

893. *Phytolacca*; fructu monopyreno, majore; folio longiore, glabro.
894. *Pilofella*, major, umbellifera, macrocaulos. *Floribus est flosculosis.* Col. Ecph. 248.
895. *Rosa*; *Pimpinellæ* folio, Scotica; flore eleganter variegato.  
*Rosa Ciphiana.* Sibald. Scot. Illust.
896. *Rosa sylvestris*, Virginienfis.
897. *Senecio Americanus*; folio hastato, nitide ferrato.
898. *Sium umbellatum*, repens. Ger. Emac. 256.
899. *Solanum*, fruticosum, Africanum; Lauri foliis.
900. *Vulneraria crecta annua*; folio subrotundo leviter crenato.  
*Loto affinis, Coryli folio.* Dod. Mem.

VI. *A Physico-mathematical Demonstration of the Impossibility and Insufficiency of Vortices: By M. de Sigorgne. Translated from the French by T. S. M. D. F. R. S.*

THAT natural Philosophers of an inferior Class, who consider only the Outside of Things, are obstinate in the Defence of *Vortices*, is, in my Opinion, not to be wondered at: The Idea of them strikes the Mind very agreeably at first, and even seems to promise the true Mechanism. But that Persons versed in the most profound Geometry, and in the most sublime Calculations, able Academicians, who incessantly apply themselves to the Study of Na-

Nature, should plunge headlong into these Notions, and sustain the *Vortices pro aris & focis*, is to me Matter of unaccountable Surprize.

It appears to me, that a *Vortex* is as shocking upon mature Consideration, as its Idea is satisfactory upon the first mentioning it. And *Vortices*, in my Opinion, are like smart Sayings (*bons mots*), which charm the Mind the first, or, perhaps, the second time, but by a Repetition become quite flat and insipid. What Man, indeed, (if free from Prejudice, and that the Spirit of Party has not depraved his Judgment) would not be astonish'd to see brought on the Scene, not only *Vortices*, but such as are compos'd of an infinite Number of smaller *Vortices*, each of which still contains an innumerable Number of others subordinate to them? For Example: What is this Air, this Water, this Oil, &c. which Monsieur *de Moliere* takes pains to introduce? A Sport of the Imagination, or of the Mind, if you please; but in reality a Paper-building. It has been long since said, that according as *Vortices* shall be multiplied, they will degenerate into Littleness and Puerility: And these are the Sentiments even of the good *Cartesians* of our Days. But might it not be said, that the great *Vortices* having the same Origin with the little, the latter shew the Meanness of Extraction of the former? As Matter is divisible *in infinitum*; as to Vorticity, there is no Difference between the Great and the Small: And consequently, we have a Right to reject the large *Vortices*, since *Cartesians* proscribe the small.

It is on this Consideration that I am resolv'd to attack the *Vortices*: For I must own, to the Shame  
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of our Nation, that the Spirit of Party is so predominant therein, that several Persons, who by a close Study have found the Insufficiency of *Vortices* for explaining the *Phænomena* of the Heavens, yet have not dared to publish their Notions on that Subject.

But as at present the System of small *Vortices* is freely attacked, I think, as already said, that I have a Right to attack the large; and to this Purpose I hope to prove,

I. That the mechanical Formation of a *Vortex* is impossible.

II. That the *Vortex*, were it formed, cannot be of long Duration.

III. In fine, that it is not sufficient for explaining the *Phænomena*.

## FIRST PART.

*The mechanical Generation of the Vortex is impossible.*

### DEMONSTRATION.

In the Hypothesis of a perfect *Plenum*, GOD at first created Matter indefinite, uniform, homogeneous, and at Rest. This is allowed by all *Cartesians*, and follows in their Principles from this alone, that Matter was created at Rest. Now, from this perfect Homogeneity of Matter it evidently results, in my Opinion, that the *Vortex* cannot be mechanically formed. Suppose, say the *Cartesians*, that while Matter is as yet at Rest, GOD imprints a Motion in a strait Line on one of its Particles: This Particle will every Instant meet with Obstacles to the recti-

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linear

linear Motion in the encompassing Matter; this Motion must therefore be turned aside, and will by this means become circular.

But why should the encompassing Matter, which is at Rest, be an Obstacle to the rectilinear Motion? Because, say they, it happens to be in the Line described by the Particle, on which Motion is supposed to be imprinted. But this very Reason would also prove, that the Body supposed to be in Motion could not circulate round a Centre at a Distance from it; because it would constantly meet with Matter at Rest in the Sides of the Polygon which it was to have described.

