the Harmattan is chiefly felt in December, January, and February. Its direction is between E. S. E. and N. N. E. It commonly lasts two days, sometimes five or six. It is always a moderate wind.

A *fog* of a particular kind, and thick enough to impede at noon all but the red rays of the sun, always presents itself where the Harmattan blows. The particles, of which this fog is formed, are deposited on the grass, on the leaves of trees, and on the skin of the negroes, in such profusion as to produce a white appearance. Of the nature of these particles we are ignorant; we only know that the wind carries them but a short distance from the shore. A league out at sea the fog is much lighter; and, at the distance of three leagues, it disappears entirely, although the Harmattan is still felt in all its force.

The *extreme dryness* of the Harmattan is one of its most striking characteristics. When it lasts some time, the branches of orange and citron trees die; the covers of books (even when these are shut up in tight trunks, and have an additional covering of linen,) warp as if they had been before a large fire. Pannels of doors, window-shutters, and furniture crack and often break. The effects of this wind upon the human body are not less remarkable; the eyes, lips, and palate become dry and painful. If the Harmattan lasts four or five days together, the skin of the hands and face comes off; to prevent this, the natives rub their bodies all over with grease.

After what has been said of the fatal effects of the Harmattan on vegetables, it may be thought that this wind *must be very unhealthy*, whereas quite the contrary is observed. Intermittent fevers are completely cured by the first breath of the Harmattan. Patients reduced by the excessive bleeding practised in that country, recover their strength; remittent and epidemic fevers also disappear, as if by enchantment. Such is the salutary influence of this wind, that, while it lasts, infection cannot be communicated even artificially. This assertion rests upon the following fact:

In 1770, there was an English vessel at Wydah, called *The Unity*, which was loaded with three hundred negroes. The small-pox having appeared among some of them, the owner determined to inoculate the rest. All who were thus operated upon, before the Harmattan began to blow, took the infection. Seventy were inoculated the second day after that wind began to blow, and not one of these had the disease, or the least eruption. However, some weeks afterwards, when the Harmattan no longer blew, these very persons took the disorder. It is also added, that during the second appearance of the malady, the Harmattan began to blow again, and sixty-nine slaves, who had it, all recovered.

The country over which this remarkable wind passes before it reaches the coast, is for two hundred and forty miles composed of verdant plains, entirely open, some woods of small extent, and here and there a few rivers and inconsiderable lakes.

4. *Was the Deluge occasioned by a Comet?*

The numerous and important geological observations, which we owe to modern naturalists, prove beyond all doubt that certain regions of the globe have been several times covered with water, and then left dry again. In the various explanations given of these deluges, recourse has so often been had to comets, that I cannot refrain from saying a few words on that subject.

I shall first notice the theory put forth, by the English geometrician and theologian, Whiston, though his work, called *A New Theory of the Earth*, is posterior to the reading, before the Royal Society of London, of the first Memoirs in which the celebrated Halley advanced a similar hypothesis.

Whiston not only proposed to show in what manner a comet might have occasioned the deluge mentioned in the Scriptures, but he wished moreover to adapt his explanation to all the minute details of this great catastrophe, as given in the Book of Genesis. Let us see how he has succeeded.

This deluge took place in the year 2349 before the Christian era, according to the modern Hebrew text, or in the year 2926, according to the Samaritan text, the Septuagint, and Josephus. Now have we any reason to suppose that at either of these epochs there was a large comet present?

Among all the comets, observed by modern astronomers, we may unhesitatingly consider that which appeared in 1680 as first in point of brilliancy.

Many historians, of our own nation as well as foreign, mention a comet of *great size, resembling the sun in brightness, and having an immense tail*, which appeared in 1106. Going still farther back, we find, in the year 531, a comet mentioned as *very large and very alarming*, called by the Byzantine writers *lampadias*, because it resembled a burning lamp. Every one has heard of the comet that appeared in the year of Cæsar's death, during the games that Augustus was giving to the Romans. This must have been a very brilliant comet, since its light began to be visible about five o'clock in the evening, or *before sunset*. The date of this is the year 43 before our era.

