THE NEWTONIAN EPOCH IN THE AMERICAN COLONIES (1680–1783)

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HISTORY in its constant recording of events of human experience moves on steadily and persistently. However certain is the course of history, it is nevertheless a varied series of epochs, events, or combination of experiences. It is therefore of vital concern from an intellectual point of view that a retrospective and introspective attitude be maintained in order to see how life as it is today has been achieved. From our present position in the course of events, we are concerned today with one of the great periods of the past movement. It is a small section to be sure, but a most interesting and timely one.

Between the years of 1680 and 1720 in English history, under the rule of William III and Queen Anne, a most brilliant and illuminating intellectual life is reported. England virtually assumed undisputed leadership only to share it later, first with France and then with Germany. In this period England gave to history her best, both in science and philosophy. The accumulated wisdom of the ages seems to have been concentrated in the lives and works of two undisputedly brilliant minds, Isaac Newton and John Locke. Theirs are beyond question the outstanding names in that epoch, which followed the discoveries and the liberations of the Renaissance and the Reformation, and preceded the great mathematical, physical and philosophical discoveries of today.

In one sense Newton and Locke were systematizers of ideas which were prevalent. Newton stands at the end of a group of scientific geniuses who effected the

Copernican and the Cartesian revolution; he finally drew up in complete mathematical form, the mechanical view of Nature—that first great physical synthesis on which succeeding science rested and remained unchanged until today, when some modification was found necessary—Relativity.

Locke stands as an apologist and heir of the great 17th century struggles for constitutional liberties and rights and toleration. It is to this expression in a systematic form of ideas, which had become common property by 1700, that the two owed their immense popularity in the new century. But in another sense both Newton and Locke stand at the threshold of a new era; Newton as the prophet of the science of Nature, and Locke as the prophet of the science of human nature.

The growth of empiricism and the enlightenment based largely upon Newton's Mathematical and Natural Philosophy and Locke's Human Understanding found its course steadily transcending all parts of the intellectual life and also moving westward with human migration.

Preceding this epoch (1680–1720) the years leading up to the limitation are in themselves full of vitality and substance for achievement. Otherwise the epoch itself could not have been what it became. Therefore, with the transition of this new philosophy of empiricism and enlightenment, the period from 1636 to 1680 in the American colonies was in preparation for the acceptance of this new order. As a matter of fact Harvard College, established in 1636, was giving forth all that was best, regardless of the rigid and frigid Puritanism by which it was surrounded. The minds of the Winthrops, Dunsters, the Mathers, Charles Morton and others gave to Harvard and the Colonies the necessarily receptive mind for Newton's and Locke's philosophies. Harvard had accepted and taught the new planetary system of Copernicus, the principles of Galileo and the magnetic force of Gilbert. It was therefore natural that emphasis should be placed on the mathemetical conception of the orderly movement of the planets and satellites about the sun. This was affected by the three laws of planetary motion of Kepler and given proof by the mathematical expressions of the laws of gravitation governing this motion as discovered by Newton. That the heavens and earth should have declared their glory by this great sweep of inductive process was the final cause of the disappearance of the Cartesian philosophy of the Universe, and the liberation of dogma in Puritan theology.

For the purpose of this paper we shall now point out only what influence the writings of Newton had. Space will not permit the parallel discussion of the philosophy of Locke and its influence upon the religious and social life of the colonies.

What is the Newtonian Philosophy and why was it so potent? Who were its leading exponents in the colonies, and what minds contributed the most toward the making of a brilliant intellectual life on this continent? As a matter of interest, the records of the Royal Society of London reflect accurately the interest which the American colonies had in science. There were, between the years 1636 and 1783, seventeen Colonials in various fields of science who were elected Fellows of the Royal Society. Emerson says that a great man is one who administers a shock to the world, and he names Newton as an example.

"*The Mathematical Principles of Natural Philosophy*" is a concise account of the principle of dynamics underlying the three great empirical laws of planetary motion set down by Kepler, a further extension of the law of falling bodies discovered by Galileo and, finally, development of the theory of gravitation as applied to the moon, comets and the planets; together with an important explanation of the irregularities known as perturbation in the movement of celestial bodies. This remarkable book of over 500 pages—quarto size—was written in less than a year, all prepared and demonstrated by geometrical analysis and was published in 1687.