In a Word, it is a received Principle, that a Body which moves in a homogeneous Medium, never quits the Line of its first Direction: It does not refract, or deviate on one Side or the other of this Direction, except when it passes from an easier into a more difficult Medium, or from a denser into a less dense Medium: and even then its Direction must be oblique on the Surface of this Medium.

Now, the Body in Question would move in a Medium intirely homogeneous; seeing all the created Matter is supposed to be so, and that all but one Particle of this Matter is at Rest. It is moreover evident, that as all the Matter is uniform, every Direction, of what kind soever, of a Body which moves in the midst of this Matter, will be perpendicular to the Surface which corresponds to it; as is demonstrated in Mechanics. The supposed *Mobile* will therefore always move in the Line of its first Direction, until it has communicated all its Force; or rather it will remain

remain at Rest after the least Shock, if Regard be had to nothing more than what I have hitherto said.

But there still remains a very important Remark to be made on this Subject, to wit, that as it is universally agreed at this Day, that Rest is not a Force, all this Matter created at Rest will be infinitely soft: Its Parts will have no Tenacity, no Connexion, no Viscosity; they will be but contiguous, and will not have more Adhesion to one another, than Two Globes which would touch out of the Bounds of the World without any reciprocal Attraction; since Tenacity, Viscosity, &c. are in the *Cartesian* System but the Effects of Compression every Way. Wherefore these Parts will be divided at the least Shock, in the same manner as if Quicksilver be thrown against a Wall, it is instantly seen to be divided into a Million of Parts, to be reflected on every Side, and be again divided as soon as it falls on the Floor. I know my Comparison is not exact, but the Advantage is on my Side; because Quicksilver is not without Viscosity, or a certain Tenacity between its Parts; whether it proceeds from Attraction, which is my Opinion, or that it be the Effect of the Pressure of the ambient Fluid. Therefore the *Cartesian* Matter will have more Facility to divide than Quicksilver, and will not be susceptible of any regular Motion; which alone demonstrates, that the mechanical Generation of the *Vortex* is impossible.

There is however this Difference between the *Vortex* imagined by *Descartes*, composed of hard Globules; and that of the infinitely soft Matter of Father *Malebranche*, whose System is revived by his Disciple Monsieur *de Molières*; that if the *Cartesians*

admitted Gravity as a Principle; besides that it would give the true Cause of Hardness, its Combination with the strait or projectile Motion would produce a Motion in a Curve; as Sir *Isaac Newton* has demonstrated. But until they will return to this Idea of primitive Gravity, and further while they will make use of no other Matter than one infinitely soft, and really unintelligible, it will not be possible to conceive a single *Vortex* formed; far from having this infinite Number, which, by-the-bye, ought to be dissipated as Waves raised in the Water, upon account of their perfect Homogeneity.

The famous *Cartesians*, always refusing to allow this primitive Gravity, and at the same time plainly seeing, that this first Manner of forming the *Vortex* was impossible, have had recourse, in order to its Formation, to the Motion of Rotation of a solid Sphere at the Centre of a small Particle of Matter at Rest, &c. and they have pretended, that this Sphere in its Circulation ought to carry along with it the circumambient Matter.

But this Notion is certainly as unsustainable as the First. For,

1<sup>st</sup>, They must explain to us the mechanical Formation of this Sphere; they must account for its Solidity: But all this manifestly supposes the *Vortex* already formed; all this supposes a Pressure equal on every Side, uniform and concentric.

2<sup>dly</sup>, This Sphere would never imprint an equal Velocity on all the Points of the concave Surface which touches and incloses it, seeing itself has not an equal Velocity in every Point of its last Surface; and therefore the *Vortex* would not have as much  
Force

Force to defend itself towards the Poles, as towards the Equator; as we shall shew hereafter.

3dly, This Sphere, in striking against the ambient Matter, would but divide it *ad infinitum*; because it is infinitely soft, and that its Parts have no Adherence with each other.