We have no exact observations of these bodies, either in —43, or in 531, or in 1106; we cannot calculate their parabolic orbits; we are without the only criterion that would enable us to pronounce with certainty on the identity of two comets; but let us observe that these, as well as the comet of 1680, were peculiarly brilliant, and let us compare their dates.

From	1106	to 1680	is a	period of	574	years
"	531	" 1106	"	"	575	"
"	—43	" 531	"	"	575	"

As we have taken no note of months or parts of years, these periods may be considered as equal among themselves, and it hence becomes *probable* that the comet which appeared at the time of Cæsar's death, that of 531, of 1106, and of 1680 are periodical returns of the same body, which, after completing its revolution in about 575 years, becomes again visible from the earth. Now if we multiply this period of 575 years by four, we have 2300, which, added to 43, the date of Cæsar's comet, carries us back within six years of the time of the deluge, according to the modern Hebrew text. If we multiply by five, we have the date of it according to the Septuagint, within eight years.

If we consider the remarkable variations which the comet of 1759 exhibited in the duration of its revolution round the sun, we must allow that Whiston was justified in believing that the great comet of 1680, or Cæsar's comet, was near the earth at the time of Noah's Deluge, and had some effect in producing this great phenomenon.

I shall not stop to examine particularly the series of transformations, by which Whiston supposes the earth to have been changed from a comet to the globe we inhabit. It will suffice to say, that he believed the nucleus of the earth to be a hard and compact substance, and that it is the old nucleus of a comet; that various kinds of matter, which, mixed together, formed the envelope, settled with more or less rapidity, according to their specific gravity; that thus the solid nucleus was at first encompassed by a thick and heavy fluid; that the earthy matter was then precipitated, forming upon the fluid a dense covering, a kind of crust, which may be compared to the shell of an egg; that water came afterwards to cover this solid crust, filtering through the fissures and extending over the thick fluid; that finally the gaseous matter remained suspended, being gradually purified, and constituting at last our atmosphere.

Thus, in this system, the *great deep* of the Bible is composed of a solid nucleus and two concentric orbs. The orb nearest the centre is formed of the heavy fluid which was first precipitated, the second is water; it is upon this latter fluid, then, that the exterior and solid crust of the earth rests.

We must now examine how, according to this construction of the globe, against which modern geology offers many objections, Whiston has explained the two principal events of the deluge, as described by Moses.

"In the six hundredth year of Noah's life, in the second month, and the seventeenth day of the month, the same day *were all the fountains of the great deep broken up, and the flood-gates of heaven were opened.*" — Gen. vii. 11.

At the time of the deluge, the comet of 1680, according to Whiston, was only seven or eight thousand miles from the earth; it must therefore have attracted the fluids of the great deep, as the moon attracts the waters of the ocean. Its action at this small distance must have produced an immense tide in the fluid beneath the earth. The terrestrial crust, incapable of withstanding the impetuous flood, must have broken in many places. The waters were thus let loose, and allowed to spread themselves over the continents. Here the reader finds *the breaking up of the fountains of the great deep.*

The ordinary rains of our globe, even if continued forty days, would have produced but a small effect. Taking for a day's rain, all that falls in a year at Paris, the quantity that would fall in six weeks, far from covering the tops of the highest mountains, would hardly form a layer twenty-eight yards deep. We must therefore look further for the *windows* or *flood-gates of heaven, that were opened.* Whiston has found them in the atmosphere and in the tail of the comet.

According to him, this atmosphere reached the earth towards the Gordæan mountains (Ararat), which mountains are supposed to have entirely intercepted the tail. The terrestrial atmosphere being thus charged with an immense quantity of aqueous particles, the consequence might be a rain of forty days, falling in such torrents as the ordinary state of the earth can give us no idea of.

I have been thus particular in describing Whiston's system, whimsical as it is, because it has long enjoyed considerable celebrity, and because I thought it not proper to treat with contempt the production of a man whom Newton himself named as his successor in the University of Cambridge. But I must now state the objections which seem to me to be insurmountable.

