The Leibniz Revolution in America, 1727-1752

by Philip Valenti

What Lyndon LaRouche terms "the pagan worship of Isaac Newton," was established as the official cult doctrine of the budding British Empire by no later than 1727. The death of the decrepit 85-year-old Newton that year was followed by a ritual deification, with the republication of his holy writ in the third edition of the *Principia Mathematica,* complete with an absurdly flattering portrait of the author on the frontispiece.

In fact, the Newtonian dogma imposed then, contained all the axioms essential to the creation of an evil Empire at any time and place, most emphatically today. The Newtonian world-view is best calculated to produce masses of self-shackled, culturally pessimistic mental slaves, the properly submissive human cattle herded and culled by a ruling elite of property and wealth.

This is why the successful American revolution against the British Empire needs must have been preceded by the passionate rejection of Newtonianism by the intellectual leaders of the North American colonies, especially among the youth, as these leaders embraced the cause of the greatest political and philosophical adversary of British liberalism, the German universal genius Gottfried Wilhelm Leibniz (1646-1716).[1] More than this, it was the Americans' bold challenge to Newtonian orthodoxy, which strengthened the resistance to the British-imposed intellectual dictatorship over continental Europe at a crucial point, inspiring the work of Abraham Gotthelf Kästner (1719-1800) and his collaborators and students, and leading to the revolutionary breakthroughs of Carl Friedrich Gauss (1777-1855).

As new historical researches confirm, it was the debate and dialogue over Leibniz's ideas among the circles of Kästner, with the leading anti-Newtonian American intellectuals of the day—James Logan (1674-1751) and Benjamin Franklin (1706-1790) of Philadelphia, and Cadwallader Colden (1688-1776) of New York—which set America on its course of independence, and averted a threatened global Newtonian Dark Age.

The Newtonian Schema

The precepts of the Newtonian slave dogma can be summarized as follows, in terms that should be familiar to all victims of modern university education:

1. The phenomena of Nature must be explained mechani-

1. See also Philip Valenti, "The Anti-Newtonian Roots of the American Revolution," *EIR,* Dec. 1, 1995.

This portrait of Isaac Newton by John Vanderbanks (1725) formed the frontispiece of the third edition to Newton's Principia. *The American scientist James Logan remarked that the picture would "be considered rather as an object of Ridicule than Respect, & much sooner raise Pity than Esteem."*

cally, as the interaction of self-evident bodies; all philosophical or "metaphysical" hypotheses are banished from science.

2. All matter is passive, inert, "dead," and composed of irreducible hard balls, otherwise termed "fundamental particles."

3. The motion of bodies, and of their component fundamental particles, is possible because between them is a vacuum, or space devoid of matter, like the empty, flat, linear space of Euclid's geometry.

4. All bodies interact through collisions, like billiard balls, or through "forces," such as "gravity," defined as an innate force of attraction which somehow acts at a distance through empty space.

"But hitherto I have not been able to discover the cause of those properties of gravity from phenomena, and I frame no hypotheses [*hypotheses non fingo*]," ordained Sir Isaac in the *Principia*'s infamous General Scholium. ". . .[F]or whatever is not deduced from the phenomena is to be called an hypothesis; and hypotheses, whether metaphysical or physical, whether of occult qualities or mechanical, have no place in experimental philosophy. In this philosophy particular propositions are inferred from the phenomena, and afterwards rendered general by induction. Thus it was that the impenetrability, the mobility, and the impulsive force of bodies, and the laws of motion and of gravitation, were discovered. And to us it is enough that gravity does really exist, and act according to the laws which we have explained, and abundantly serves to account for all the motions of the celestial bodies, and our sea."[2]

5. There is no ultimate purpose, intention or direction in the Universe, and any such philosophical or moral concepts have no place in science. Since everything occurs mechanically, like clockwork, the Universe can only "wind down" due to friction among the bodies, becoming increasingly disordered and chaotic.

Here, then, are the axioms of the culturally pessimistic mental slave, who must conclude that there is likewise no ultimate purpose or meaning to his or her mortal life, since the world is destined to die an entropic death, no matter what good is done by the individual in society. This slave must see human beings as just like the Newtonian self-evident "hard balls," each pursuing his own individual special interest in the here-and-now, seeking pleasure and avoiding pain, in conflict with all others.

Here also is the ideology of Empire, since, in the "Newtonian" schema, some outside force is required to maintain order among the conflicting interests of society, either an absolute monarch or dictator, as in the system of Thomas Hobbes, or an oligarchy of rich men of property, as advocated by that arch enemy of America, John Locke.

Opposition to Newton Arises in America

By the 1727 death and deification of Newton, agents of the official imperial dogma, such as Voltaire, Pierre de Maupertuis, Leonhard Euler, Jean d'Alembert, Joseph-Louis LaGrange, Count Francesco Algarotti, Antonio Conti, et. al., had been deployed to the crucial intellectual centers of continental Europe, while the English-speaking world was supposed to be securely in the Newtonian grip.

Yet, at that very moment, the intellectual and political leader of Pennsylvania, and former secretary to William Penn, James Logan, was expressing his disgust and indignation against the Newton cult, heaping particular scorn on the ridiculous picture of Newton in the *Principia*'s third edition.

"But there is not less Humour shewn in his Picture in the front," Logan wrote to his friend Gov. William Burnet of New York, "much more like W. Leybourn in his own hair at the age of 40 or 50 than Sir Isaac Newton at 83. And by all those who have seen him of late, as I did, bending so much under the Load of years that, with some difficulty, he mounted the stairs of the Society's Room, that Youthful Representation will, I fear, be considered rather as an object of Ridicule than Respect, & much sooner raise Pity than Esteem."[3]

After Newton's death, Logan wrote irreverently to Burnet, "I hope also G. Strahan has by this time furnish'd thee

2. Isaac Newton, *Mathematical Principles of Natural Philosophy, General Scholium* (Chicago: Encyclopedia Britannica, Inc., 1952).

3. Edwin Wolf II, ed., *Catalogue of the Library of James Logan* (Philadelphia: The Library Company of Philadelphia, 1974), p. 349.

with the new Edit. of Newton, for whose age and strength, Death has not, it seems, consulted his new picture."[4]

At the time Logan was thus mocking Newtonian pretensions, he was in the process of accumulating the greatest Classical library in North America, a collection of more than 2,500 volumes frequented by the young Benjamin Franklin and his friends of the newly formed Philadelphia Junto. Logan, born in Ulster, the son of a Scots Quaker schoolmaster, had arrived in Philadelphia in 1699 as Penn's secretary and political lieutenant, having already taught himself Latin, Greek, Hebrew, and several modern European languages. He corresponded with the foremost scientists of the day, and established himself as a scholar and independent thinker in the physical sciences, astronomy, and mathematics.

But most significant for the future course of history, Logan took the side of Leibniz against Newton in the preeminent philosophical/political dispute of the age, which today's history books falsely characterize as merely a misguided controversy over priority in the invention of the calculus.

Leibniz's Battle Against the Oligarchy

In fact, G.W. Leibniz nearly accomplished one of the greatest political coups in all history, which could have crushed the British imperial serpent in the egg. Through meticulous historical researches, Leibniz had established the claim of his student and patroness, the Electress Sophie of Hannover, to the English throne. With the help of Leibniz's political allies in England, led by Robert Harley, Jonathan Swift, Daniel DeFoe, and Anthony Ashley Cooper (the Third Earl of Shaftesbury), Sophie's claim was made law in the 1701 Act of Succession. Because Queen Anne was childless, Sophie was set to become Queen of England at Anne's death, and Leibniz himself was to be the real power behind the throne.[5]

Throughout this period, Leibniz served as the rallying point for anti-oligarchical forces throughout the world, but particularly among the anti-imperial Commonwealthsmen of England. Leibniz recognized the ominous political implications of the ideas of Hobbes, Locke, and Newton, and challenged each of them personally to engage in a dialogue. The 24-year-old Leibniz received no response to his 1670 letter to Hobbes. Similarly, Locke ignored repeated attempts by Leibniz and his English friends to provoke an exchange of views. Leibniz considered Locke's ideas so dangerous to humanity, that he wrote a chapter-by-chapter refutation of Locke's *Essay on Human Understanding.* Leibniz's *New Essays on Human Understanding,* written between 1701 and 1704, were circulated privately, but never published until Kästner and his circles based at Göttingen University, arranged its publication in 1765, a year before Franklin's visit there.[6]

As the demise of Queen Anne became more imminent, and Leibniz's English allies more influential in her government, the vile, lying attacks on Leibniz as a foreign plagiarist of the "English hero of science" were launched by the British Royal Society, orchestrated by Newton himself. By that time, Newton had cast aside all pretenses of scientific work, and had dedicated the remainder of his life to money-making and political intrigue as the well-paid Master of the Mint, recruited personally for the job by the ringleader of the imperialist faction, Charles Montague.

In 1714, as the jingoistic hysteria against Leibniz reached its height with the official condemnation of him by the Royal Society, Sophie died less than two months before Anne, and the succession passed to Sophie's misanthropic son George Lewis, who had been long bought-and-paid-for by Montague. The new King George I forbade Leibniz from traveling to England.

The Leibniz-Clarke Correspondence

Ironically, in the aftermath of this seeming defeat, Leibniz was finally able to force the Newtonians into a debate momentous for the future intellectual development of America. Sophie's granddaughter, Princess Caroline, wife of the future King George II, persisted in her advocacy of Leibniz's ideas, so Newton and his mouthpiece Samuel Clarke, assisted by the Venetian operative Abbot Antonio Conti, had no choice but to attempt a reply to Leibniz's devastating challenge of November 1715:

"1. Natural religion itself seems to be declining [in England] very much. Many will have human souls to be material: others make God himself a corporeal Being.

"2. Mr. Locke, and his followers, are uncertain at least, whether the soul is not material, and naturally perishable.

"3. Sir Isaac Newton says, that space is an organ, which God makes use of to perceive things by. But if God stands in need of any organ to perceive things by, it will follow, that they do not depend altogether upon him, nor were produced by him.

"4. Sir Isaac Newton, and his followers, have also a very odd opinion concerning the work of God. According to their doctrine, God Almighty needs to wind up his watch from time to time: otherwise it would cease to move. He had not, it seems, sufficient foresight to make it a perpetual motion. Nay, the machine of God's making is so imperfect, according to these gentlemen, that he is obliged to clean it now and then

4. *Ibid.,* p. 350.

5. See H. Graham Lowry, *How the Nation Was Won: America's Untold Story* (Washington, D.C.: Executive Intelligence Review, 1988).

6. This first publication of Leibniz's *New Essays* is listed in the catalogue of Franklin's Library Company of Philadelphia, under the title, *Oeuvres philosophique latines & françoises de feu Mr. de Leibnitz,/Tirées de ses manuscrits qui se conservent dans la bibliothèque royale à Hanovre, et publiées par Mr. Rud. Eric Raspe.; avec une préface de Mr. Kästner.* For a listing of Leibniz's works in Franklin's collection, see the Online Catalog of the Library Company (WolfPAC) at www.librarycompany.org/.