4thly, It is not sufficient, that a Sphere turns round its Centre, to draw into its Circulation the ambient Matter: It is moreover requisite, that to press on this Matter in a Direction from the Centre to the Circumference, (which a solid Globe either cannot do, or can hardly be conceived possible for it to do) and further still, it is necessary there should be Unevennesses on this Sphere, and on the concave Surface of the ambient Matter; because otherwise, though the Sphere should press this Surface by its centrifugal Force, it would only raise it up, or tend to raise it, and it would slide along the Surface without dragging it away with it: On which Head there is this Particularity to be remarked, that, for the uniform Circulation and Conservation of the *Vortex*, and still more for the preserving of *Kepler's* Laws, the Spheres and Surfaces must be strictly Mathematical, as we shall soon see; and for its Formation they must be rough, and full of Unevennesses: But what can be more whimsical? And further, though these Surfaces were full of Prickles, yet could not the *Vortex* be formed in the Hypothesis of Father *Malebranche's* soft Matter; because the Parts which would form these Eminences and Unevennesses on the concave Surface of the Matter surrounding the Sphere, not being connected with the other Parts of the same Matter, would be carried off without Difficulty by the Rotation of  
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the Sphere ; and the rest of the Matter would remain at Rest. And those who would pretend, that these Unevennesses, these Parts which form the Hillocks we are speaking of, could not, in consequence of GOD'S Decree, loose themselves from the other Parts of the Matter, would evidently abandon Mechanism, without reaping any Advantage : Because, supposing it true, that by this Means the ambient Matter would be compelled to circulate, yet could it not form a fluid *Vortex*, wherein *Kepler's* Laws could be observed ; because both the Sphere and these Surfaces being by these Unevennesses wedged into each other by solid hard and inflexible Parts, they would necessarily move all of a Piece, as the Parts of a Sphere do.

*stly*, By means of this Sphere one could have but a great *Vortex* formed ; and not that infinite Multitude of small *Vortices*, with which the great ones are at this Day supposed to be filled, and in the Centre of all, or most Part of which, People will not allow that there are hard Globules, and so of the rest : For I am persuaded, that the Reader, by a little Meditation on this Subject, will find almost as many Reasons against this System, as there are small *Vortices* supposed to exist.

It may be objected, that we do not pretend to form a *Vortex* : We suppose that GOD formed it in the Beginning, and in Consequence hereof we account for its Properties and Conservation.

But, besides that the Impossibility of the mechanical Generation of a *Vortex* is a strong Prejudice against its Conservation ; I pretend, in the Principles  
of



of our Adversaries, GOD could not form a single *Vortex*.

I desire Attention may be given, that a circular Motion is a redoubled and forced Motion; and not, as Mr. *Perault* thought, a natural Motion. Now the rectilinear Motion cannot be redoubled thus, as against its Nature, in order to become circular, but upon a Supposition that it meets in the ambient Matter invincible Obstacles to its Direction; or that by a primitive Law it is carried towards a Centre by a Motion of Gravitation, at the same time that it receives a Motion in a strait Line. Therefore, since on one hand this universal and primordial Gravity is obstinately rejected; and on the other, as it is solidly proved above, that the ambient Matter is no Obstacle to the rectilinear Motion; it remains certain, that the Formation of the *Vortex* is impossible. Q. E. D.

## SECOND and THIRD PART.

*The Vortex, though once formed, cannot last, and it is not sufficient for explaining the celestial Phenomena.*

### P O S T U L A T U M.

The cylindric *Vortex* cannot long subsist, and is not sufficient for explaining the celestial *Phænomena*: This Principle is allowed by all *Cartesians* in both its Parts. It cannot subsist; because not having Force to defend itself towards the Poles, if it happened to hit on that Side against another cylindric *Vortex*, that presented its Equator, it would soon be broke into,  
and

and burst to its very Centre. If, on the contrary, its same Side touched another cylindric *Vortex* by the Poles, they would both mix together, and would compose but one *Vortex*.

It is not sufficient for explaining the celestial *Phænomena*; because it is allowed, that the translative Velocities of its Points cannot be in an inverted *Ratio* to the Roots of the Distances, and that its centrifugal Force does not diminish in the inverted *Ratio* of the Squares of these Distances, &c.

#### C O R O L L A R Y.

Therefore the spherical *Vortex*, in order to be of Use, must have other Properties than the cylindric: That is to say, it must have a relative Force to one and the same Centre; for it is by this Force alone that it can be different from the cylindric *Vortex*.

This Force, moreover, must be equal in all the Points of the same spherical Superficies; because otherwise it might be burst and broke into in its weak Parts, as well as the cylindric, &c.

#### T H E O R E M I.

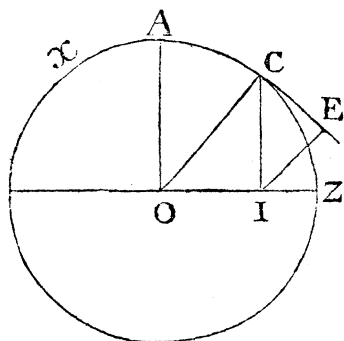
Even in the spherical *Vortex* there is no relative Force to one and the same Centre: That is to say, that it has properly but an axifugal Force.