Whiston, having occasion for an immense tide, in order to explain the phenomena of the *great deep* of the Bible, is not contented with making his comet pass very near the earth at the time of the deluge; he has moreover given to it a mass six times as great as that of the moon.

Such a supposition is wholly gratuitous, and yet that is its least defect; for it does not, after all, explain the phenomena. The reason why the moon produces such a great effect upon the waters of the ocean is, because its daily angular motion is comparatively small; in the course of a few hours, its distance from the earth scarcely varies at all; for some considerable time it continues vertical over the same points of our globe; the waters attracted by it, have always time enough to yield to its influence, before the moon removes to another region, where its force would be differently directed. But this was not true of the comet of 1680. When near the earth, its angular motion, apparently through the constellations, must have been extremely rapid. In a few minutes it must have corresponded to a numerous series of points situated on meridians of the earth very distant from each other. As to its rectilinear distance from the earth, that might certainly have been very small, but only for a few short moments. These circumstances taken together are, it must be allowed, very unfavorable to the production of a great tide.

I am aware that in order to lessen these difficulties we have only to enlarge the comet, to make its mass not merely six times, but thirty or forty times, that of the moon. We cannot, however, be allowed this latitude with respect to the comet of 1680. In that year, on the 21st of November, it passed near the earth; it is proved, that at the time of the deluge its distance was not less: now, as in 1680 it produced neither floods from above, nor tides from below, nor any breaking up of the *great deep;* as, moreover, neither its tail nor its envelope inundated us, we may affirm with confidence, that Whiston's theory is a mere romance, unless, giving up the comet of 1680, the same effects are ascribed to another body of the same kind, but *much larger.*

Whiston, as we have just seen, undertook to account, by physical causes, not only for inundations in general, but particularly for that described by Moses, and for all the attendant circumstances as recorded in the Book of Genesis. His celebrated countryman, Halley, considered the problem in a *more* general manner.

There are, said he, marine productions very distant from the sea, and on the tops of the highest mountains. These regions have therefore been at some former period under water. By what agency has the ocean ever left those limits, by which at the present day, with the exception of slight oscillations, it is constantly circumscribed? Here Halley calls to his aid, not a comet passing near and causing a great tide, like Whiston's, but a body of the same kind, which, in an elliptical orbit round the sun, is supposed to strike directly against the earth. Let us examine closely what the effects would be of such an event.

Imagine a *solid body*, moving in a straight line, with a certain velocity; and, at the beginning of its course, suppose another body, much smaller, to be simply *laid upon it*. These two bodies, though not fastened together, will not separate as they move, because the force that carries them forward has gradually, and from the beginning, communicated to both the same velocity. But suppose that an insurmountable obstacle suddenly stops the first body. Those portions of the surface which are foremost, the parts struck, are, strictly speaking, the only ones whose velocity is destroyed by the obstacle; but as all the other parts are necessarily connected with these, since, according to the hypothesis, the *body is solid*, the *whole* will be arrested together.

This will not be the case with the small body, which was only *laid upon* the other; being held to it, by nothing but a slight degree of friction, it will not lose its velocity. Acted upon therefore by this velocity which it has acquired, and which is not destroyed, this smaller body will separate from the larger one; it will continue to move on in the same direction until its weight brings it down to the earth. It will now be seen why a person is thrown to a great distance, when, by the falling of a horse, a carriage is suddenly stopped in its course; why also travellers on a rail-way, seated on the top of a steam carriage, are shot into the air like so many projectiles, when an accident suddenly stops the swift motion of these ingenious machines. What is our earth but a carriage, which, in its course through the regions of space, has need of neither wheels nor rail-ways? All that has now been said is directly applicable to it.

The velocity of the earth's motion round the sun is about twenty miles in a second. If a comet of sufficient mass ran against this globe and distroyed its motion at a single stroke, the objects upon its surface, as living creatures, carriages, furniture, utensils, every thing in short, which is not rooted or imbedded in the soil, would be thrown towards the point struck with the velocity above mentioned, that is, at the rate of twenty miles in a second. Now we may conceive what the effects would be of such an occurrence, if we call to mind that a shot from a twenty-four pounder, on leaving the cannon's mouth, moves only at the rate of a quarter of a mile in a second: all animated nature would certainly be annihilated in an instant.