See also David Shavin, "Leibniz to Franklin on 'Happiness,' " *Fidelio,* Spring 2003.

Gottfried Leibniz, one of the greatest philosophers and statesmen of all history, forced the Newtonians into a momentous debate on the nature of man, God, and the universe. Newton put forward his mouthpiece Samuel Clarke for the combat, rather than daring to take on Leibniz personally.

by an extraordinary concourse, and even to mend it, as a clockmaker mends his work; who must consequently be so much the more unskillful a workman, as he is oftener obliged to mend his work and set it to right. According to my opinion, the same force and vigor remains always in the world, and only passes from one part of matter to another, agreeably to the laws of nature, and the beautiful pre-established order. And I hold, that when God works miracles, he does not do it in order to supply the wants of nature, but those of grace. Whoever thinks otherwise, must needs have a very mean notion of the wisdom and power of God."[7]

The subsequent dialogue, disastrous for the Newtonians, continued until Leibniz's death on Nov. 14, 1716. Within months, under continued pressure from Caroline, the exchange of five letters on both sides was published in London, with Leibniz's original French facing Clarke's English translation. A copy of the original 1717 edition, under the title, *A Collection of Papers which passed between the late learned Mr. Leibnitz and Dr. Clarke,* was studied by Logan, and passed on to Franklin's Library Company of Philadelphia.

With great patience, pungency, and wit, Leibniz demolished the precepts of the Newton cult, which he, LaRouche-like, termed "chimerical occult qualities" and "the idols of the tribe." In this, to the chagrin of the Newtonians, he made powerful use of metaphysical concepts, such as the "principle of a sufficient reason, *viz:* that nothing happens without a reason why it should be so, rather than otherwise," and the application of "final causes" of intention, direction, and purpose to explain natural phenomena, beyond merely mechanical "efficient causes."

"All those who maintain a vacuum, are more influenced by imagination than by reason," Leibniz wrote in his fourth paper. "When I was a young man, I also gave in to the notion of a vacuum and atoms; but reason brought me to the right way from what had been pleasing to the imagination. The atomists carry their inquiry no farther than those two things: they (as it were) nail down their thoughts to them: they fancy, they have found out the first elements of things, a *non plus ultra.* We would have nature go no farther; and to be finite, as our minds are: but this is to overlook the greatness and majesty of the author of things. The least corpuscle is actually subdivided *in infinitum,* and contains a world of other creatures, which would be lacking in the universe, if that corpuscle were an atom, that is, a body of one entire piece without subdivision. In like matter, to admit a vacuum in nature, is ascribing to God a very imperfect work: it is violating the great principle of the necessity of a sufficient reason, which many have talked of, without understanding its true meaning. . . . [B]ecause matter is more perfect than a vacuum, reason requires that a geometric proportion should be observed, and that there should be as much or more matter than vacuum, as the former deserves to have the preference before the latter. But then there must be no vacuum at all; for the perfection of matter is to that of a vacuum, as something to nothing. And the case is the same with atoms: What reason can any one assign for confining nature in the progression of subdivision? These are fictions merely arbitrary, and unworthy of true philosophy. The reasons alleged for a vacuum are mere sophisms."[8]

When Clarke continued his sophistical arguments and evasions in his fourth reply, Leibniz questioned "whether the author be willing to hearken to reason, and to show that he is a lover of truth; or whether he will only cavil, without clearing anything. I shall soon find out what I am to think of it, and I shall take my measures accordingly."

Leibniz pursued the polemic against a "vacuum" in his fifth paper:

"The author objects against me the vacuum discovered by Mr. Guericke of Magdeburg, which is made by pumping the air out of a receiver; and he pretends that there is truly a perfect vacuum, or a space without matter (at least in part), in that

7. Philip P. Wiener, ed., *Leibniz Selections* (New York: Charles Scribner's Sons, 1951), pp. 216-217.

8. *Ibid.,* pp. 235-237.

receiver. The Aristotelians and Cartesians, who do not admit a true vacuum, have said in answer to that experiment of Mr. Guericke, as well as to that of Torricellius of Florence (who emptied the air out of a glass-tube by means of quicksilver), that there is no vacuum at all in the tube or in the receiver: since glass has small pores, which the beams of light, the effluvia of the lodestone, and other very thin fluids may go through. I am of their opinion: and I think the receiver may be compared to a box full of holes in the water, having fish or other gross bodies shut up in it; which being taken out, their place would nevertheless be filled up with water. There is only this difference; that though water be fluid and more yielding than those gross bodies, yet it is as heavy and massive, if not more, than they: whereas the matter which gets into the receiver in the room of air, is much more subtle."[9]

Leibniz attacked the Newtonian "action-at-a-distance" dogma, developing the concept of "matter void of heaviness [and which does not sensibly resist]; such as is probably that of the rays of light, and other sensible fluids; and especially that which is itself the cause of the gravity of gross bodies, by receding from the center towards which it drives these bodies. For, it is a strange imagination to make all matter gravitate, and that towards all other matter, as if each body did equally attract every other body according to their masses and distances; and this by an attraction properly so called, which is not derived from an occult impulse of bodies: whereas the gravity of sensible bodies towards the center of the earth, ought to be produced by the motion of some fluid. And the case must be the same with other gravities, such as that of the planets towards the sun or towards each other. (A body is never moved naturally except by another body which impels it by touching it; and afterwards it advances until it is stopped by another body which touches it. Every other operation on bodies is either miraculous or imaginary.)"[10]

The Newtonian idol of "attraction" as an innate quality of matter, was smashed to pieces by Leibniz's unanswerable irony:

"I objected that an attraction properly so called, or in the scholastic sense, would be an operation at a distance, without any means intervening. The author answers here that an attraction without any means intervening, would be indeed a contradiction. Very well! But then what does he mean, when he will have the sun to attract the globe of the earth through an empty space? Is it God himself that performs it? But this would be a miracle, if ever there was any. This would surely exceed the powers of creatures.

"Or, are there perhaps some immaterial substances, or some spiritual rays, or some accident without a substance, or some kind of *species intentionalis,* or some other I know not what, the means by which he claims this to be performed? Of which sort of things the author seems to have still a good stock in his head, without explaining himself sufficiently.

"That means of communication (says he) is invisible, intangible, not mechanical. He might as well have added, inexplicable, unintelligible, precarious, groundless, and unexampled.

"But it is regular (says the author), it is constant, and consequently natural. I answer; it cannot be regular, without being reasonable; nor natural, unless it can be explained by the nature of creatures.

"If the means, which causes an attraction properly so called, be constant, and at the same time inexplicable by the powers of creatures, and yet be true, it must be a perpetual miracle; and if it is not miraculous, it is false. It is a chimerical thing, a scholastic occult quality."[11]

Logan's Defense of Leibniz

James Logan qualified himself as an expert judge of the Leibniz-Newton issue, having immersed himself in the ideas of Leibniz's European networks. Logan was proud to own and to have studied almost every edition of the *Acta Eruditorum* of Leipzig, the Latin-language periodic journal, which published the works of Leibniz and his co-thinkers on the calculus and other mathematical and philosophical issues, in opposition to Newtonianism, Cartesianism, and other dogmas. "I have all the Acta Eruditorum from 1688 to 1727," Logan told a correspondent in 1749, "except for three intermediate years between 1700 & 1710 & some Supplementa."[12] Inserted in one edition was a four-page English explanation by Logan of "The first Accot of fluxions delivered by Leibnitz In the Acta Eruditorum of Leipsic Octob 1684 pa 467."

Logan was upset by the politically motivated editing of the second edition of Newton's *Principia* in 1715, where, as Logan wrote at the time to New York Gov. Robert Hunter, the name of the "violent Whig," former Royal Astronomer John Flamsteed, was left out by the Royal Society, "ye Better (I suppose) to express their abhorrence of his Principles. . . . This will be owned I Suppose to be Carrying ye matter very far, And indeed upon ye whole they seem on all sides to be ripening for their own destruction."[13]

Logan recognized the disastrous political circumstances of the time, as George I had authorized massive repression against Leibniz's English allies. "Our unhappy Divisions in ye last Years of ye Queen appear'd terrible," Logan wrote Hunter, "And now after so favourable a Conjuncture thrown in by Providence that one might have expected would set all to rights, they are rendered more dreadful than ever. The unhappiness of having a Nation generally distempered seems to me to be inexpressible."[14]

With the 1726 publication of the infamous third edition,

9. *Ibid.,* pp. 247-248.

10. 10. *Ibid.*

11. *Ibid.*

12. Wolf, *op. cit.,* p. 4.

13. Wolf, *op. cit.*

14. Wolf, *op. cit.,* p. 349.

Logan's righteous indignation was aroused, not only against the pagan worship of Newton, but in passionate defense of Leibniz. In his letters to Governor Burnet, Logan expressed his own firm convictions in favor of Leibniz as a universal genius and independent inventor of the calculus, and denounced the tyrannical tactics of the Newtonians against him:

"So now in this third they have done what I Doubt impartial men of sober thought and solid judgment, who alone ought in such cases to be considered, will look upon as a yet greater Instance of the same Infirmity, in dropping the scholium to the 2 Lemma between the 7 or 8th Propp. of the 2d Book, wherein Leibnitz was named & his Discovery of the differential Method was justly taken notice of, and substituted another mentioning the Author's Letter to J. Collins in 1672, which I doubt will scarce give so honorable an Idea of that Great man.

"Tis certain the world was obliged only to Leibnitz for the Publication of that method, who was so fair as to communicate it in a great measure to Oldenburg in 1677, when Sir Isaac was so careful of concealing his, that he involved it in his Letter of 1676 in strange knots of Letters, that all the art and skill of the universe could never Decipher, as giving only the number of each Letter that entered his short proposition. And yet foreigners have generally been so Just as to pay all possible deference to Sir Isaac as an Inventor, tho' till his Publication of the Principia in 1687, they never had anything of it from him.

"I have often indeed wished that Sir Isaac himself had never entered into the Dispute, but would, if it must be disputed, have left it to others, for then the world would have been inclined to do him more Justice, than now perhaps they will, when he is considered as a party, which he has so warmly made himself."[15]

In his next letter to Burnet, Logan not only questioned Newton's mental competence, but argued that England would have been better off if both Newton and Queen Anne had died by 1710, an event that he knew would have made Sophie Queen of England, and Leibniz, in effect, her Prime Minister:

"He [Newton] is, however great, but a man, & when I last saw him in 1724 walking up Crane Court & ye stairs leading to the Society's Room, where I also had the opportunity of viewing him for about two hours, he bent under his Load of years exceeding unlike what they have Represented him two years after as in body. 'Tis but reasonable to expect a Declension elsewhere, so that for his own honour, as well as ye Nations, to which he has been a very great one, had he & Queen Anne both been gathered to their Ancestors by the year 1710, before that fierce, unnatural Dispute broke out between him & Leibnitz, which I always believed was blown up by the Forces of the Society in opposition to the house that had so long employ'd Leibnitz, they might have set in their Horizon, as I formerly thought, with a somewhat greater Glory.