#### D E M O N S T R A T I O N.

The spherical *Vortex* is composed, as well as the cylindrical, of several parallel Circles, but with this Difference, that in the spherical *Vortex* the *Radii* of the parallel Circles are not all equal, but on the contrary

trary diminish according as they recede from the Equator, and approach the Poles. Now it is manifest, that all the parallel Circles circulating round different Points of the Axis in the spherical *Vortex*, as well as in the cylindrical, tend to recede only from these different Points of the Axis, round which they circulate; because a Body cannot tend to recede from any Centre but that of its Circulation. In a Word, in order to make a *Vortex* spherical, which was cylindrical, they have but proportionally shortened the parallel Circles. But let the *Radius* of a Circle be ever so much shortened or lengthened, that will not change the Direction of its dilatative Effort. I am mistaken! an imaginary Line is going to change the Direction of the axifugal Force. This Force, as all agree, has for its Direction the *Radius* IC, in the Circumference whereof it is the *Radius*; but the Direction IC is oblique to CE the Tangent to the Sphere; therefore it changes, according to the general Law of an oblique Shock, into the Determination IE or OC relative to the Centre O.

But if Lines may be imagined, and that nothing more is requisite to realize them, than Points that correspond to them; we shall have some of all sorts in the *Vortex*: We shall have oblique Lines on the *Radius* OA, a perpendicular one, and some more or less oblique, on the *Radius* IC, and by that means we shall be able to determine nothing. Let us grant however, that there is a Tangent to the Sphere CE, at the Point C, and let us see if it will be a sufficient Reason for decomposing the centrifugal Force IC into a central Force IE or OC. For that Purpose I ask, What are the Points that compose this Tan-



gent? It is evident, that it can only be the Globules of the upper *Stratum* that answer thereto. The Line CE is therefore composed only of a certain Number of Points separate one from the other, and which consequently can move one without the other. Therefore if the Line IC is perpendicular to the Globule that occupies the Point C, and that it passes through its Centre; there will be no Decomposure, and the Force IC will not change into a Force that has the *Radius* OC for its Direction.

Now it is infinitely probable, that the *Radius* IC passes through the Centre of the Globule C; and it is easy to demonstrate, that it is actually so even in the Principles of Monsieur *Saurin*, who first invented this central Decomposition. For what has been the Cause of the Decomposition of the circular Velocity into the centrifugal Force IC? It seems plain to me, that no other Cause can be assigned than the Point or Globule C; seeing there is but that one at the Point where it happened. The Line IC passes then through the Centre of the Globule C; since the  
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Decomposition is always made in a perpendicular Line to the Point that caused it.

And indeed, either the *Radius* IC passes through the Centre of the Globule C, or the Centre of this Globule is on one Side or the other of this *Radius*, but so as that this *Radius* cuts the Point C; or else, it is a Space intercepted between Two Globules, which directly answers to the Point C. In the First Case, there is no Decomposition: In the Second, and in the Hypothesis, that the Centre of the Globule C happens to be between the *Radius* IC and the Equator, there will be a Decomposition; but it is manifest, that it will not be a central one: It will, on the contrary, be relative either to the very Pole, or to one of the polar Circles. In the Third Case, wherein it is supposed, that it is a Space intercepted between Two Globules, which answers to the Point C; there may be a Decomposition, but it will be double, the one relative to the Centre O, and the other relative to the Pole Z.

Now the *Cartesians* can never draw from this Decomposition the Advantage they propose; because there will not be more Reason for heavy Bodies precipitating to the Centre of the Sphere by means of the central Force, than to the very Pole by the Assistance of the polifugal Force; or rather, the Complication of these Two Forces will compel the *Mobile* to precipitate to the Centre I of the Parallel it happens to be in.

Wherefore, in order to defend the spherical *Vortex*, they must say, that the Centre of the Globule C is comprehended between the Poles and the *Radius* IC. But on what Foundation will they assure it?

What are the Proofs they will give for it? One must certainly be a very bold Gamester, to hazard this Point; because besides the Appearance of Truth, the Adversaries of *Vortexes* may wager Three to One, that it does not so happen. But in case it be allowed, will they ever find in the soft Matter of Father *Malebranche* and Monsieur *de Moliere*, a sufficient Cause of the Decomposition? There must be a Resistance to produce a Decomposition, and an infinitely soft Matter does not resist. And further, in the Hypothesis of the Decomposition of IC or OC, the *Vortex* would not be in Safety; because there would be a Remainder of the centrifugal Force IC, that would be parallel to the Tangent CE, and would evidently spread Confusion in the *Vortex*, by driving all the parallel Circles towards the Equator.