The waters of the ocean, not being fixed to the solid part of the earth, would also be thrown in a body towards the point struck. This terrific mass would overturn, in its impetuous course, every obstacle it met with; it would rise above the highest mountains, and in its reflux would be attended with scarcely less destructive effects. The disorder observed here and there, in the position and arrangement of certain strata of different kinds of rocks, of which the crust of this globe is formed, may be called a mere microscopic accident, compared with the horrible chaos that would inevitably result from the shock of a comet of sufficient force to stop the earth in its course.

We need make only a small deduction from these prodigious effects, in estimating what would be the consequences of a blow which, without stopping our globe, should sensibly *affect its* velocity. Now it is certain that it was never stopped entirely; for, in that case, the centripetal force, being no longer balanced by the centrifugal, would cause the earth to fall in a straight line towards the sun, which it would reach in sixty-four days and a half after the shock.

The velocity of the earth and the size of its orbit are so connected together, that one cannot change without a variation in the other. We do not know whether its orbit has always been the same; there is nothing therefore to prove that the velocity of the globe, in the course of ages, has not been more or less altered by the shock of a comet. In any event, it is undeniable that the inundations caused by such an occurrence, would not explain the effects, now well described by geologists, of those deluges to which the earth has been subjected.

I must add a few words, before quitting this subject, upon the consequences of a comet's striking the earth, so far as its rotatory motion is concerned.

The earth turns upon its axis in twenty-four hours, from west to east. The axis of rotation is called the *axis of the world*, its extremities the *poles*, and the circle equally distant from the two poles, the *equator*. The circumference of the equator is a little more than twenty-four thousand miles.

Twenty-four thousand miles, therefore, is the distance travelled by the equatorial regions, solid and fluid, every twenty-four hours, in consequence of the rotatory motion of the globe. An observer, who should be placed in space, and far enough removed from the earth and its atmosphere not to be carried round with it, would see every part of the equator pass before his eyes at the rate of about one thousand miles an hour, or seventeen in a minute. At the very poles there is no motion. In the latitude of Brest, the earth moves only at the rate of about ten miles in a minute.

The waters of the ocean, though they participate in this rapid movement, do not overflow the land that surrounds them; but this is because, in every country, the land has exactly the same velocity as the water; in all latitudes the continents and the seas that border on them are, with regard to each other, in a state of *relative rest*. If this state of things were changed, if the water, in a given part of the globe, continued to move at its usual rate, whilst the land near it suddenly lost a part of its velocity, the ocean must overflow its boundaries.

In order to have a clear idea of this subject, let us imagine, that, by an oblique stroke from a comet, all the *solid parts* of the earth were suddenly made to turn round the diameter, for instance, that passes through Brest. This town having become a pole, the whole peninsula of Brittany would be in a state of nearly absolute rest; but the case would be very different with the ocean that washes it on the west, because, as we said just now, in speaking of the progressive motion, the water is only *laid* upon the solid bed which contains it. The water would then be thrown in great masses on the shore, which would no longer flee before it with the former velocity of the parallel of Brest, namely, with a velocity of about ten miles a minute.

Thus, through the agency of a comet, vast portions of a continent might be inundated, and high regions covered with water; but is it really in this way that the marine deposits, discovered on the tops of mountains, have been formed? Not at all. These beds are frequently horizontal, very extensive, deep, and regular. The shells are of various kinds, and it often happens that there are among them very small ones, in which the most delicate points and most fragile parts remain unbroken. All this is against their being carried there by violence; every thing shows that the deposit was formed upon the spot. In what way, then, can we account for these marine beds, without supposing them to be formed by an irruption of the ocean? We must consider the mountains and the lands more or less elevated, which serve as their base, to have been gently heaved up from below, to have risen through the bosom of the waters, *as mushrooms rise out of the earth.* In 1694, Halley gave this hypothesis as a *possible* explanation of the presence of marine productions on the tops and sides of mountains; this explanation was the *true* one; and it is now almost universally admitted to be such. A comet which should perceptibly change either the progressive or rotatory motion of this globe, would, no doubt, occasion frightful convulsions in the crust of the earth; but, I must again repeat it, these physical revolutions would differ, in a thousand ways, from those which are now the objects of study to geologists.