The first scholar in the colonies to catch the real spirit of Newton's philosophy was the intellectual leader and Puritan high priest Cotton Mather (1663–1728). While not a mathematical scholar, he was able, in his role of prophet, to visualize the mental development of students in terms of the *Principia* and he felt that here was something of greater importance than the classics. Mather was a graduate of Harvard College, but never a teacher. Always, whether on or off the pulpit, he admonished the students "to avoid philosophical romances and get as thorough an insight as you can into the principles of our perpetual dictator—Sir Isaac Newton."

In 1680 we find a most interesting fact, namely, that direct aid was given to Newton by a series of comet observations made by Thomas Brattle (1657–1713), a graduate of Harvard. These observations were sent to the Observatory at Greenwich near London, where Flamstead, the Director, communicated them to Halley and Newton, who were then working upon the theory of the gravitational influence of the sun upon the moon and comets. Newton expressed his commendation upon the excellent set of observations made by the observer in Boston, namely, Brattle. This study of the gravitational influence of the sun on the moon and comets was the actual foundation and the beginning of the writings of the immortal Principia. A contemporary associate of Brattle and the Mathers was Thomas Robie (1689–1729), a young tutor of Harvard College, who was greatly interested in astronomy, meteorology and medicine. As a tutor he evidently instructed the college youth in mathematics and natural philosophy and, in addition, compiled celestial almanacks. These commonplace books bear evidence of his reading and use of Newtonian philosophy. Robie retired in 1727.

We now come to the most puzzling fact that up until Robie's period apparently no copy of the great Principia was in the Harvard College Library, or in the private libraries of any of the tutors. The absence of this work is noted in the Library's first catalogue of books prepared in 1723 for Thomas Hollis. We do find a copy of Newton's Opticks. It is evident, therefore, that what Newtonian philosophy was taught came from secondary sources. At this time Colonial scholars could boast of having fifteen Fellows of the Royal Society in their midst, each with a set of the Transactions. New tutors coming from Cambridge and Oxford Universities usually came with the new learning, or books advocating the Newtonian philosophy.

With the establishment of the endowed chair in mathematics and philosophy at Harvard College in 1727, by Thomas Hollis, a wealthy merchant of London, we now enter upon a new period of mathematical instruction in the American colonies. Isaac Greenwood (1702–1745) graduated from Harvard in 1721 and became the first Professor to occupy this chair. He received much of his inspiration from Robie, whose student he was, and he had the added experience of study in London, where he went presumably to prepare for the high office to which he was later called. While in London, he apparently did not make the acquaintance of the venerable Newton, who was now past eighty, but there is evidence that he brought back books, primarily in the field of mathematics. If he brought back a copy of the Principia, which seems quite possible, that copy is lost to posterity. However, upon his return he was very active in enlarging the course in mathematics at Harvard, thereby laying a firm foundation for coming students in the mastery of Newton's work. Greenwood curiously did not offer to give, or did not think it advisable to institute a course in Newton's philosophy at the College, but there are records of his offering to give instruction in Newton's mechanical principles of nature, in algebra, in the fluxions, and their application to modern astronomy. Greenwood retired from the professorship in

1738, without having furthered to any appreciable extent the mathematical study of Newton's work.

Before entering into the more active and profound phase of Newton's influence on the scientific life of the colonies, as well as on the religious controversies in the pulpit, we should step back in time to see what other colonial colleges were offering in this new order of learning. William and Mary College, founded nearly 50 years later than Harvard, was organized under the accepted practice of English universities, known as the Oxford curriculum. The third part of this curriculum consisted of natural philosophy and mathematics, and its first Professor was the Reverend Hugh Jones (1670–1760), who was educated in an English university. Jones served from 1717 to 1722. There is no evidence as to what he taught or what degree of influence he exerted on the students and community concerning the new learning. There were nine men up to the time of the Revolution who served in this professorship (founded in 1712), and no record is existing relative to whether or not Newton's works were being taught, or whether they were available in the Library.

It is inconceivable that by 1758 with the appointment of William Small (1734–1775) the courses in mathematics and science should not have greatly changed due to the Newton influence. The two disasters, namely, war and fire which overtook William and Mary College destroyed all evidence of the part taken by it in the progressive teaching of science in that period. More recent evidence is in abundance that the college has accepted the new philosophy in science and advanced accordingly.