"Tis only from this way of thinking I dropt what I did of him, in which, if I have not altogether thy concurrence, my tenderness for his Reputation, I hope, will be easily excused. I verily believe Leibnitz had the first hints from Newton's Letter & others concerning his Inventions, & that from thence, that Great Genius, which we find in no man else, did build his great superstructures, but from all I can find in the Commercium, I no where perceive that Sir Isaac intended any mortal should discover his method of working, or what we call his algorithm of this fluxions, & his having afterwards given us nothing new beyond what Leibnitz had published of that kind in the Acta Eruditorum of 1682, is not altogether so much to his advantage as might be wished in his favour."[16]

Demolishing Thomas Hobbes

With Franklin and other promising youth looking to him for intellectual guidance, Logan determined to demolish the very ideological foundations of British liberalism, by writing his own American refutation of Thomas Hobbes, "taking this for my foundation against Hobbes that Man was primarily in his Nature formed for Society."[17] Logan started his book, *The Duties of Man as they may be deduced from Nature,* in 1735, and circulated handwritten copies among his friends in Philadelphia and correspondents in England. Logan's 400-page manuscript, including several drafts of each of its six chapters, was considered lost for more than 200 years, until a copy was discovered in the early 1970s under some cartons stored in the Historical Society of Pennsylvania, where it still lies, unpublished.

Logan established his theme against Hobbes in his first pages, asserting "that Man was formed for Society and Benevolence; and therefore that He, who in the last age got himself a Name by denying this, and asserting the State of Nature to be a State of War, was as defective in his Philosophy; tho' then believed by numbers to have searched into human Nature deeper, and more successfully, than any who had gone before him; as he was proved by demonstration to be in the Mathematics; to which also he made the highest pretenses. And the proofs for what is here advanced are these."

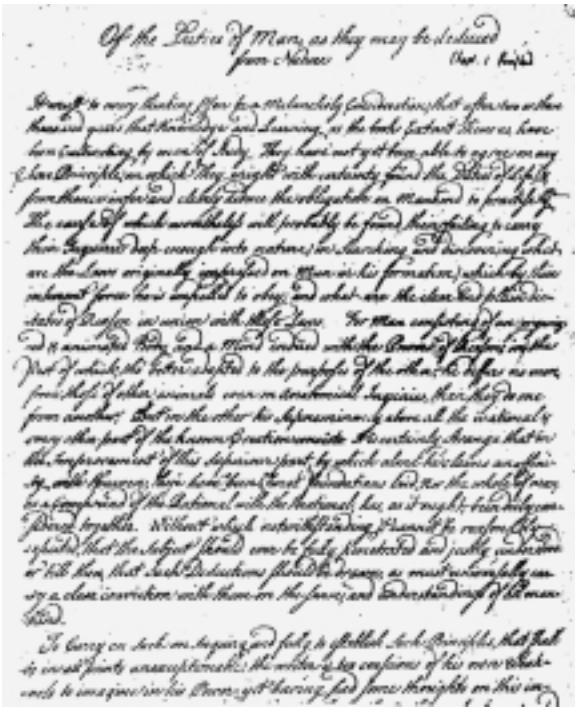
Logan devoted his first four chapters, and the beginning of the fifth, to demolishing Hobbes' "detestable Notion" and "pernicious Opinion," and exposing "the destructive Consequences of a Doctrine subversive of all the sacred and endearing ties that should engage men in Social Life, and that minister all the comforts of it." Logan's powerful attack on Hobbes evidently came as a salutary shock to some young Americans perhaps too influenced by British ideology. "It seems to me that the Author is a little too severe upon Hobbes," Franklin wrote to Logan, after reading Chapter Five, *Of Moral Good or Virtue,* "whose Notion, I imagine, is somewhat nearer the Truth than that which makes the State of Nature a State of Love: But the Truth perhaps lies between both Extreams."[18]

15. Wolf, *op. cit.,* p. 149.

16. Wolf, *op. cit.*

17. Letter to Thomas Story, Nov. 15, 1737.

18. Benjamin Franklin to James Logan, 1737?, Edwin Wolfe II, ed.



James Logan (1674-1751), an associate of Benjamin Franklin and William Penn, and a fierce opponent of British philosophical liberalism. Shown here is the first page of Logan's manuscript "Of the Duties of Man, as they may be deduced from Nature," a refutation of Hobbes, Locke, and Newton. The manuscript was supposedly "lost" in England, and was rediscovered only in 1971.

To conclude the fifth chapter, Logan launched a well-prepared offensive against John Locke, attacking the "unhappy mistake in the subject of Morals" in his *Essay on Human Understanding*. Logan's manuscript contains three drafts of this section, under the head, "Answer to Locke, after the moral sense and ground of virtue is stated," along with a list of references to chapters of the *Essay.*

However, Logan's declaration of intellectual independence of British imperial ideology could not be complete without a blast at Newtonian orthodoxy. This was accomplished in a lengthy footnote in his Chapter Two, which attacked the doctrine of a "vacuum" in terms almost identical to Leibniz in his fifth letter to Clarke, but which also put forward a new, heretical hypothesis about electricity, one destined to seize the imagination of our Franklin:

"Electricity was formerly regarded but as a trifling appearance in Nature, and therefore in the last curious age was very little considered; for that quality was supposed to be excited, only by putting into motion the finer parts of the body it was found in, and yet the excellent R. Boyle has observed that these parts being put in motion, excited also the same quality in any other body, as Silver, Iron, Marble that was brought within the sphere of their action. But now more lately by F. Hawksbee's Experiments in producing Light, and particularly by the surprising phenomena arising from Electricity in those of Geo. Gray, we may see a field open'd for Speculations, that if duly pursued, may probably lead us into more just and extensive Notions of our bodies, and the world we live in, than have hitherto been generally thought of.

"And if there be no heresy in mentioning it in the present age, why may we not venture to question the reasonableness of asserting a vacuum as indispensably necessary to the continuance of motion? The argument indeed may hold in relation to all such bodies, the matter of light excepted, as our senses are formed to take cognizance of; but shall we from thence presume to judge of all the kinds of Subtile matter that space may be filled with? Can we be sure that there is no electric or elastic medium that instead of obstructing or retarding Motion, may be the very means of continuing it?

"Can we say an exhausted Receiver is a vacuum because the air is drawn out of it, while at the same we see it filled with light, the matter of which in the true nature of things, and on a just estimate of them, tho' not according to our apprehensions, may possibly be a more essential Substance than the earth and stones we tread on. But if a Vacuum be not absolutely necessary, as that allotted by some to the etherial spaces cannot, then undoubtedly to have all Space in the Universe possessed by some kind of matter is much more consistent with the Dignity, Beauty and order of the whole, than to imagine those vast voids which carry even a kind of horror in the thought."

Franklin and Colden Join the Fight

In his autobiography, Franklin says that he began his electricity experiments in earnest, after attending a demonstration of electrical phenomena in Boston in 1746. Soon after, Logan's friend, the Quaker Fellow of the Royal Society, Peter Collinson, sent Franklin's Library Company a gift of a glass tube from London to encourage his electrical studies. In the meantime, Franklin had struck up a friendship with a fellow independent thinker, 18 years his senior, and member of the New York Governor's Council, Cadwallader Colden.

Over the next several years, Franklin and Colden mobilized a philosophical/scientific offensive against Newtonian orthodoxy, inspired by Logan's defiance of British imperial ideology, which saved science in Europe, and set America on a course to independence. "Tis well we are not, as poor Galileo was, subject to the Inquisition for philosophical heresy," Franklin wrote to Colden in 1752, reflecting on the battles of those years. "My whispers against the orthodox doctrine in private letters, would be dangerous; your writing and printing would be highly criminal. As it is, you must expect some Censure, but one heretic will surely excuse another."[19]

Colden's heretical writing and printing, challenging every axiom of the Newton cult, were his treatises, *An Explication of the First Causes of Action in Matter, and of the Cause of Gravitation,* published in New York in 1745, and *The Principles of Action in Matter, the Gravitation of Bodies, and the Motion of the Planets, explained from those Principles,* published in London in 1751 as an elaboration of the earlier work. These works were seen in Europe, by both sides of the Leibniz/Newton divide, as an application of Leibniz's dynamics and theory of monads to the solution of Newtonian paradoxes. Although these writings do not name Leibniz explicitly, Colden freely acknowledged his debt to Leibniz in private letters, some just recently published for the first time.

Like Logan, Cadwallader Colden was born in Ireland of Scots-Irish descent. He graduated from the University of Edinburgh, and pursued the study of medicine until economic hardship led him to emigrate to Philadelphia in 1710. He spent the momentous years of 1715-16 in England and Scotland, where he participated in some proceedings of the Royal Society, and returned to Philadelphia to practice medicine. He was soon recruited by Gov. Robert Hunter to relocate to New York, where he was appointed surveyor general, and launched a career of political leadership sponsored by the common friends of Logan and Jonathan Swift, including Hunter, his successor William Burnet, and astronomer James Alexander.

Colden's extensive dealings with the Iroquois Confederation made him a zealous advocate of just relations with the Indian tribes, which he developed in his 1727 *History of the Five Indian Nations of Canada.* He argued for protective tariffs in a treatise printed in 1726 by Peter Zenger. Although Colden, at age 87 in 1776, did not support independence, his grandson, Cadwallader D. Colden, went on to play a leading role in the early economic development of the United States as a friend and sponsor of Robert Fulton.

Ironically, Colden had foreseen future relations between America and Britain, in a 1749 letter to Franklin. "It is a common argument [that] the power and strength of a nation consists in its riches and money," Colden wrote. "No doubt money can do great things, but I think the power of a nation consists in the knowledge and virtue of its inhabitants, and in proof of this, history every where almost shews us that the richest nations abounding most in silver and gold, have been generally conquered by poor, but in some sense, virtuous nations."

The fundamental premise of Colden's treatises is a rejection of the Newtonian dogma of matter as passive, inert and "dead," and therefore subject to the inevitable entropic "winding down" into chaos and doom. The Universe is composed of principles of action, Colden argued, not hard, irreducible particles of dead matter.