5. *Has Siberia ever experienced a sudden Change of Climate, by the Influence of a Comet?*

All the regions of Europe contain, either in the bowels of their mountains, in caverns, or at moderate depths, in certain kinds of earth, the bones of animals, such as the rhinoceros, elephant, &c., which are not now the inhabitants of such cold climates. We must then suppose, either that Europe, in the course of many ages, has become colder, or else that, during one of the violent deluges which this planet has experienced, currents, running from the south to the north, have carried with them the remains of numerous species of animals that were actually destroyed.

Two very remarkable events have occurred to contradict the latter explanation, and to show its insufficiency. One is, the discovery, made in Siberia, in the year 1771, on the sandy shores of the Wilhoui, some feet below the surface, of a rhinoceros so perfectly preserved that it was covered with flesh and skin; and the other is the later and still more curious discovery, made in 1799 on the shores of the Frozen Ocean, near the mouth of the Lena, of an enormous elephant, enclosed in a block of ice, the flesh of which was so unchanged, that the *Yakoutes* of the neighbourhood cut it up for their dogs to eat. In such a case as this, there could be no action of a current, no long transportation from the south to the north; for if such large animals as these had not been frozen as soon as killed, their flesh would have become putrid. We are thus led to suppose that Siberia was once a warm country, since elephants and rhinoceroses lived in it; and also to conclude that the same catastrophe which killed those animals, suddenly rendered that part of the globe the cold region we now find it.

In the present state of our knowledge, we can think of but one way, in which the thermometrical character of a country could be materially and suddenly changed, — and that is, by suddenly changing its latitude; all other circumstances would make but a very slight difference.

If deep snows cover Spitsbergen during half the year, it is only because it is situated very near one of the poles of rotation. Change the place of the pole 90°, — this archipelago would be at the equator, and its desert valleys, fertilized by the solar heat, would be clothed in the richest verdure. Imagine the earth's axis to be somewhere in Peru or Brazil, without the inclination of the equator to the ecliptic being changed, and we should soon have ice-bergs floating in the ports of Callao and Rio Janeiro. The thousand beautiful plants, which now enrich and embellish those countries, would perish under deep snows, and be replaced by lichens. I think we need not hesitate to say, that if any other tropical region became *suddenly* the pole of the earth, it would freeze there in less than twenty-four hours.

The problem to which the elephant of Siberia has given rise, leads then, at last, to this question; Can the earth's axis of rotation have ever suddenly changed its direction?

Such a change, particularly if very sudden, could not be *produced by the* forces usually acting upon our globe;

but if the earth should be violently struck by a foreign body, a change of place in the axis round which it turns, would be the *almost* necessary consequence. I say *almost*, because there are directions in which a blow, however hard, would not alter the original position of the axis.

Comets are evidently the only foreign bodies in our system that could possibly strike the earth. The Lena elephant, and the Wilhoui rhinoceros seem then to prove, however strange such a catastrophe may seem, that in the lapse of ages a rencontre of that nature has taken place. This proof would even be indubitable, if it were well ascertained that elephants have never been able to live in such a climate as that of Siberia. Now some doubts are entertained on this subject, of which the reader may judge from the following facts.

In form and dimensions, the elephant of the Frozen Ocean bore a great resemblance to those that inhabit Africa and Asia. His tusks were ten feet long; his head weighed four hundred and fifty pounds, &c.; but his skin exhibited a very marked peculiarity, and one well worthy of notice; it was covered with long black hair and a reddish, woolly coat. The white bears, in devouring the flesh, had trampled into the wet soil more than thirty pounds of this hairy coat, which were taken up by Mr. Adams. The neck was also furnished with a long mane.