Then comes the point where we almost touch hands with Newton. In 1701 Yale College became the third Colonial college of higher learning and by 1714 found itself in great need of books and scientific apparatus. The Connecticut colonial agent, J. Dummer, in London, was called upon to seek aid among the wealthy and cultured at home. London was always filled with colonial agents, and Dummer was one of the most successful. He was fortunate to be received by Newton, whose interest in the advance of learning and science was always expressed in terms of gifts. Newton handed Dummer, from his own shelves, a copy of the second edition of the Principia (1713) and also a copy of his Opticks (1704). Both books may be seen today in the Rare Book Room of the Yale Library. Samuel Johnson (1696–1772) and Daniel Browne were seniors in college when these books arrived and were kindled with an ambition to acquire a working knowledge of mathematics in order to master the Principia. Unfortunately, the courses in mathematics then offered at Yale gave no solid foundation for mastering the methods of geometrical analysis used by Newton. It was a revelation to these tutors, who seemingly possessed a high opinion of their own mathematical ability. However, their failure had the salutary effect of introducing courses in mathematics and astronomy of a more advanced type. From 1714 the college accepted the new order of Newtonian philosophy. For the first few decades of Yale's development theological doctrines of various shades occupied the minds of the tutors and the President, but it was not until President Clap's administration (1739–1756) that definite advances were made in the more liberal courses, as he himself was especially proficient in mathematics and philosophy. A course in fluxions of Newton's type was introduced and taught by him. In 1770 the college established a second professorship. To this position was called Nehemiah Strong (1728–1807), graduate of 1755. Strong as a tutor had read much from the new astronomy and, in addition, as a student under Clap had acquired a knowledge of the Newtonian fluxions. In 1781 he published a small volume intended for a textbook, entitled "Astronomy Improved, or a New Astronomy." The whole purpose of this treatise was to outline a clear understanding of the laws of gravitation as affecting or operating upon the planetary system. Although he does not mention Newton or Kepler, nevertheless, it is the Newtonian philosophy upon which he bases his writing and lecturing. Cautiously, he refers the origin of the law of gravitation to God. This was done so that the theologians might not be offended, for they were still dominating the curriculum of the colonial college. Progress continued in the new empirical philosophy, relative to the study of nature, for on the retirement of Strong, we meet one of the most enlightened scholars of the colonies—Ezra Stiles (1727–1795). Stiles was appointed President of Yale in 1778, during the early part of the Revolution. At this time the college suffered the loss of many students and tutors, as well as financial income; and with the absence of these tutors, Stiles undertook to carry on the duties of several. The professorship of Mathematics was not filled on the retirement of Strong, but President Stiles, due to his interest in astronomy, lectured once a week on mathematics and natural philosophy. Manuscript notes taken during his student days and later life reveal that he increased the scientific reputation of the growing college to such a degree that Professor John Winthrop of Harvard expressed due praise for Stiles.

The copy of the *Principia* received from Newton in 1714 remained on the Library shelves intermittently with little evidence that either Clap or Strong used it. With all of his theological interest, Stiles gave a large share of his busy life to the mastery of Newton's principles from the original source. Stiles was able to reconcile his old understanding of God with his new understanding of God's laws as interpreted by Newton in the orderly movement of the celestial bodies. Notebooks still extant at Yale show us that practical studies came from his understanding of the Principia. He calculated the true place of the sun on April 20, 1745; the moon's place on June 22, 1745; the conjunction of planets, parallax of the moon and, above all, he made a most careful study of the laws of gravitation.

In 1795, Stiles' career ended in the midst of a returning prosperity.

While the introduction of Newtonian philosophy into the early colonial intellectual life interfered with Puritan Calvinism more than any other scientific or philosophical system, it nevertheless had a purifying or clarifying effect, in that it tended to brush aside all doubts of reality. True, it seemed to the Calvinists that Newtonianism was a purely materialistic, or mechanical philosophy, but they were limited by a mental outlook which foreshortened their vision and ability to understand.