"You think, as many others do, that the phenomena cannot be truly explained on any other than mechanical principles," Colden addressed a critic in a 1753 letter. "But I think the first principles of action cannot be mechanical mechanism, [cannot] consist only in the shape or figure, quantity and disposition of the parts of the machine, but neither shape, quantity nor disposition of themselves can produce any action. They can only regulate and determine the action to some particular end or purpose, but there must be some power or force to put it in action. You think what you call dead, inert matter has no action. In this opinion you have almost all the world with you and against me, and yet I am clearly persuaded that this universal opinion is a universal error."[20]

Whereas Newton argued the passivity of matter from the quality of inertia, or "resistance," Colden, following Leibniz's *Dynamics,* maintained that the seeming "resistance" of matter is a manifestation of a principle of activity or force inherent in things. Thus was posed a crucial issue for humanity—would the power or "live force" hidden from our senses in the microcosm of molecules, atoms, and beyond, be discovered and unleashed in a series of scientific and technological revolutions, sweeping away the backwardness and poverty of oligarchical society, or would future advances in steam power, electricity, the internal combustion engine, nuclear power, matter/anti-matter reactions, etc., be strangled in the cradle by the ideological Inquisition of a Newtonian Dark Age?

Leibniz Refutes Descartes

Leibniz created his new science of dynamics in the course of refuting the notion of matter popularized by Descartes and his followers in the last decades of the 17th Century. Determined to banish "metaphysics" from natural philosophy, Descartes asserted that "the nature of matter or of body in its universal aspect, does not consist in its being hard, or heavy, or coloured, or one that affects our senses in some other way, but solely in the fact that it is a substance extended in length, breadth, and depth."[21]

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19. Franklin to Colden, April 23, 1752, Albert Henry Smyth, ed., *The Writings of Benjamin Franklin* (New York: MacMillan Co., 1907).

20. Scott L. Pratt and John Ryder, eds., *The Philosophical Writings of Cadwallader Colden* (Amherst, N.Y.: Humanity Books, 2002), pp. 211-212.

21. *The Philosophical Works of Descartes,* Vol. I (Cambridge: Cambridge University Press, 1979), pp. 255-256.

Leibniz, in the *Acta Eruditorum,* in letters, and elsewhere, pointed out the paradox created by this definition, because of the phenomenon of "resistance," or what Kepler called "inertia":

"If the essence of a body consists in extension, this extension alone should suffice to account for all the properties of the body. But that is not the case. We observe in matter a quality which some have called *natural inertia,* through which the body resists motion in some manner, in such wise that some force must be applied to set it into motion (not even taking into account the weight), so that it is more difficult to budge a large body than a small one. For example, if the body A in motion meets the body B at rest, it is clear that if B were indifferent to motion or rest, it would let itself be pushed by A without resisting it and without diminishing the speed or changing the direction of A; and after the impact, A would continue its path and B would accompany it ahead. But it is not so in nature. The larger the body B, the more it will diminish the speed of A until A is forced to rebound from B if B is very much larger than A. Now, *if there were nothing more in bodies than extension* or position, that is to say, what Geometers know about it, combined with the sole notion of change, this extension would be entirely indifferent with respect to this change, and the results of the impact of the bodies would be explained solely by the Geometric position of the motions. The moving body would (on this hypothesis) carry along the body B which is at rest, without receiving any diminution of its velocity, and without any possible change arising from the equal or unequal magnitudes of the bodies; this is a consequence which is entirely *irreconcilable with experiments.* . . .

"All of this shows that there is in matter something else than the purely Geometrical, that is, than just extension and bare change. And in considering the matter closely, we perceive that we must add to them some *higher or metaphysical notion, namely that of substance, action, and force;* and these notions imply that anything which *is acted on* must act reciprocally, and *anything which acts must receive some reaction;* consequently, a body at rest should not be carried off by another body in motion without changing something of the direction and speed of the acting body."[22]

Leibniz went on to develop the concept of active or "living force" (*vis viva*) in his landmark *Specimen Dynamicum* of 1695, the founding document of the technological revolution to come. Here, he demonstrates his earthshaking theorem, that the *vis viva* acquired by a body in motion is proportional *not* to the product of the mass and velocity, or "momentum," as believed by the Cartesians and Newtonians alike, but rather to the product of the mass and the *square of the velocity.* This metaphysical discovery led Leibniz to encourage the researches of his friend, the French scientist Denis Papin, to discover means of harnessing the direct "force of fire" as applied to high pressure steam, or even gunpowder or alcohol, knowing that the power of such an engine would increase as the square of the velocity of the exploding fuel, although the mass of the particles were tiny. (For example, the Cartesians and Newtonians would argue that the force of a 1 ounce body moving at 1,000 mph, is equivalent to a 1,000 ounce (62.5 lb) body moving at 1 mile per hour, whereas the smaller body contains *one thousand times* the *vis viva* of the larger one! Consider also the application of this for so-called "subatomic particles" moving at the "speed of light," as in Einstein's $E = mc^2$.)

In his *Dynamics,* Leibniz was quite explicit concerning his objective of transcending the mechanical principles and basic machines passed down from the ancient Greeks and Egyptians:

"Thus there appears a new twofold distinction of forces; *viz.,* one—which I call inert or inactive force—refers primarily to the element of force while the motion itself does not yet exist in it but only the tendency to motion, as, for example, the stone in a sling which tries to fly off in the direction of the tangent, even if it is pulled back by the chain which holds it securely. On the other hand, the other force, which I call living or active force, is the usual one which appears in actual motion. An example of inert force is centrifugal force, or gravitational or centripetal force, or also the force which tries to restore a stretched elastic body to its original state. However, active or living force appears in impact—e.g., the force or impact of a heavy body that has been falling for a certain time, or that of a stretched bow which gradually resumes its earlier position—and such an active force arises from an infinite number of constantly continued influences of inactive forces.

"The ancients, so far as is known, had conceived only a science of inactive forces, which is commonly referred to as Mechanics, dealing with the lever, the windlass, the inclined plane—pertinent to the wedge and screw—though there is discussion of the equilibrium of fluids and of similar problems; only the effort or resistance of bodies and not the impetus they have acquired through their action, is discussed. Now even though the laws of inactive force are transferred in a certain way to active forces, it is nevertheless necessary to be very circumspect in this matter. Hitherto, the error has been made of mistaking the product of the mass and velocity for the whole absolute force because it was seen that the inactive force is proportional to these two factors. However, as already noted above, this depends on a quite separate circumstance, to wit, on the fact, for example, that at the very commencement of the motion of a falling heavy body, the path or space covered, so long as it is of infinitesimal or elementary magnitude, is proportional to the velocity. However, once the weight has progressed a finite distance and given rise to an active force, the velocity acquired in falling is no longer proportional to the distance covered . . . but to the element of velocity. . . .

"Next I came to work out accurately and exactly the same

22. From "Whether the Essence of a Body Consists in Extension," *Journal des Savans,* June 18, 1691, quoted in Wiener, *op. cit.* pp. 100-102.

calculation of forces by quite different methods: one truly *a priori,* by the simplest consideration of space, time, and action (which I explain elsewhere); the other *a posteriori,* namely, by calculating the force through the effect produced in using itself up. For here I refer not to any effect, but to one produced by a force which completely expends itself and may therefore be called violent; such is not the case with a heavy body moving on a perfectly horizontal plane and constantly preserving the same force; this is a harmless sort of effect, so to speak, which we can also calculate by our method but it is not the one we wish to consider now. Furthermore, I am choosing to consider that particular kind of violent effect which is homogeneous or capable of being divided into similar and equal parts such as we have in the ascent of a heavy body: for the ascent of such a body two or three feet is exactly double or triple the ascent of the same body one foot; and the ascent of a body twice as heavy to a height of one foot is twice the ascent of the single body to a height of one foot, and hence, the ascent of a double heavy body to a height of three feet is exactly six times the ascent of the single body to a height of one foot."[23]

Leibniz goes on to show that the force (or work) expended in raising a body to a certain height, is equal to the force acquired by that body in falling from that height. To continue his argument with a simplified example, calculate the rate of acceleration of a falling body near the Earth's surface to be about 32 feet per second per second. Therefore, if a 1 pound body A hits the ground after 1 second, its velocity on impact will be 32 feet per second, and it will have traversed 16 feet. Similarly, if a 1 pound body B hits the ground after 2 seconds, its velocity on impact will be 64 feet per second, and it will have traversed 64 feet. But the force required to raise B 64 feet, is four times the force required to raise A 16 feet, which shows that twice the velocity, results in four times the force, i.e., *vis viva* is proportional to the *square* of the velocity.

The Monadology

When this concept of *vis viva* is combined with his *Monadology,* Leibniz emerges as the philosopher of perpetual scientific and technological progress, and of unlimited advancement of the human condition only possible in a republic. For Leibniz, the monad is the "simple substance" which expresses the intent, end or purpose of the body with which it is associated:

"1. The monad of which we shall here speak is merely a simple substance, which enters into composites; simple, that is to say, without parts.

"2. And there must be simple substances, since there are composites; for the composite is only a collection or aggregation of simple substances.

"3. Now where there are no parts, neither extension, nor figure, nor divisibility is possible. And these monads are the true atoms of nature, and, in a word, the elements of all things."[24]

Since there can be no fundamental, irreducible hard particles, therefore matter is infinitely subdivided, not like slicing salami, but in the manner of "worlds within worlds," or "monads within monads" (as revealed by the newly invented microscope), which creates unlimited potential to harness the *vis viva* of the microcosm:

". . . each portion of matter is not only divisible *ad infinitum,* as the ancients recognized, but also each part is actually endlessly subdivided into parts, of which each has some motion of its own: otherwise it would be impossible for each portion of matter to express the whole universe.

"66. Whence we see that there is a world of creatures, of living beings, of animals, of entelechies, of souls, in the smallest particle of matter.

"67. Each portion of matter may be conceived of as a garden full of plants, and as a pond full of fishes. But each branch of the plant, each member of the animal, each drop of its humors is also such a garden or such a pond.

"68. And although the earth and air which lies between the plants of the garden, or the water between the fish of the pond, is neither plant nor fish, they yet contain more of them, but for the most part so tiny as to be imperceptible to us.

"69. Therefore there is nothing fallow, nothing sterile, nothing dead in the universe, no chaos, no confusion except in appearance; somewhat as a pond would appear from a distance, in which we might see the confused movement and swarming, so to speak, of the fishes in the pond, without discerning the fish themselves.

"70. We see thus that each living body has a ruling entelechy, which in the animal is the soul; but the members of this living body are full of other living beings, plants, animals, each of which has also its entelechy or governing soul."[25]

The implication of all this for the advancement of technology, and for the development of humanity and of the Universe, is beautifully summarized by Leibniz in his 1697 essay, *On the Ultimate Origin of Things:*

"And in addition to the general beauty and perfection of the works of God, we must recognize a certain perpetual and very free progress of the whole universe, such that it advances always to a still greater improvement. And as to the possible objection, that if it were so the world ought long ago to have become a paradise, the reply is ready: Even if many substances have already reached great perfection, nevertheless on account of the infinite divisibility of the continuum, there always remain in the depths of things slumbering parts which must yet be awakened and become greater and better, and, in a word, attain a better culture. And hence progress never comes to an end."[26]

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23. Wiener, *op. cit.*

24. *Ibid.*

25. *Ibid.*

26. *Ibid.*

Colden's Critique of Newton

The very subject of Colden's 1745 treatise, which presumes to explicate the *first causes of action in matter,* and the *cause of gravitation,* is an assault upon the most sacred Newtonian incantation, *"hypotheses non fingo",* as in the penultimate paragraph of the *Principia,* cited above: "But hitherto I have not been able to discover the cause of those properties of gravity from phenomena, and I frame no hypotheses [*hypotheses non fingo*]; for whatever is not deduced from the phenomena is to be called an hypothesis; and hypotheses, whether metaphysical or physical, whether of occult qualities or mechanical, have no place in experimental philosophy."