This double coat of the polar elephants, and the stiff hair, three or four inches long, which covered the skin of the Wilhoui rhinoceros, were too well adapted to the severity of a Siberian climate, for us to entertain a doubt as to these animals being able to live in very cold climates, though, without such warm covering, those of their race now living could not endure them. Moreover, my illustrious friend, M. de Humboldt, became acquainted, in his last travels, with an important fact, very much to our purpose, and likely to throw new light upon the subject. He ascertained that the royal tiger of India, which we are accustomed to call a tropical animal, lives now in Asia in very high latitudes, and that in summer it makes excursions to the western side of the Altaï mountains, near Barnoul, where several have been killed of an enormous size. It appears, then, that elephants with thick coats must have been formerly able to travel, during summer, as far as Siberia. Once there, any common accident, a mere slide of earth, would be sufficient to account for their bodies being found in frozen beds, capable of preserving them from decomposition. The observations of M. de Humboldt prove, that, in the steppes beyond the 62d degree of latitude, the earth, at a depth of fourteen or fifteen feet, is always frozen.

While it is thus shown that we can satisfactorily account for fossil elephants being found in Siberia, without admitting that there has been *a sudden change of climate,* I may here also assert that nothing has yet been brought forward to prove that a comet has ever had any agency in the great physical revolutions on our globe, of which traces are every where to be seen.

6. *Is it necessary to have recourse to a Comet to explain the Severe Climate of North America.*

As soon as the northern regions of America were discovered, navigators remarked that they were much colder than the same parallels in Europe. This fact, for which the *astronomical theory* of climates does not satisfactorily account, has exercised the ingenuity of many philosophers, and, among the rest, of Halley. According to that learned and celebrated man, a comet formerly struck the earth obliquely, and changed the position of its axis of rotation, in consequence of which the north pole, which was once very near Hudson's Bay, was carried further eastward. The country which it left had been so long and so deeply frozen, that the *effects* of this once polar cold are still experienced, and a long series of years must elapse before the northern parts of the new world can receive by the action of the sun's rays that climate which its geographical position indicates.

This might have appeared to be a plausible hypothesis in the time of Halley. But now that the meteorological fact, which it was meant to explain, is undertood in all its details, it is found to be insufficient and useless, and even opposed to the results of observation.

It is true that, in the same latitudes, it is much colder in the United States than in Europe; but this difference disappears almost entirely when the points of comparison in America are taken from the western side of that continent, that is, on the shores of the Pacific Ocean. Thus, according to Halley's hypothesis, the old north pole has modified only the temperature on the eastern side of the continent; this pole must then have been situated originally in that part or on the meridians near it. But then what is to be said as to the cause of the excessive cold on the coast of Asia, which, in similar latitudes, is not less severe than it is on the Atlantic coast of North America? It cannot be denied, that Halley was acquainted with but a small part of the interesting phenomena that belong to the subject of climate. He was not aware, that, in the old world as well as in the new, the eastern coast is remarkable for its low temperature; that the lines of equal temperature, called now *isothermal* lines by M. de Humboldt, differ greatly from terrestrial parallels; that they incline towards the equator according as, leaving the western coast, we approach the interior of continents, &c. The reader will find many more particulars upon this subject in a former *Annuaire*. I have here limited myself to showing that Halley's hypothesis is wholly unsatisfactory, and that there are no meteorological phenomena to prove that the axis of the earth has ever undergone any change by the shock of a comet.

7. *Has the Depression of the Land in a great Part of Asia been occasioned by a Blow from a Comet?*

Russia and Persia present us with a geographical phenomenon truly extraordinary. There is in these countries a vast region, covered with populous towns, great commercial establishments, and fertile lands, which is, nevertheless, *much below the level of the ocean.* According to M. de Humboldt, the extent of this low region cannot be less than 100000 square miles. That no one may imagine the depression to be slight, or that it is over-estimated on account of errors liable to be committed in ascertaining the level of very large tracts, I will observe that the level of the Caspian Sea and consequently that of the city of Astracan, is more than 300 feet below the level of the Black Sea or of the ocean. I may also add, that, even in the heart of Russia, the course of the Wolga and the countries through which it flows are depressed 150 feet.

This enormous sinking of a whole country, a phenomenon, of which the globe does not, I believe, offer another example, being very difficult to explain by the operation of known causes, has led persons, in despair of all other agency, to attribute it to the action of a comet.