It is interesting to note, as we study the trend of scientific thought from the northern to the southern colonies, that we meet a change of attitude. Newtonian philosophy in the colonies of New York and Pennsylvania came into contact with an established system of ethics, and brought about a new approach to moral philosophy. The principal proponents of this view in New York were Samuel Johnson and Cadwallader Colden.

Samuel Johnson became the first President of Kings College (now Columbia University) in 1754 and if we are to accept Johnson's intellectual leadership as shown while a Yale senior and tutor, he did not fail to recognize the influence of Newtonian philosophy already manifested at Harvard and Yale. There were no other outstanding scholars during the early period of Kings College who developed interest in the new trend of thought. However, in the colony of New York we meet with an unusual man, who attempted to do more than had thus far been done, that is, to criticize and make practical applications of the Newtonian mathematical and physical theories of fluxions and gravitation—Cadwallader Colden.

Cadwallader Colden, born in Ireland in 1688, graduated from Edinburgh University as an M.D. His contemporaries were Samuel Johnson, Benjamin Franklin, James Logan, David Rittenhouse and John

Winthrop. During his busy life as Administrator of the Province of New York, first as Surveyor General and then as Lieutenant Governor, Colden gave great attention to scientific and philosophical writings. Two of his publications have come down to us as priceless documents of the critical Newtonian philosophy. The first is an application of "The First Cause of Action in Matter and the Cause of Gravitation" published in 1746, the second "An Introduction to the Doctrine of Fluxions, or the Arithmetic of the Infinite" in 1751. The former is in one an attempted criticism and enlargement of the Newtonian doctrine, and also a starting point for Colden's own speculation. Although this monograph reveals that Colden had a mathematical mind, all of his studies and writings show a marked tendency toward philosophical speculation. He undertook to analyze Newton's system of fluxions after Dean Berkeley had criticized it and found it defective, also in many cases inconsistent. Colden differed with Berkeley, after he had carefully examined the idea, or concept of finite and infinite—which is the basic principle of fluxions. While his studies were comparatively well received in England, they were not apparently appreciated in the Colonies. This is understandable when one considers that there were in the colonies at that time perhaps a dozen scholars who were able to understand and work with the theory of fluxions and the application of gravitation to celestial bodies.

Contemporary with Colden, Johnson and others was James Bowdoin (1726–1790), a scholar of independent means, who became the first President of the American Academy of Arts and Sciences, Boston. He gave much of his time to the theoretical application of Newtonian concepts of Natural Philosophy. Bowdoin came under the influence of John Winthrop of Harvard and at the same time carried on scientific correspondence with Benjamin Franklin in Philadelphia. Without analyzing Bowdoin's work, it is sufficient to give the long titles of his three most learned dissertations on Newton's theories, particularly upon gravitation, light and matter.

1. "Observations upon an Hypothesis for solving the Phenomena of Light; with incidental Observations, tending to shew the Heterogeneousness of Light, and of the electric Fluid, by their Intermixture, or Union with each other."
2. "Observations on Light, and the Waste of Matter in the Sun and fixt Stars, occasioned by the constant Efflux of Light from them: with a Conjecture, proposed by Way of Query, and suggesting a Mean, by which their several Systems might be preserved from the Disorder and final Ruin, to which they seem liable by that Waste of Matter, and by the Law of Gravitation."
3. "Observations tending to prove, by Phenomena and Scripture, the Existence of an Orb, which surrounds the whole visible material System; and which may be necessary to preserve it from the Ruin, to which, without such a Counterbalance, it seems liable by that universal Principle of Matter, Gravitation."