Colden, like Leibniz, was seeking a dialogue with his adversaries, and therefore often wrote diplomatically of "the great" Newton, "the sagacious Sir Isaac," etc. His language, however, is sometimes reminiscent of Mark Antony's ironical references to Brutus as "an honorable man" at Caesar's funeral. Moreover, all pretence of diplomacy is dropped in his private letters, where the vindictiveness and prejudice of the Newtonians is excoriated, particularly in their condescending attitude toward American intellectuals.

Colden's assertions about Newton were boldly stated in the Preface to his 1751 *Principles,* printed in London and inscribed to the Earl of Macclesfield, President of the Royal Society:

"The doctrine of the mutual attraction of matter had in it something so unphilosophical, something so like the occult qualities, which had been exploded, that nothing could have made it pass with the learned, but the accurate agreement which Sir Isaac Newton shew'd it had with the phenomena. However justice must be done to this great author, that he nowhere calls it a *real* attraction, only *apparent,* the cause of which we know not. In this tract the author presumes to think, that he has discovered the cause of this apparent attraction, and from which all the phenomena in gravitation evidently follow, as necessary consequences: and that he has likewise discovered an error, which had slipped from the sagacious Sir Isaac, by his not knowing the cause of this apparent attraction. . . .

"Sir Isaac Newton no where gives the cause of the motion of the planets, but only supposes a certain degree of velocity to have been impressed upon them: in consequence of which no reason is given for the most general and obvious phenomena of the motion of the planets, as particularly for the different distances at which the planets severally, and the comets revolve, and the different eccentricities of their orbits. The author pretends to have discovered the true cause of the motion of the planets and comets, and from thence to deduce the reason of all the phenomena. . . .

"Though the author has presumed, in some material points, to differ in opinion from the great Sir Isaac Newton, and to point out some errors he has fallen into (and what man never fell into any error?), yet no man can have a greater opinion of Sir Isaac's wonderful sagacity and accuracy in discovering the most hidden truths, then the author has: this work itself will shew what great advantages has been made of Sir Isaac's discoveries."

Chapter II of the *Explication,* "Of Aether and Gravitation," is similarly introduced with an understated, but devastating critique of the "great man":

"Sir Isaac Newton, with wonderful Sagacity, has discovered, that Gravitation is an Effect of some Cause or Agent, which operates in every Part of the Universe of which we have any knowledge; and he has described its Manner of acting, so far as can be concluded from the Effects: But what that Cause is, whether it acts by Attraction or Pulsion, he has no where determined. And tho' in several parts of his Writings (in the last Editions) he has more expressly declared his Opinion, that the Agent which makes all Bodies gravitate towards each other, acts by Pulsion; yet the Manner he had taken to explain this Pulsion, has not given that general Satisfaction which the other parts of his Writings have; and he having at first explained himself, as done by Attraction, his Followers have frequently been puzzled, and Foreigners have received a Prejudice to the Whole of that Doctrine. Suppose that Gravitation be by Attraction, how can two Bodies be supposed to draw each other, without something like Strings passing between them? But the free Motion of any other Body between these two, shews, that there can be Nothing of that Kind between them. If I can show then, how Gravitation is performed, so as one may be able to form a clear Conception of the same, consistently with all Manner of acting, of which we have any certain Knowledge, and founded on the Principles before explained, I hope to do Something that will be acceptable to the Curious."

Colden later dismissed the Newtonian "action-at-a-distance" with biting sarcasm in his 1760 *An Introduction to the Study of Philosophy, Wrote in America for the Use of a Young Gentleman:*

"Not withstanding that in this enlightened age, no maxims in philosophy are admitted, but what are self-evident, and which the unlearned as well as the learned clearly perceive to be true: and no theorem or conclusions are received, but what are demonstratively deduced from these maxims; yet we find many, of great reputation for their knowledge in physics, asserting, that all bodies attract each other, while at a distance from each other, without supposing any thing between these bodies, or passing from the one to the other, by which any kind of action can pass from the one to the other; but by some inherent quality or power in the bodies themselves. Can anything in the occult quality of the schools be more absurd than this? It supposes that bodies act where they are not, and with equal reason they may be supposed to act after they have ceased to be. I can see no reason why a man who admits of this mutual attraction in bodies should be shocked at Transubstantiation, or at any other fashionable absurdity..

"It seems, then, necessary to conclude, that this mutual tendency and motion of bodies to each other is by the action of some medium, surrounding all bodies, or in which all bod-

ies are placed."[27]

Colden also very neatly dismisses the other great Newtonian bugaboo, the *vacuum:*

"If we can have no conception of an absolute void, we cannot affirm that it is, or is not; and what conceptions can a man have of a place void of every thing, and of which nothing can be affirmed? We cannot affirm any thing of it, for the moment we do, it must be something, and if it be any thing, then that thing exists in that place, and the place is not void in contradiction to what would be proved. It is evident, from what was before said, that all the parts of the ether are contiguous, or no void space between them, except where their place is taken up by resisting matter, and if so there can be no vacuum. Sir Isaac Newton and his followers on the contrary think there must be a vacuum, and their reason is that all matter has the *vis inertiae* or the force of resisting. If it were so, then the supposition of a *vacuum* would become absolutely necessary; for without it there could be no motion. If all matter were equally endowed with the power of resistance, as Sir Isaac supposes, the supposition of a vacuum becomes necessary; but if it be true, as I think I have proved, that there are different species of matter, and that only one species has the power of resisting, and that this (as will appear upon the least reflection) is by far the least part of the universe, all the difficulties as to motion on the supposition of space being everywhere full, vanish."[28]

Fundamental to Colden's philosophy is his view of matter as active, not passive or dead. He takes the phenomena of inertia to be an active principle, since "resistance," he argues, is also an action. He adduces a second "species," or principle of action, which he calls "self-moving matter," hypothesizing that light is a reflection of that principle, since light, as well as electricity and magnetism, are types of "matter" without inertia. The third species is the "elastic" principle filling space, the medium that accounts for gravitation. The influence of Leibniz's *Dynamics* is clear from his discussion of the power or force inherent in things:

"The Thing endowed with the Power of Resistance, or Vis Inertiae, is an Agent, or active Substance, Subsistence, Existence, or Being, endowed with a certain Power or Force, whereby it persists in its present State, and opposes or resists all other Power that would change that State, whether it be in Motion or at Rest; and thereby weakens, or renders more or less ineffectual, the Action of all other Power or Force; which Force it exerts in a Manner peculiar to itself, and different from all other natural Agents. Force without Action, is a Contradiction in Terms; yet we are so accustomed to join Motion with all Action, that I find it very difficult to convey any Notion of Action or Agency in the Power of resisting, tho' it demonstrably be an Agent or acting Principle."

Colden goes on to refute Newton's "conservation of motion," which asserts that the motion acquired by one body must be at the expense of motion lost in another, using the Leibnizian example of the force of fire:

"When we see a small Spark gradually set a large City all in a Blaze; can any Man imagine that there is no more Motion in all the Parts of the City, thus on Fire together, than there was in the first little Spark that began the Fire? That there is no more Power or Force in this prodigious Fire, than there was in the scarce distinguishable Spark which began it? But if there be not supposed something mixed in the Materials of the City thus set on Fire, which has a Power of moving of itself; all the prodigious Force of Motion in the City thus on Fire, must be supposed in the first little Spark which began the Fire; for Nothing can give what it has not. There are innumerable other Phaenomena, which evidently show, that some Parts of Matter are self-moving Agents, and which ever move, unless hindered by the superior Force of resisting Matter; and that as soon as the resisting Power is by any Means removed, the self-moving Matter immediately recovers its Motion."

Colden adds his third principle, or "species of matter," to his "self-moving" and "resisting" agents, an "elastic" or "expansive" principle characteristic of the matter that fills space. He distinguishes this "elastic Matter" from the "Aether" postulated by Newton in the last paragraph of the *Principia,* and in several "Queries" appended to Newton's *Optics,* and describes his concept in terms echoing Leibniz's *Monadology:*

"In the last Place, I must observe, that, tho' I call that Matter or Power, Elastic Matter, which reflects any Action, or conveys any Action from the acting Matter or Agent, to any Distance from it (being a Term used by Sir Isaac Newton, and other Philosophers) yet the Action of this Elastic Matter must not be conceived as in any Manner similar to that of Elastic Bodies, such as a Ball of Ivory [a billiard ball—PV]; but as a kind of Action singular and peculiar to itself, and which cannot be explained by any Similitude to the Action of any other Thing, no more than the Actions of resisting or thinking can be explained by any Similitude to the Action of moving. Therefore, if one should imagine, the elastic Matter to consist of innumerable small globules (as of Ivory) whose Parts being pressed together, rebound with the same Force with which they are compressed; he would have no Conception of the elastic Matter which I mean. The Actions of all first Principles, and the Ideas of them, must be all simple; Nothing of Shape, or of Parts, or of Number, or of any Thing like Composition, can enter into these simple Actions, or into the Ideas of them; for otherwise they cannot be simple."

Colden devotes a chapter of his *Principles* to a discussion of the "foresight, design and purpose . . . in every part of the universe that comes within our knowledge," and, from this, demonstrates the existence of an "intelligent being." He goes on to distinguish between final and efficient causes, and notes that a mixture of the two are frequently necessary to the discovery of the reason for things:

"The essential or characteristic distinction between the

27. Pratt and Ryder, *op. cit.,* p. 53.

28. Pratt and Ryder, *op. cit.,* p. 86.

Franklin's friend Cadwallader Colden, in a 1755 letter, underlined his profound respect for Leibniz, whose work Specimen Dynamicum *he had just become acquainted with: "In this I find my opinion confirmed, that an active principle constitutes the essence of substance. Though I be well pleased to have my thoughts confirmed by so great an authority, I suspect this agreement with Mr. Leibnitz will not recommend my performance to the gentlemen in London to whom it is submitted."*

material agent and the intelligent agent is this: the material agents always act uniformly, and in all directions, they have no power in themselves to increase their force of action, or to determine it to one direction more than to another, all alteration in their action or in the direction of them is made by something external, which for that reason is called an *efficient cause,* they have no will, purpose, view, or design in their action. But the intelligent being determines and directs its own actions, by the purpose, design, or view which it has, and therefore its actions are said to be determin'd or directed by *final causes,* and this direction by final causes is called the *will;* therefore in all actions of intelligent beings, which are likewise called *moral actions,* the intention, purpose, or will, is principally to be considered. This is the guiding principle in morality, policy, and religion.