In *ricochet* firing, it is evident that the spot struck by the ball is somewhat depressed. Thus, according to some, the Caspian Sea and the surrounding country has been indented by the stroke of an immense ball, that is, a comet

In the present state of geological science, this idea of Halley's cannot be favorably received; no one doubts now that isolated peaks as well as the longest and highest ranges of mountains have been gradually heaved up from the bosom of the earth. (See the *Annuaire* for 1829.) Now the very idea of a rise necessarily implies a void in some neighbouring part, and the possibility of an ulterior depression.

In looking at a map of Asia, it will be easily seen that no other part of the world contains so much high land. Around the Caspian Sea are the large elevated regions of Iran and of central Asia, those of Himalaya, of Kuen-Lun, of Thian-Chan; the mountains of Armenia, those of Erzerum, and the range of Caucasus. Now, without calling in the aid of a comet, may we not suppose, as M. de Humboldt does, in his excellent "Asiatic Fragments," that the up-lifting of so many enormous masses must be attended with a perceptible depression in the intermediate places? This solution of one of the most curious problems in physical geography is less liable to objection on account of the actual state of the ground in the region to which it belongs, which has not yet become stable. The bottom of the Caspian Sea, for instance, is occasionally raised and depressed; on which subject it is expected that much light will soon be thrown by the numerous observations of Dr. Eichwald, not yet made public.

8. *Was the Moon ever a Comet?*

The Arcadians thought themselves of older date than the moon. They maintained that their ancestors had inhabited this planet before it had any satellite. Struck with this singular opinion, some philosophers have imagined that the moon was formerly a comet, which, in performing its elliptical course round the sun, came into the neighbourhood of the earth, and was drawn in to revolve around it.

Such a change of orbit is possible; but, evidently, it could not have taken place if the comet's perihelion distance had been great. The comet must, therefore, have passed very near the sun, and have experienced an intense heat, capable of dissipating every trace of humidity. The almost entire absence of an atmosphere round the moon, the scorched appearance of its vast mountains and deep valleys, and the few plains that are seen, have been cited as proofs that this luminary was once a comet.

This reasoning, I must say, is founded upon the strangest confusion of language. The moon has indeed a scorched appearance, if by that is meant that all parts of its surface show traces of former volcanic eruptions; but nothing in its aspect indicates or can indicate at the present day what temperature the moon has heretofore been subjected to by the action of the solar rays. These two phenomena have no connexion with each other. The volcanoes of Iceland, of Mayen's Island, and of Kamtschatka, show every year that the frosts at the surface of polar regions have no effect upon the subterraneous matter, the chemical action of which produces eruptions.

In all the multitude of bodies, of various forms and degrees of brightness, which the firmament displays, comets are the only ones which are evidently and sensibly surrounded with a gaseous envelope, a real atmosphere. I do not deny, that this atmosphere has been formed by the evaporation of matter which originally existed in the nucleus; but it is always found to accompany a comet, and there would be no reason for its being separated from it, whatever derangement the comet might experience in the form and original position of its orbit, from an accidental attraction. Thus the almost entire absence of all atmosphere around the moon, is rather against than for the opinion, that it was once a comet.

9. *Are Ceres, Pallas, Juno, and Vesta, Fragments of a large Planet broken in Pieces by a Blow from a Comet?*

Planetery Astronomy has been enriched, since the beginning of the present century, by the discovery of four new bodies, which, not being visible to the naked eye, could not be known to ancient observers. These planets are called *Ceres, Pallas, Juno,* and *Vesta.*

Their orbits are all comprehended between those of Mars and Jupiter.*

Two of these orbits, those of Ceres and Pallas, are almost exactly equal to each other. The orbit of Juno is rather less, and that of Vesta considerably less, in its dimensions; the four curves, although they are in very different planes, are, as it were, interwoven, and appear to have formerly had parts in common. Every thing, in a word, leads us to the supposition, that these four small planets, at each revolution, *passed originally through the same point in space.*

It would certainly be a very extraordinary circumstance if Ceres, Pallas, Juno, and Vesta had always been independent of each other. But the phenomenon becomes a very simple one, derived from the nature of things, if we regard these four small bodies as fragments of a much larger planet rent asunder at some former period.