This seems to me sufficient to discredit, in the Minds of rational People free from Prejudice, this central Force, which is attempted by all means to be introduced. But let us not be tired of examining this Point thoroughly: It is of Consequence, and the *Cartesians* well deserve the Trouble of an abundant Refutation. Wherefore let us suppose, that GOD forms a *Vortex* cylindrical and fluid; it is a received and evident Principle, that its Points will have but an axifugal Force. And if a Sphere be conceived to be inscribed in this Cylinder, the Points that compose it, will not in like manner have any central centrifugal Force, according to the Axiom: *Nostrum intelligere nihil ponit in re*. Now let us realize this spherical *Vortex*, which before we had but conceived; that is, let us suppose, that GOD has destroyed the translative Velocity of the Points that form the

angular Spaces intercepted between the last Surface of the inscribed Sphere and that of the Cylinder; it is manifest, that no Change will happen in the Velocity and axifugal Force of the rest of the Points, which are not included in these; for this Reason, that the Points which fill the Two kinds of Basons that mark the Excess of the Cylinder above the inscribed Sphere, remain in the same Order, Disposition, and Direction, with regard to the inferior Points, which they were in at the time of their Motion. And there is no other Difference to be perceived herein, except that at present it is the same Point that constantly corresponds to the same Place; and that before this Place was successively occupied by Points intirely resembling each other, and that which remains or is supposed constantly to remain therein.

Now whether this Place be constantly occupied by one and the same Point, or successively by Points intirely alike and in the same Order, is what ought not to produce any Variation in the Effect which we are examining: And this appears to me at least as clear as Noon-day.

Wherefore, since these inferior Points had then but an axifugal Force, it follows that even now they have no other Tendency than to recede from the Centres of their Circulations, without having any Force relative to the Centre of the *Vortex*.

This is all that pure Reason dictates to me on this Point of the Nature of the *Vortex*, whether spherical or cylindrical: And I dare flatter myself, that whosoever will attentively examine my Reasonings, will find

find them as demonstrative as can be desired in Natural Philosophy.

In Effect, Experience agrees here with Reason. If a glass Globe filled with Water be rapidly turned on its Axis, one sees little Foulnesses; the small Atoms which it never fails to contain, gather together along the Axis, and form a little Cylinder round it.— Which very plainly shews, that in this spherical *Vortex* of Water there is but an axifugal Force.  
Q. E. D.

#### C O R O L L A R Y.

Therefore Gravity is inexplicable in the *Vortex*, and it has not Strength to defend itself towards the Poles.

#### T H E O R E M II.

Supposing there was in the spherical *Vortex* a central Force according to the *Radius*  $OC$ , it could not by Reaction be changed into a centripetal Force according to the *Radius*  $CO$ .

This Proposition is well known to all who are somewhat conversant in Mechanics.

It is therein demonstrated, that if the *Radius*  $IC$ , for Example, forms with the Tangent  $CE$  an Angle of 45 Degrees, the Line of Reflexion will be parallel to the Axis; and that from the Point  $C$  to the Pole  $Z$ , the Lines of Reflexion will be divergent to the Axis; and, in fine, that from the Point  $C$  to the Equator, these same Lines of Reflexion will be indeed convergent to the Axis, but will never terminate at the Centre  $O$ : In a word, that because the Angle of Reflexion is always equal to the Angle  
of



of Incidence, it is only at the Equator that the centrifugal Force can be changed into a centripetal Force.  
*Q. E. D.*

C O R O L L A R Y I.

Therefore the modern *Cartesians* are strangely mistaken, when they pretend to account for Gravity by the Reverse of the central centrifugal Force.

C O R O L L A R Y II.

And they can never, *à fortiori*, in their Principles, explain the Figure of the Earth and of *Jupiter*, which are flatted Spheroids made by the Conversion of an Ellipsis upon its small Axis.

L E M M A I.

If the centrifugal Force represented by IC (see p. 420.) be decomposed on the spherical Tangent into a Force, that for its Direction has the Centre of the Sphere; the central Force, which results from this Decomposition, will be to the centrifugal Force, as the *Radius* IC to the *Radius* OC.

For the centrifugal Force IC, being decomposed into C on the Tangent of the Sphere, will strike this Tangent with a Force that will be represented by IE. But on account of the simular Triangles IEC, IOC; IE. IC :: IC. OC.