"The actions of intelligent beings cannot be the object of mathematical inquiry. For quantity, and the ratios of quantities, is the sole object of mathematics, but there can be nothing of quantity in design, intention, or will. Therefore any inquiry into the actions of an intelligent agent must be on different principles, from what are used in an inquiry into the actions of matter. But frequently our ideas arise from the complicated actions of intelligent and material agents, in which case, a mixture of mathematical and metaphysical principles become necessary in our inquiries."[29]

Colden's conclusion-"all Nature is alive"—could not be more anti-Newtonian:

"It follows then, from the Whole of what has been said, that these Species of Matter above described, are Agents or acting Principles; that each have a Power or Force peculiar to itself, differing from the others in its Essence and Manner of acting. Whether there be any more Species of Matter, is not easy to determine, though most of the Ancients agree in this Number. That these three are essentially distinct, I can make no Doubt: If there be any other distinct Species of Matter, it must likewise be an active Principle; for we can have no Idea of any Thing but what arises from Action, and there can be no Property without some Power or Force: For this Reason some of the antient Philosophers said, all Nature is alive; that is, all Nature is active. Try to describe Matter without Action, Power or Force, the whole Description must consist of Negatives, that is, it must be the Description of *No Thing;* and then it very certainly follows, that No Thing or No Being, exists No Where. The Word *Matter,* defined to be Thing without Action, without Power or Force or Property, is synonymous to the Word *No-Thing;* and then I think it requires no great Penetration to demonstrate, that it exists No Where, or is not; and yet this is the Sum of some late learned and elaborate Discourses."

The Influence of Colden's Work

The early correspondence between Franklin and Colden is replete with creative hypotheses and lively dialogue in multiple branches of knowledge, from improved methods of printing, to the motion of blood in the heart (including comments on Colden's original explanation of the "doctrine of fluxions," or infinitesimals, conceived as an answer to Bishop Berkeley). Both men were passionately concerned to see a society for the promotion of the arts and sciences established in America, which Franklin effected in 1744 with the founding of the American Philosophical Society. Franklin and Logan were also among the first, along with James Alexander, to receive drafts of Colden's treatise, and Franklin offered to print it at his own expense.

"As the winter is the only time that I have leisure to apply my self to speculations," Colden wrote Franklin in December 1744, "I should be glad to know your sentiments and Mr. Logan's as soon as may be, either to prevent my throwing away time uselessly or to encourage me to go on in the pursuit of a study which requires much time and leisure more than I can hope for in my life. I know none besides Mr. Logan, Mr. Alexander and your self in this part of the world to whose judgment I can refer any thing of this kind."[30]

Once published, all the leading men of Philadelphia set about studying Colden's work, the first of its kind by an American. "Some of our Gentlemen, to render themselves more capable of comprehending your Doctrine, have been mustering up and reading whatever else they could find on Subjects anyway akin to yours," Franklin wrote Colden, Oct. 16, 1746. He went on to recount how these readings led to a major dispute over "the Vis Inertiae of Matter" between Franklin and several others.

29. *Principles,* p. 162-163.

30. Pratt and Ryder, *op. cit.* p. 270.

While most readers of Colden's treatise, Franklin reported, "say they cannot understand it, it is above their Comprehension," Logan compared Colden's ideas to concepts familiar to him from the Leibniz networks of the *Acta Eruditorum,* which prominently included the mathematical Bernoulli family of Switzerland. "Mr. Logan, from whom I expected most, said just the same;" Franklin wrote, "only added, that the Doctrine of Gravity's being the Effect of Elasticity was originally Bernouilli's, but he believ'd you had not seen Bernouilli."[31]

Meanwhile, Colden forwarded copies of his work to his foreign correspondents for comment. His letter to Dutch botanist Jan Frederik Gronovius also reveals that he was quite conscious of his intervention into the great philosophical/political dispute of the age:

"I design to order 3 copies of a small piece to be put up in this parcel, which I intend to submit to the examination of the learned, the printing of which I hope will be finished before this goes. It is on a subject which has puzzled philosophers in all ages; the solution of which I fancy that I have hit upon, and that it may be of use in the improvement of knowledge in every part of physics. I know not whether your taste be in this dept. of learning; but whether or not, I must beg the favor of you to desire some of your mathematicians, those chiefly versant in the Newtonian and Leibnitzian systems, to peruse it, (of which no doubt you [have] some of distinguished character in your university) and that you will favor me with your own and their opinion of it, as soon as your conveniency permits."[32]

The British Royal Society reacted instinctively to this challenge from America, and determined to crush it, particularly after the 1751 London publication of Colden's *Principles.* Colden sent a revised edition of this work to Peter Collinson in London, along with a letter warning of "the strongest prejudice of any taken to my performance and received by those whom I think the best judges, *viz.,* that it is thought contradictory to what Isaac Newtone has demonstrated.

"I hope it will appear that this arises only from a mistake in not understanding truly what I have advanced," Colden continued, "and in not distinctly enough seeing where the force of Sir Isaac's demonstration lies. However I must likewise observe that tho a prudent man will be very cautious in advancing any thing contrary to the sentiments of those who have most deservedly obtained great Authority. Yet all men do sometimes err and very great men have sometimes fallen into Paralogisms. It is well known what Authority Aristotle had in the Schools before Des Cartes pulled him down. But the followers of Des Cartes could as little bear to have their Master's Decisions called into Question as the Aristotelians did theirs, and Sir Isaac's Principles were received at first with great prejudice because contradictory to Des Cartes. So universally are people governed in their opinions by Authority."[33]

"I received your revisal of your principles," Collinson replied to Colden on March 13, 1755, "It is now under the inspection of Dr. Bevis,—for really its bulk, and the attention it required to enter thoroughly into your system would take more time than I could find any would please to dedicate for that purpose—the state of the case seems to be this—that every one is so satisfied with Sir Isaac's that they have no curiosity to examine yours. Was it in Latin—in Germany or France it would not want for perusal."[34]

Colden was quite blunt in his letters, concerning the ignorance and conceit of the Newtonians. "I find the English gentlemen are so much possessed with an opinion that Sir Isaac Newton has carried natural philosophy to the outmost stretch of human knowledge," Colden told a correspondent in 1755, "that they receive everything with prejudice that looks like an attempt to go farther, though it contain nothing contradictory to what he has demonstrated. I have no knowledge of Dr. Bevis, or of any other of the gentlemen to whom my work is to be subjected for examination, and by whose judgment probably it will die or live."[35]

In his correspondence with another Scotsman, the accomplished botanist Alexander Garden of South Carolina, both frankly expressed their disgust with the anti-American philistines of the Royal Society. "I have a real and sincere satisfaction in seeing truth gain ground, but you have not been the first whose works have been denied the Countenance of the English Society," Garden wrote. "They appear to me to be either too Lazy and Indolent to examine or too conceited to receive any new thoughts from any one but an F.R.S. [Fellow of the Royal Society—PV]. Your works I think are another testimony against them, for it's a thousand to one but they will implicitly receive your notions if only countenanced by foreigners, tho they would stumble at them promulgated by one in America tho supported by the Clearest reasoning and Demonstration."[36]

"I know not when you will see any part of my new performance, because I have only sent part of it to London for examination: and I wait to hear how it pleases them before I presume to trouble them with any more of it," wrote Colden.

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31. Franklin to Colden, Oct. 16, 1746, Smythe, *op. cit.*

32. May 30, 1746, *Selections from the Scientific Correspondence of Cadwallader Colden with Gronovius, Linnaeus, Collinson, and Other Naturalists,* arranged by Asa Gray, M.D. (New Haven, 1843).

33. November 1754, *Collections of the New York Historical Society for the Year 1935,* Vol. 68, *The Letters and Papers of Cadwallader Colden,* New York Historical Society, 1937.

34. Peter Collinson to Colden, March 13, 1755, *The Letters and Papers of Cadwallader Colden* (New York: New York Historical Society, 1923), Vol. 5.

35. Pratt and Ryder, *op. cit.,* p. 216.

36. Garden to Colden, March 14, 1758, *op. cit., The Letters and Papers of Cadwallader Colden.*

"One, who had the perusal of the first edition, turned up his nose in saying, 'What! does a man in the woods of America pretend to teach us of the sublime parts of philosophy, which have escaped the researches of the most sagacious among us?' Perhaps it may die in obscurity in America with its author."[37]

However, Colden added a significant postcript to this 1755 letter to Garden, revealing the deeper motive of Royal Society animus against him. This paragraph, published for the first time in 2002, leaves no room for doubt of the true inspiration of America's greatest thinkers:

"P.S. Turning over a book since I wrote what is above, I accidentally met with an extract from Mr. Leibnitz's *Specimen Dynamicum,* which though I have certainly seen before, had entirely escaped my memory, by reason probably of my not being in the same way of thinking I am now, and therefore giving little attention to it. In this I find my opinion confirmed, that an active principle constitutes the essence of substance. Though I be well pleased to have my thoughts confirmed by so great an authority, I suspect this agreement with Mr. Leibnitz will not recommend my performance to the gentlemen in London to whom it is submitted. The sentiments of these two great men in philosophy, Sir Isaac Newton and Mr. Leibnitz have been strangely misrepresented by their commentators in their altercations with each other."[38]

Garden responded with delight to Colden's explicit identification of his ideas with Leibniz, and provoked his friend to elaborate his thinking on the Leibniz-Newton dispute. "What you lastly observe about Mr. Leibnitz gives me great pleasure," Garden wrote Nov. 22, 1755, "for tho I believe your principles are sufficiently supported by your consequent natural account for the Phenomena, yet so great an authority is very agreeable. I have a paper wrote by Mr. Reid professor at Abdn on the Difference of Opinions between these two Great men—it was read before the Royal Society and he had a letter of thanks for it—The Ingenious Author made me a present of a Manuscript Copy which I shall transcribe and Send you by next opportunity."

Colden responded with his own analysis of the differences between Leibniz and Newton on the question of power and force, stating clearly that *Leibniz was correct in his conclusion that the force of a body in motion is as the square of the velocity:*

"We certainly have no other way of judging of the force of any power but by the effects produced by it. The constant effect of motion or of any degree of velocity is change of place and indeed we have no other conception of motion but by its effects *viz.* change of place.

"It follows then evidently that we can have no conception of a greater degree of motion or force of velocity than by a greater effect or change of place in equal time, consequently the ration or force of velocity must allwise be in the ration of the change of place or distance run in equal times and indeed I think it impossible to conceive it otherwise.