We have reserved to the last an account of three of the best known Newtonian scholars of the Colonies. James Logan, David Rittenhouse, and John Winthrop. But first let us see what instructions were given at Princeton, Pennsylvania and Brown colleges. At Princeton, from the date of its founding in 1746 to 1783 there were a number of mathematical professors who were more interested in other fields of learning than that of mathematics. Some astronomy was taught which was included in the lectures on natural philosophy. Emphasis seems to have been placed on the calculation of eclipses. Newtonian philosophy may have been considered but not with any degree of importance, which may have been due to the lack of interest on the part of the tutors. However, not until the time of Walter Minto, a Scotch mathematician, did Princeton in 1787 attain mathematical importance. The University of Pennsylvania (1755) under the Presidency of Dr. William Smith showed early the value and plan of mathematics in education. During this period Robert Patterson, a native of Ireland, was appointed professor of mathematics in 1779, and held the post for 35 years. Patterson contributed a number of scientific papers to the Transaction of the American Philosophical Society and certain mathematical journals, bearing upon Newtonian mechanics. He also edited a number of books—but these were published after 1783. Brown University, established in 1764 gave promise of being mathematically and astronomically important. This was largely due to the influence of Harvard College, whose professor of mathematics and astronomy, John Winthrop, was the outstanding scholar of his period. Benjamin West was an early correspondent of Winthrop's and proved so able in his comments upon the problems of mathematics, that he was prevailed upon to prepare and observe the transit of Venus in 1769. This phenomenon was one of the most difficult to observe in those pioneer days—yet West observed and prepared his reductions to the great satisfaction of his master.

West in his youth came under the direct influence of Bishop Berkeley while the latter was residing at Newport from 1728 to 1731. Berkeley was a profound Newtonian scholar and possessed a large library from which young West was able to secure much of his learning—besides receiving instruction from Berkeley. With this background of experience with these two leading men of learning, West prepared himself well in Newtonian mathematics and astronomy. It was therefore natural for the authorities of Brown College to appoint West as professor of natural philosophy and mathematics in 1786 which he held for a few years.

Of the "philosophical trio of the Revolution," Benjamin Franklin, John Winthrop and David Rittenhouse, the last named was the mathematician, par excellence. The late Professor Florian Cajori, reviewing the life and work of the mathematicians of the colonial period, said: "The mathematicians mentioned in the previous pages were all engaged in the profession of teaching. But strange as it may seem, the most noted mathematician and astronomer of early times was not a professor in a college, nor had he been trained within college walls. We have reference to David Rittenhouse, who was born near Philadelphia in 1732. During boyhood on his father's farm in Norristown, he manifested great mechanical and mathematical ability, which at twelve years of age was stimulated by a chest of tools and books inherited from his uncle, among which latter was an English translation of Newton's Principia. Doctor Benjamin Rush in his Eulogy of Rittennouse says: 'It was during the residence of our ingenious philosopher with his father in the country that he made himself master of Sir Isaac Newton's Principia, which he read in the English translation of Mr. Motte. It was here, likewise, he became acquainted with the science of fluxions; of which sublime invention he believed himself, for a while, to be the author; nor did he know for some years afterwards, that a contest had been carried on between Newton and Leibnitz for the honor of that great and useful discovery.' So ignorant was he of the progress which this calculus had made, and of the discussions in relation to its invention and improvement, that he for a time considered it as a discovery of his own. In this impression, however, he could not have long continued; as he made, in his nineteenth year, an acquaintance who was well qualified to set him right on this important point." He refers, of course, to the Reverend Thomas Barton, an Episcopal clergyman, graduate of Dublin University, who taught in the Rittenhouse neighborhood. "Desirous to peruse his admired Newton in the original dress, Rittenhouse now applied himself to the study of the Latin language, which he speedily mastered."

No evidence is available to show that Rittenhouse did any original independent work in fluxions. It is clear, however, that he acquired a complete mastery of the mathematical principles of Newton and was able to apply them in numerous complicated problems.

In his annual oration on astronomy before the American Philosophical Society, February 24, 1775, Rittenhouse ardently supports the philosophy of Newton, both natural and metaphysical, and expresses himself in no uncertain terms against atheists and skeptics. After reviewing the history of Astronomy to the time of Newton he says:

> It was Newton alone who extended the simple principle of gravity, under certain just regulations, and the laws of motion, whether rectilinear or circular, which constantly take place on the surface of this globe, throughout every part of the solar system, and from thence, by the assistance of a sublime geometry, deduced the planetary motions, with the strictest conformity to nature and observation.
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> Other systems of Philosophy have been spun out of the fertile brain of some great genius or other; and for want of a foundation in nature, have had their rise and fall, succeeding each other by turns. But this will be durable as science, and can never sink into neglect, until "Universal darkness buries all."
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> Other systems of Philosophy have ever found it necessary to conceal their weaknesses and inconsistencies, under the veil of unintelligible terms and phrases, to which no two mortals perhaps ever affixed the same meaning. But the Philosophy of Newton disdains to make use of such subterfuges; it is not reduced to the necessity of using them, because it pretends not to be of nature's privy council, or to have free access to her most inscrutable mysteries, but to attend carefully to her works, to discover the immediate causes of visible effects, to trace those causes to others more general and simple, advancing by slow and sure steps towards the great First Cause of all things.