L E M M A II.

A Body which describes a Curve, strikes this Curve every time it passes from one Side to the other, with an infinitely small Force of the first kind with regard to its Velocity.

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To the best of my Remembrance, this Proposition is demonstrated in Dr. *Clarke's* Notes on *Robault's Physica*, and in Monsieur *de Moliere's* Lectures: And it is evident from this alone, that it can only be by a Force represented by the Sine of the Angle of Contact that this moveable Body strikes the Tangent of its Curve.

### T H E O R E M III.

Let us put Complaisance on the Stretch, and grant that *Vortexes* have a central and centripetal Force relative to one Centre O: I say, that the spherical *Vortex* will not have as much of this central Force, to defend itself towards the Poles, as towards the Equator.

### C O N S T R U C T I O N .

Let us take, in the same Superficies X (see the Fig. p. 420.) Two Points at Pleasure, the Point A in the Circumference of the Equator, and the Point C in the Circumference of a subduple parallel Circle; we will give in the Demonstration an equal Velocity to the Globules which circulate in these Two Circumferences; which is the most favourable Concession imaginable for the Patrons of *Vortexes*.

### D E M O N S T R A T I O N .

It is manifest, that if the Point A is in an equal Space of Time struck an equal Number of Times as the Point C, and that each Stroke against the Point A be double each Stroke against the Point C; it is manifest, I say, that there is more Force at the  
Equator

Equator than at the parallel Circle. Now the Supposition is very certain in both its Parts: For,

1. Since the Circumference of the Equator is the double of that of the parallel Circle, and that being at an equal Distance from the Centre O, (see Fig. p. 420.) the Globules they contain are equal to each other; if there be a Thousand Globules in the Circumference of the Parallel, there will be Two thousand in the Circumference of the Equator. And as these Globules are supposed to have in both an equal Velocity, they will make (but) One Revolution in the Equator, while those of the subduple Circumference will make Two. Therefore, in both, there will be Two thousand Strokes employed in the same Space of Time, against the Points A and C.

2. Each central Stroke is double at the Equator: Because, as there is in both an equal Velocity, and that (LEM. II.) each centrifugal Stroke in every Circumference is a Fluxion of the first kind, with regard to the Velocity of the Globule which is in Motion; it follows that the centrifugal Strokes both in the Equator, and in the parallel Circle, are equal to each other. But the central Effort (which is the only one by which a *Vortex* can defend itself towards the Poles) is at the Point C (LEM. I.) but half the centrifugal Effort, since it is represented by IE subduple of IC; whereas at the Equator the central Effort is the same with the centrifugal Effort, because the *Radius* OA is perpendicular on the spirical Tangent, which corresponds to it. Therefore, &c.  
Q. E. D.

## COROLLARY I.

Therefore if a *Vortex* be in *Æquilibrium* with another *Vortex*, and that the Equator of one happens to answer to the Poles or Tropics of the other; the latter will be burst and penetrated to the Centre: And I do not think, that the *Cartesians* can find their Account in this Consequence.

## COROLLARY II.

Therefore if the *Vortex* was the mechanical Cause of Gravity, Gravity ought to be greater at the Equator than at the Poles; and the Earth would be an oblong Spheroid; which is contrary to Observations.

## REMARK.

I have said, that it was making a large Concession to the *Cartesians*, to suppose that the Globules of both the Circumferences have an equal Velocity. For if a Sphere full of Water be made to turn on its Centre, Experience teaches, that the Velocity is greater at the Equator than in the parallel Circles; since it is observed, that the Times of their periodical Revolutions are equal. Whence it follows, that I have, in my Demonstration, made the most favourable Supposition for the *Cartesians* that was possible.

## THEOREM IV.

In order to determine the Tendency of a Layer towards the Upper Part of the *Vortex*, regard must be had not only to that which results from its own Circulation, but also to that which it receives from the

the other lower Layers, unless it be the Layer next the Centre.

#### DEMONSTRATION.

While a Layer is in Circulation, it visibly makes a continual Effort towards dilating itself, by reason of the centrifugal Force, with which all its Parts endeavour to recede from the Centre of Circulation: But its actual Dilatation being impeded by the Layer next above it, this last will be naturally pressed by it. And thus it is that the first or lowest Layer, being put into Circulation, presses the Second; and the Second, assisted by the First, presses the Third; this, assisted by the Two preceding, presses the Fourth; and so on from Layer to Layer, through the whole Extent of the *Vortex*. Whence it follows, that in order to estimate the Quantity of Force with which a Layer tends towards the Surface of the *Vortex*, one must take the centrifugal Force proper to this Layer and that, which all the Matter of the Fluid contained under it acquires by Circulation. *Q. E. D.*

#### COROLLARY I.

Therefore the dilatative Effort of the Layers increases with the Layers in a greater Proportion than these Layers.