"But it is said that Mr. Leibnitz proves, and I think truely proves from experiments, that the distance run or the several heights to which the same body ascends when projected perpendicularly with different velocities are as the squares of the velocity with which the body at the several times is projected and therefore is not as the velocity directly but as the squares of the velocity."[39]

At the same time, Colden extended an olive branch to the Newtonians, suggesting that Sir Isaac could have reached the same conclusion, if he had considered Leibniz's example of "violent action," i.e., where the force acquired by a body from falling from a height, is equal to the force, or work, required to raise it to that height:

"Now it is plain that according to Sir Isaac Newtone's rule of measuring velocity or its force by the distance run directly, the height to which bodies projected from the earth rise are as the squares of their beginning velocities as Mr. Leibnitz proves.

"For the like reason the depth of the impression which a body (makes) into another soft yielding body is as the square of the velocity with (which) it at first strikes the surface of the soft body because (the) impression is made by the sum of continuously decreasing velocities (in) the body which makes the impression stop.

"Thus I think the dispute between the Newtonians and Leibnitzians may be fairly determined."[40]

Garden determined to forward Colden's essay to Scotland, hoping for a better reception than in England. "I have just now copied over your very ingenious reflexions on the Newtonian and Leibnitzian Controversy to send to the Edinburgh Society," he wrote Colden Jan. 10, 1757, "who I doubt not will be greatly pleased with them, as not only I, but likewise some much better judges have been here."

Three months later, Garden reported the results. "He [Colden's friend Dr. Whytt of Edinburgh—PV] received your former Letter to me with great joy and satisfaction, but says he is afraid that some of the Socii will (they are all rigid and literal Newtonians) have their objections. He was to read it before them at first meeting. I have sent him your observations on the Leibnitzian Controversy."

The Battleground in Germany

At virtually the very moment that Franklin and Colden had launched their American offensive against Newtonian orthodoxy, with the 1745 publication of Colden's *Explication,* forces of the Newton Dark Age seized control of the

37. Pratt and Ryder, *op. cit.,* p. 223.

38. Pratt and Ryder, *op. cit.,* p. 223.

39. Colden, *Remarks on Mr. Reid's Essay on Quantity,* New York Historical Society Manuscript Dept.

40. Colden mss., *op. cit.* (parentheses indicate missing words due to a torn page of manuscript).

crucial Leibniz-founded Academy of Sciences of Berlin. In 1740, on the poisoned advice of British agent Voltaire, the newly crowned King Frederick ("the great") of Prussia appointed the Newtonian degenerates Maupertuis, Euler, d'Alembert, and Algarotti to direct the Academy. In June 1746, Maupertuis announced a new prize essay contest on the subject of monads, and rigged the results with the naked objective of discrediting Leibniz in his own nation. Contestants were required to either refute the "doctrine of monads," or "deduce from them an intelligible explanation of the principle phenomena of the Universe, and in particular the origin and motion of bodies."[41] In the foul environment of philistine mockery of "metaphysics" created by Maupertuis, et al., and enforced worship of the Newtonian idols, a stacked jury awarded the prize to the author of a crude diatribe against Leibniz's ideas. Thus was the witch-hunt against Leibnizians in Germany launched with a vengeance.

It was in this supercharged historical context, that Abraham Gotthelf Kästner, a 29-year-old professor at the University of Leipzig and proponent of Kepler and Leibniz, arranged for a German translation of Colden's work, with Kästner's critical comments appended, which was published in Leipzig in 1748. Although Colden maintained that he was unfamiliar with Leibniz's "doctrine of Monades," and declined to engage in a direct polemic on the subject of the *Monadology,* nevertheless his treatise addressed the very issue raised by Maupertuis' 1746 contest, and answered it in a manner recognized as Leibnizian by all concerned. Thus, Kästner counterattacked the British onslaught with the political weight and intellectual weapons provided by America.

Colden did not see a copy of Kästner's work until 1752. "I have received a Copy of the Translation of my first piece into High Dutch with Animadversions in it at the end of it printed at Hambourg and Leipsic 1748, but I do not understand one word of them," Colden wrote Franklin, May 20. "I find my name often in company with those of very great ones Newtone, Leibnitz, and Wolfius and Leibnitz's Monades often mentioned a New Doctrine which perhaps you have seen and is of great repute in Germany. The animadversions end—*Magnis tamen excidit ausis* which being in Latin I understand."[42]

Colden wrote indignantly to Collinson in July, worried that Kästner was trying to credit his concept of the aether to the Germans of Pennsylvania! "I received the Translation of my first piece into high Dutch with remarks upon it, but I have not been able as yet to get the remarks translated," Colden wrote July 28. "A German minister stopt at my house a little. He did not speak good English. I got him to look over some parts of it and was surprised to find one paragraph in it asserting that the Account or Explication I give of the Ether was done in Pennsylvania and not in New York. I am very sure he has no true foundation for this assertion and believe he will even find it difficult to excuse this publication in any shape. But as there are many Germans in Pennsylvania it seems the Translator has a mind to lay in a claim for his Nation to this Discovery. After I shall have got the remarks translated I shall say something more particularly to it. This gives me the better opinion of the performance by its drawing Envy and Calumny on the Author."

Franklin was anxious to read Kästner's comments, and wrote to Colden in September to request a copy of them. "I understand a little of the German Language, and will peruse and return it," he promised. Franklin joked that Kästner's remark about Pennsylvania "may be some kind of Dutch wit," comparing Colden's concept of inertia as *action without motion* to the religious sect of Quietism, "which in Germany is supposed to be very prevalent in Pennsylvania, many of their Quietists having removed hither."

By October, Colden could report to Franklin that Kästner's remarks were "well translated by Mr. Hartwick, a Lutheran Minister who is well acquainted with the German systems of Philosophy and thereby more capable of making a good Translation. I have likewise drawn up an answer to the remarks which I expect may assist you to form a better conception of my principles and of the truth of them than what you have already seen. I now send both the remarks and Answer to Mr. Alexander and I shall desire him to transmit them to you if he do not think it necessary to alter any thing in the Answer. In the mean time I send you the original remarks in the German language that you may better judge of the Translation when you shall see it. The remarks and Answer are chiefly on the Metaphysical parts of my System" (Oct. 24, 1752).

Kästner and the Americans

Kästner's sharp and polemical comments (as translated somewhat awkwardly by Hartwick), were clearly designed as much an intervention against the Newtonian dictators of the Berlin Academy, and the bowlderizers of Leibniz in Europe, as an overture of dialogue and collaboration with the Americans. Kästner argues as if engaged in a debate among Leibnizians, over the proper understanding of dynamics and the meaning of the *Monadology.*

"It would be something remarkable," Kästner began, "if we should obtain from America, the solution of difficulties in Physicks, which have seem'd insurmountable to the greatest Geniuses in Europe, and if that, what was incomprehensible to a Newtone should now be cleard up, by a Countryman from the New world. Nevertheless have I in perusing of this work found yet some doubts which don't yet allow me to ascribe to the author thereof the honor of a discovery, which otherwise every sincere lover of Physicks, because of its excellent uses which therefrom would accrue to this Science,

41. Quoted in Shavin unpublished report.

42. Latin from Ovid, *Metamorphoses,* II, 328; freely: "At least he dared greatly, though he failed."

gladly would allow him.

Kästner went on to raise objections to Colden's "three species of matter":

"Matter resists the motion and in general the change of its state; motion arises where there was none before; this motion communicates itself from one matter to another. These observations have all made who have been but a little attentive to the Phenomena in the corporeal world. The invention of Mr. Cadwallader Colden can therefore not intend, to teach us THAT this happens; consequently must his intention be to shew us, HOW it happens? What is it then now that he says with this view? Matter resists, because, there is a matter, which has a resistive power; motions arise, because there exists a matter, which has the power to cause motions; and the actions of matter communicate themselves by a matter, which has the faculty to communicate actions. According to my apprehensions these definitions are too light to be right; or rather, they are no definitions at all, that is taken for granted which ought to have been defin'd. Either would Mr. Colden tell us only, that those powers existed in nature, and were foundations of the Phenomena of the corporeal world, and if that is the case, he has at least not told us Europeans any thing new; or his intention has been to shew whence they spring, and in this case there was something more necessary than to call their names."

Kästner challenged Colden on his view of inertia as an active power, arguing that it is merely an *apparent* power, in the same way that gravitation is merely an *apparent* power of attraction of bodies at a distance.

"If you presuppose the undeniable truth, that nothing happens without a sufficient reason," Kästner wrote, "then you will know at the same time, that no power is requisite to that, that a body should remain in the state in which it has once been constituted . . . ; but if you suppose the subsistence of the body, let from whencesoever it springs, then the same power by reason of which it continues its subsistence, makes it continue its subsistence in the same circumstances wherein it has once been constituted. For there is no reason, why those circumstances should be changed. For a body to rest it wants no power when there is no reason why it should be moved: to continue the motion once impress'd with the direction happens without a power thereunto necessary when there is no reason to change this motion and its direction. An alteration requires power but not the continuation in the same state. When one says that a body resists the change of its state it says no more then that a power is required to alter its state; and that no change can happen without a sufficient reason."

Notwithstanding Kästner's invocation of Leibniz's principle of sufficient reason, in this case Colden appears to have the deeper understanding of dynamics. Leibniz himself addressed the issue in a 1699 letter to De Volder:

"I have noticed that Descartes (in one of his letters), following the example of Kepler, also recognized inertia in matter. They wished to derive this inertia from the power which each object has to persevere its own state and to admit nothing external to its nature. I admit that every object perseveres in its state until some sufficient reason for change arises. That is a principle approaching metaphysical necessity; but it is not the same thing whether we assert that something simply preserves its state until something happens to change it—a case which also arises when the object is quite indifferent in regard to both states—or whether, on the other hand, we assert that it is not indifferent but possesses a power accompanied by an inclination to preserve its own state and thus to resist actively causes that would change it."[43]

As Kästner develops his objections to Colden's concept of inertia, it becomes clear that he is criticizing Colden's ideas as a misapplication of Leibniz's *Monadology!*

"It is not necessary, to make a power," Kästner writes ironically, "whereof great Mathematicians, and even such whom you have no reason to accuse that they are infected with the Leibnitizian metaphysic, confess that one can't form a right clear idea thereof, to make it still more incomprehensible. For the rest have you on the other side ascribed reasons to beware of extravagancies. Leibnitz himself confesses that the original power of the bodys is not sufficient to explain all the phenomena. It is therefore probable that he has not made his Monadology for that purpose, that the Laws of motion should be explained therefrom. The Baron Von Wolff has long ago observed that from the representative power of Leibnitz in the monads, the phenomena of motion in the corporeal world are not to be explained. Our idea of motion is too obscure to comprehend how it springs from the first idea of the Body. Those, who endeavor to shew how from the representative power of monads motion springs, should first endeavor to explain how from the seven Newtonian colored Rays the yellow sun light springs forth. If therefore I believe that the phenomena which I call inertia and motion spring from an idea which my Soul has of a multitude of Monads, so dare I not therefore venture to explain how this multitude of Monads can produce the same unto us. The saltus from Monads to motion is without doubt greater than that, from the color-rays to the sunlight, and if my knowledge is not sufficient in the latter then I shall not venture to wage the first."