A planet, properly so called, pursues constantly the same course, with the exception only of the derangements called *perturbations*. At each revolution it passes through the same series of points. Now at the very instant when, according to the hypothesis under consideration, the large planet was

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* It may not be amiss to put down here a simple method of remembering the distances of the different planets from the sun.

Write in a line the following series of numbers, the law of which is evident.

0, 3, 6, 12, 24, 48, 96, 192.

Add four to each, and we have

4,	7,	10,	16,	28,	52,	100,	196.
☿	♀	⊕	♂	⚳	♃	♄	♅

It will be seen by the signs, placed under these numbers, that if 10 represents the distance of the earth from the sun, 4 will be the distance of Mercury; 7 that of Venus; 16, 52, 100 and 196 the respective distances of Mars, Jupiter, Saturn, and Uranus. We may mention, as a curious circumstance, that this progression had been remarked before the discovery of the small new planets, which together are found to occupy a place that had been considered as vacant.

broken up, each of its fragments became, in the full meaning of the term, a real planet, and began to describe the curve in which its own motion must for ever carry it. Some difference of intensity and of direction, in the forces which projected the various pieces, would produce great dissimilarity in the form and position of their orbits; but all these ellipses must have one point in common, namely, that in which the different fragments of the planet separated, each to perform its own revolution. This common point then, which the small planets appear to have had formerly, gives a coloring of truth to the supposition, that these four bodies were originally one and the same.*

This theory of the common origin of the four telescopic planets was for a time very generally received; but when a cause was to be found for the rupture of the large planet, there was great difference of opinion among philosophers. Some, considering the powerful subterraneous action which is continually producing eruptions of lava, stones, and cinders, thought that if the craters of volcanic mountains did not, like safety-valves, give them the necessary vent, and that if the crust of the earth were without any fissure, the globe itself could not long resist the accumulating forces developed by the chemical phenomena within its bowels, and that some terrible explosion must be the consequence. In this manner, they supposed the great planet to have been rent asunder, of which we see four fragments in Ceres, Pallas, Juno, and Vesta. Others, rejecting all similitude between planets and the boilers of our steam-engines, which are so liable to burst, suppose that a celestial body can be broken only by a very strong blow. The reader has no doubt

* It may be well to observe here, that these ideas of Olbers were suggested to him by the resemblance between the orbits of Ceres and Pallas, and that they were anterior to the discovery of Juno and Vesta.

anticipated me in perceiving that these philosophers believe a comet to be the striking body.

It appears difficult to find, in the form and aspect of the four small planets, unanswerable arguments in favor of either of these hypotheses to the exclusion of the other. Nevertheless, I ought here to give some singular reasons urged by those who attribute the rupture of the large planets to the blow of a comet.

The four new planets are very small. According to some measurements, the diameter of Ceres is one hundred and sixty miles; that of Pallas, only eighty miles. Thus the surface of the latter, supposing it spherical, would scarcely exceed that of a certain kingdom which I could name.

In the large planets, Mars, Jupiter, and Saturn, traces of an atmosphere are perceived, but only by the aid of the nicest observations. In the telescopic planets, on the contrary, the atmospheric phenomena are on a very large scale.

According to the measurement of Schröter the atmosphere of Ceres cannot be less than 667 miles high; that of Pallas, though smaller, is nevertheless 460 miles. Hitherto comets only have appeared thus accompanied by extensive gaseous atmospheres. Now then, it is said, let us suppose the large, ancient planet, comprehended between Mars and Jupiter, to have been struck by a comet, and every thing is explained! The cometary atmosphere, that nebulous appearance which we have called the envelope, incapable of being annihilated by the blow, would be divided among the different fragments, and would form about *each of them* a large atmosphere!

This theory is ingenious, but unfortunately an important fact comes in to overthrow it; Vesta has hitherto not shown traces of any atmosphere at all! Now, what cause can have deprived it entirely of its share of the cometary atmosphere?

END.