#### COROLLARY II.

Therefore it is impossible to explain in the *Vortex*, how Gravity decreases in an inverted *Ratio* of the Squares of the Distances; and consequently there will be nothing found in the *Vortex* to answer to

Attraction, whose Existence Sir *Isaac Newton* has so demonstratively established.

### COROLLARY III.

Thus we have re-established in its full Light the Difficulty, which Monsieur *de Fontenelle* proposed to Monsieur *Villemot* in the Memoirs of the Academy for the Year 1705 \*. This learned Academician pretends, that as in the *Vortex* the lower Points ought to move faster than the upper, in order to preserve *Kepler's* Astronomical Law; they ought also to have a greater centrifugal Force, and consequently compel them to descend, particularly in proportion to their Fluidity. The Objection made a great Noise, and the only Method found of getting rid of it, was by saying, that although each lower Point had more centrifugal Force than each upper; yet as the *Vortex* was in *Equilibrium*, and the Sums of the Force of each of the Two Layers were equal, there was no Reason why the lower *Stratum* should get the better of the upper; because this was as prevalent by the Number of its Points, as that was by the Force of each of its own.

But it is manifest, after what has been demonstrated above, that the second Layer, being assisted by the first, must have a greater Force than the third, and consequently compel it to descend, pursuant to the Principle then granted to Monsieur *Fontenelle*.

But if it be asked, How could the upper Layer descend, seeing Matter is impenetrable?

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\* He afterwards published a Book, intituled, *Nouveau Systeme, ou nouvelle Explication du Mouvement des Planetes, par M. Philippe Villemot, Pretre, Docteur en Theologie, &c.* Lyon, 1707. in 12<sup>o</sup>.

I shall ask in my turn, How, in an intire *Plenum*, do heavy Bodies fall to the Centre? And I reason on the Principle granted to Monsieur *Fontenelle*.

But yet, because what is allowed by one *Cartesian* is not always allowed by all; let us suppose, that the upper Layer cannot descend; this, at least, will follow from my Demonstration, that, according to the Principles of all these Gentlemen, an upper Layer being pressed by all the under ones, it must hasten its Circulation, as long as it is slower than that of these under Layers; by reason that the Excess of their Velocities will act upon it, as if it had been at Rest.

#### COROLLARY IV.

Therefore the Layers of a *Vortex* will move all of a Piece, as do those of a solid Sphere; and *Kepler's* Law cannot possibly be preserved. We shall now give other Proofs upon other Principles.

#### THEOREM V.

The Motion of the Points of the Equator is absolutely independent of the Motion of the parallel Circles; and consequently, in order to determine the *Equilibrium* of the Points of the Equator, we must attend to nothing but its Motion.

#### DEMONSTRATION.

The Plane of the Equator is parallel to the Planes of the other parallel Circles, that turn round the same Axe with it: Its centrifugal Force is perpendicular to the Tangent to the Sphere, which answers to it: It has not then any lateral Tendency towards these  
parallel

parallel Circles, and by a necessary Consequence its Motion is absolutely independent of theirs.

And indeed, if it be supposed, that the Motion of the other parallel Circles stops, there is still some Motion conceived in the Equator, just as in the Case of the cylindrical *Vortex*: It is likewise conceivable, that the Velocity may be greater at the Equator than in the parallel Circles, as the Experiment already cited shews us: And if no Regard be had to the lateral Frictions, as the *Cartesians* would have it, who suppose them none or insensible, and as indeed they are obliged to say, that the *Vortex*, by the lateral Friction of the Equator, may not become cylindrical; this Equator will always continue to circulate uniformly, without communicating any of its Velocity to the Points that laterally surround it. Therefore, &c. *Q. E. D.*

#### C O R O L L A R Y I.

Therefore for the *Equilibrium* of the Points of the Equator, it is necessary, at least, that an upper Circumference should have as much Tendency towards the Superficies of the *Vortex*, as another under concentric Circumference; because, if it had less, there would be no *Equilibrium*, even in the Principles of the *Cartesians*; and the under Circumference, pressing the upper, would either make it descend, or communicate to it a Force equal to its own. Wherefore, calling *F* the proper centrifugal Force of a Point of the upper Circumference, and *f* that of a Point of the under one; if *S, s* mark the different Sums of the Points contained in these Two Circumferences, we shall have  $FS = fs$ .