Colden's three-page answer was edited by Franklin, who embraced the opportunity for dialogue with fellow truth-seekers, in contrast to their experience with the Newtonian ideologues. Franklin emphasized to Colden that Kästner, although critical of his work, "himself freely says, 'that the many new, good and just Thoughts contain'd in it, made him willingly undertake the Task enjoin'd him.' "[44]

Colden defends his hypothesized three species of matter,

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43. Wiener, *op. cit.,* p. 159.

44. *Cadwallader Colden Papers,* Vol. 1 in New York Historical Society Papers, 1917, Vol. 4, pp. 446-447, quoted in Shavin, unpublished report.

emphasizing that the existence of the power he calls Aether is on as good or better ground than Newton's apparent power of attraction-at-a-distance through a vacuum:

"Philosophy is thought the surest (way) for improving our knowledge in Physics. By it not only the number of Phenomena or effects are produced at pleasure, but they are ranged in such order and the circumstances attending them so accurately observed, as to lead us with the greatest certainty from the effects to the knowledge of the cause. But it frequently happens that the phenomena can not be produced at pleasure, as in the Phenomena of the heavenly bodies, then an accurate observation of the several circumstances is to the same purpose as making experiments. It was from this that Sir Isaac Newtone proved the apparent attractive power of Matter as a general phenomena, and on that evidence only Philosophers have allowed it. Now it is from the same evidence, that Mr. Colden proves the existence of a power of receiving and reacting the actions of the resisting and moving powers which he attributes to Aether. In the Essay on first causes, he proves this from the phenomena of the Gravitation of Bodies, and in his Principles of Action in Matter, he proves the existence of all the three Species of Matter, from the Phenomena of the celestial bodies, by shewing that such effects necessarily follow from such causes: and he hopes hereafter to prove it, from some very general phenomena, which Philosophers have not been able to explain, from any Principles hitherto observed by them in Physics. So that the proof of the existence of such a Being which he calls Aether, is on as good evidence as the existence of any other thing, which is the object of our senses, by its action on them. Tho' this and the other may not be so evident to every common observer, as the effects of resistance of motion are; yet to the more curious, who consider its effects in gravitation and in the motion of the planets round the sun, the existence of such a power which Mr. Colden attributes to Aether, or by whatever name it be called, must be very evident. The Professor seems not to have given a proper attention to Mr. Colden's reasoning when he treats it as a mere fiction. But how far Mr. Colden has succeeded in explaining the Phenomena of Gravitation and of the Celestial bodies from his Principles and has thereby improved our knowledge of Nature must be left to the judgment of the Readers of his Principles of Action in Matter."

Colden goes on to defend his inquiry into "the first causes of action," but at the same time declines a direct dispute over monads. "Several things in the remarks are passed over as having no reference to Mr. Colden's Principles," he wrote. "Such are Leibnitz's Monads and their representative power."

Colden concludes by expressing his appreciation for Kästner's efforts, while suggesting that Kästner was directed by other unnamed persons to undertake the work. "After all Mr. Colden must think himself obliged to the Professor not only by his taking the trouble to translate Mr. Colden's treatise but likewise by exposing the difficulties it lies under in the opinion of others as it thereby gives an opportunity of explaining his sentiments more fully to the satisfaction of others, for certainly if the Professor had thought it a mere trifling performance he would have taken no such trouble on himself, notwithstanding the commands he received to translate it."

Meanwhile, the dialogue of Colden and Kästner did not escape the scrutiny of the Newtonian thought-police of the Berlin Academy. A copy of Leonard Euler's remarks on Colden's *Principles,* dated Nov. 21, 1752, were forwarded to Colden by Peter Collinson. "The Book contains many Ingenious Reflections upon that Subject for a Man that has not entirely devoted Himself to the study of it," Euler wrote. "Butt at the bottom he has not acquitted Himself so Well as I expected in the explanation which has undertaken to give."

Euler ridiculed Colden for "attempt[ing] to attack the best Establish'd propositions of the late Sir Isaac Newton, upon reasons destitute of all foundation." Colden's explanation of the movement of the planets, Euler declared, "shows but little knowledge of the principles of Motion & entirely disqualifies the author from Establishing the True Forces requisite to the Motion of the Planets, from whatever cause He may attempt to Derive them. Besides his explication founded on the Elasticity of the Ether, is so ill imagined, that it is absolutely contrary to the first principles of Hydrostatics. What an absurdity it is to assert, that the Ether between Two of the Coelesial Bodies, has not the same Spring with that of the Rest, etc."[45]

Colden disposed of Euler's tirade against his work in a letter to Franklin, where he reported that "Mr. Collinson sent me some remarks made on it by Professor Euler of Berlin. He writes much like a Pedant highly conceited of himself."[46]

Franklin had expressed his satisfaction that Colden had declined to respond to Kästner's curious remark about Pennsylvania, referenced above. The remark came in the context of a polemic against Colden's Aether. "I shall not detain myself by his third Elastic-Matter," Kästner wrote, "for to tell him short, I have no conception of it, the whole discription in the 20th paragraph appears to me, as if it was not fram'd in N.Y. but in Pennsylvania."

The Electricity Revolution

Had Logan's hypothesis concerning the "electric or elastic medium" filling space, come to be known among the Leibnizian circles of Europe? In any case, this was the very "Pennsylvania hypothesis" now pursued with a vengeance by Franklin and Colden, as they proceeded to revolutionize science with their discoveries in electricity.

Franklin's early electrical experiments convinced him that the "electric fluid" was indeed a "species of Matter," and one "pretty equally diffus'd in all the Matter of this terraqeous

45. Euler to Collinson, Nov. 21, 1752, *The Colden Papers—1748-1754,* New York Historical Society.

46. *The Colden Papers,* Nov. 19, 1753.

Globe." As his experiments proceeded, and were quickly duplicated by Colden's son David in New York, Franklin foresaw the application of his discoveries to technologies capable of transforming human society without limits. "There are no Bounds (but what Expence and Labor give) to the Force Man may raise and use in the Electric Way," he wrote to Colden in 1751. "For Bottle may be added to Bottle in infinitum, and all united and discharg'd together as One, the Force and Effect proportion'd to their Number and Size. The greatest known Effects of common Lightning, may, I think, without much Difficulty be exceeded in this way: Which a few Years since could not have been believed, and even now may seem to many a little extravagant to suppose. So we are got beyond the Skill of Rabelais's Devils of two Year old, who, he humourously says, had only learnt to thunder and lighten a little round the Head of a Cabbage."[47]

Franklin's hint concerning the identity of electricity with lightning, became the implicit theme of a series of letters exchanged with Colden on the application of Colden's ideas to electrical phenomena.

"In my opinion no set of experiments which I have read lead so directly towards discovering the cause of Electricity as yours do," Colden wrote in a letter dated March 16, 1752. "However I find it difficult to form any conception of this cause which in any degree satisfies my mind. I conceive it to be a most subtile elastic fluid like our air but incomparibly more subtile and more elastic." He went on to suggest that his treatise "perhaps may be of use or serve as a hint for explaining the electrical fire."

Franklin replied at length in his letter of April 23, in which he challenged Newtonian orthodoxy with his own version of the heretical Logan hypothesis, "supposing Universal Space filled with a subtle elastic Fluid." "Your Conception of the Electric Fluid, that it is incomparably more subtil than Air, is undoubtedly just," he wrote Colden. "It pervades dense Matter with the greatest Ease:. Who knows then, but there may be, as the Antients thought, a Region of this Fire, above our Atmosphere, prevented by our Air and its own too great Distance for Attraction, from joining our Earth? Perhaps where the Atmosphere is rarest, this Fluid may be densest; and nearer the Earth, where the Atmosphere grows denser, this Fluid may be rarer, yet some of it low enough to attach itself to our highest Clouds, and thence they becoming electrified may be attracted by and descend towards the Earth, and discharge their Watry Content together with that Etherial Fire. Perhaps the Aurorae Boreales are Currents of this Fluid in its own Region above our Atmosphere, becoming from their Motion visible. There is no End to Conjectures. As yet we are but Novices in this Branch of Natural Knowledge."[48]

Colden answered on May 20, the same letter in which he announced his reception of Kästner's translation and remarks, telling Franklin, "Your conjecture of the Electric fluid's taking place in the superior regions of our atmosphere pleases my fancy, as it in some measure confirms what I have advanced in the Treatise now in the press."

By June of 1752, Franklin's hypothesis was no longer "conjecture." He had earlier sent a paper "on the sameness of lightning with electricity" to the British Royal Society, where "it had been read, but was laughed at by the connoisseurs," as he reports in his autobiography. The reception was different in France, where his friends defended his ideas, and succeeded in one of his proposed experiments "for drawing lightning from the clouds."

"This engag'd the public attention every where," Franklin writes. "M. de Lor, who had an apparatus for experimental philosophy, and lectur'd in that branch of science, undertook to repeat what he called the *Philadelphia Experiments;* and, after they were performed before the king and court, all the curious of Paris flocked to see them." In the midst of the popular intellectual excitement triggered by these spectacular demonstrations, Colden's treatise was published in Paris in 1751 under the title, *Explication des premières causes de l'action dans la matière: et de la cause de la gravitation.*

Franklin's crucial experiment was duplicated enthusiastically all over Europe, with the most dramatic version being Franklin's own death-defying kite and key adventure in Philadelphia. His invention of the lightning rod later that year offended the superstitious by overcoming the awesome power of the lightning bolt, wielded for centuries against a hapless Mankind by tyrant gods like Zeus or the Christian fundamentalists' irrational "God of Thunder." *The same intellectual force would soon overpower the scepter wielded by earthly tyrants.*

Thus did the Americans settle the argument with the Newtonians, by proving that the "electric fluid" does indeed, in some fashion, fill space. Scientific inquiry could no longer be restricted to impotent contemplation of passive particles interacting like billiard balls in an empty, dying Universe, as the phenomena of light, electricity, and magnetism—Colden's "self-moving" and "elastic" species of matter—opened vast fields of experimentation and hypotheses concerning the geometry of space and the inner nature of things, as in the work of Kästner's student Gauss, leading to Weber, Ampère, Riemann, et al., the results transforming mankind through technological revolutions.

Thus also was James Logan's prophecy fulfilled, "that by the surprising phenomena arising from Electricity . . . we may see a field open'd for Speculations, that if duly pursued, may probably lead us into more just and extensive Notions of our Bodies, and the world we live in, than have hitherto generally been thought of."

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47. Benjamin Franklin to Cadwallader Colden, Oct. 31, 1751, *Benjamin Franklin Papers.*

48. Franklin to Colden, April 23, 1752, Smyth, *op. cit.*