COROLLARY II.

Therefore the centrifugal Force does not diminish in the Plane of the Equator in the inverted *Ratio* of the Squares of the Distances from the Centre; for since  $FS = fs$ ;  $F.f :: s.S$ . But the Points being supposed equal on both Sides, their Sums are as the Circumferences, and one has  $s.S :: d.D$ , which gives  $F.f :: d.D$ . instead of  $:: d.d.DD$ .

COROLLARY III.

Therefore *Kepler's* Rules cannot be observed in the *Vortex*, or at least in the Plane of its Equator; for since  $F.f :: d.D$ ; by putting in the Place of  $F, f$ , their Values, we shall have  $\frac{VV}{D} \cdot \frac{uu}{d} :: d.D$ , and therefore  $V = u$  and  $D^2.d^2 :: TT.tt$ . whereas we ought to have  $V.u :: \sqrt[2]{d} \cdot \sqrt[2]{D}$  and  $D^3.d^3 :: TT.tt$ .

REMARK.

There is here a *Finesse* of the *Cartesians* to be observed. These Gentlemen consider only the *Equilibrium* of the spherical Layers of the *Vortex*, and from the Equality of their central Forces they deduce *Kepler's* Laws, as well as they can.

But it is manifest, that whatever becomes of the Equality of Force in different spherical Superficies of the *Vortex*, there must be an *Equilibrium* in the Plane of the Equator; because it is in this Plane that the Planets move; and if there had not actually been an *Equilibrium* between its Points, they would soon place themselves there, by reason that Fluids always

always tend to the Side where they are less pressed; and it is by an actual *Equilibrium* alone that they are kept in their Places; which intirely overturns the Theory of these Gentlemen.

Let us however grant to the *Cartesians*, that the Sums of the Forces of the Two spherical Surfaces are equal; I cannot see, that they can thence infer, as they do, that the central Force diminishes in a reciprocal *Ratio* of the Square of the Distance from the Centre. Let us examine their Argument:

$F\mathcal{S} = fs$ , say they; therefore  $F.f :: s.\mathcal{S}$ ; but  $s, \mathcal{S}$  mark the Sums of the Points contained in the Two Surfaces; therefore they are as these Surfaces, which, being as the Squares of their Distances, give,  $F.f :: dd.DD$ .

But it must be remarked, that the Surfaces of the *Vortex* are not Mathematical, they are Surfaces which have some Thickness: They cannot then be proportional to the Squares of their Distances from the Centre, except in the Case when their Thickness is equal. Now, according to the *Cartesians*, the Points or Globules, which compose the *Vortex*, increase in Bulk according as they recede from the Centre; and, besides, they are homogeneous, or of an equal specific Density, at least in their common System. And consequently it is certain, that the different natural or real *Strata* of the *Vortex* are not of an equal Thickness, and that the Matter contained therein is not proportionate to the Squares of the *Radii* of these Surfaces, but only to the Squares of these *Radii* multiplied by the Thickness of the *Strata*. Therefore, *&c. Q. E. D.*

## COROLLARY IV.

Therefore, even allowing the *Cartesians*, what one has a Right (COROL. I. THEOR. IV.) to refuse them, they will never be able to explain *Kepler's* Rules in the *Vortex*; for it is only by the Proportion, which I have just now annulled, that they pretend to do it. See *M. de Moliere's* *Leçons de Physique*.

And if it be objected, that I have not, in the preceding Corollaries, had any regard to the Thickness of the Circumferences; I answer, that it was by way of pure Concession that I have not done it; and if any Person will be at the Pains of doing it, he will easily find, that *Kepler's* Rules will only be the more disturbed thereby.

## CONCLUSION.

Therefore the *Vortex* is every way impossible, and insufficient in Natural Philosophy. Its mechanical Generation is impossible (PART I.); it has only an axifugal Force, and not a centrifugal and centripetal Force, as it should have (THEOR. I. and II.); and even if it had, it cannot (THEOR. III.) defend itself equally on all Sides. It is not sufficient for explaining Gravity, and its Properties; it destroys *Kepler's* Astronomical Laws (COROL. III. THEOR. IV. and V.). What more can be desired, in order to conclude with *Sir Isaac Newton*? “Itaque hypothesis Vorticum  
“ (est impossibile &) cum phænomenis astronomicis  
“ omnino pugnat, & non tam ad explicandos quam  
“ ad perturbandos motus cœlestes conducit.” *Q.E.D.*