Neither Christian nor free-thinker could attack Newton with impunity before this gallant defender. Perhaps it was this impartial attitude that gave the impression to some that Rittenhouse was not a believer in the Christian religion. His testimony, however, throughout his life gave evidence of his religious devotion. Like Newton, whose philosophy he adopted, his soul was white.

The many mathematical and astronomical papers of Rittenhouse were all published in the Transactions of the American Philosophical Society. They are too technical in their content for discussion in this paper. Rittenhouse stands high in the history of science in colonial America and in the Republic, and was the second President of the American Philosophical Society.

A name new to mathematical scholarship in Colonial history is that of James Logan (1674–1751), who was the private secretary of William Penn. He was educated in England and migrated to the colonies in 1671. It appears that he possessed considerable free time which he devoted to scientific study in botany and mathematics, which were his chief interests. There is evidence that Logan had considerable ability in mastering Newton's fluxion theory and the Principia. Logan's first paper on mathematical ideas was in the form of a letter addressed to William Jones, F.R.S., residing in London. This letter has to do with Newton's theory of the moon's motion involving parallel forces and Kepler's second law of motion, and seems to be the only manuscript left by Logan bearing evidence of his Newtonian study. There are a series of letters to his correspondent, William Jones, containing comments, requesting assistance, and directions as to methods of solving certain problems found in the works of Newton. There is, however, no collected series of papers written by Logan showing anything in the form of a completed work. He published several papers on certain physical phenomena in the Transactions of the Royal Society.

Logan's studies of Newton's Principia, 1st edition, 1687, reveals that this was the first copy to arrive in the colonies in 1708. An examination of Logan's copy of the Principia bears evidence of careful reading and study of the problems Newton proposed. This is found in the form of annotations, corrections, notes and cross references made in Latin in his own handwriting. His study of the new science of mechanics is also disclosed in the later works of Newton, such as in the 3rd edition of the Principia, in the Opticks, fluxions, infinite series, as well as Halley's astronomical tables. Inserted in his copy of these tables is an eight-page manuscript in Latin on a method of calculating the moon's motion. At times his critical mind seems to have taken exception to Newton's methods and results.

Had Logan been prepared, or had he been able to give more attention to research, he undoubtedly would have ranked as our first able mathematical scholar.

We have now brought our story of the early development of scientific thought in America down to the middle of the 18th century. We have outlined how the faint attempts to establish higher mathematical learning and a new philosophy based on the Newtonian doctrine, laid the foundation for what follows. The thorough Newtonian scholar is now to appear upon the scene. To know him we must turn our thoughts back to Harvard at the time that Yale received her first great gifts from Newton. In 1714, the very year that Newton's Principia arrived in America, a child was born who was destined to carry the torch of Sir Isaac Newton to still greater heights and to maintain it there.

John Winthrop IV was a direct descendant of the Winthrops so well-known in early American history. Born in Boston, December 19th, 1714, of parents already distinguished in the social and intellectual life of the community, he made rapid advances in his studies. At the age of fourteen, he graduated from the famous Boston Latin School, then entered Harvard and established his place as one of the best students of his class. His great fondness for mathematical studies and experimental science, combined with a temperament tending toward idealism, soon led him to contemplation of the stars and the laws governing their motions. After his graduation in 1732 with the degree of Master of Arts, he retired to his father's home and for the next six years very little was known of him. Then John Winthrop was appointed, at the age of twenty-four, to the Hollis professorship of mathematics and natural philosophy. Winthrop had been examined as to his proficiency in mathematics and the physical sciences, but the question of examining his religious statutes gave the authorities real concern. His views were suspected as being a little too broad for Harvard, even though his ideas embodying the spirit of the Lockean or English philosophy of empiricalism were just the force that Harvard needed. At any rate, he was accepted on the first examination, passed over on the second, and was duly inaugurated to the office which he held for the next forty years with honor and distinction to Harvard and to the history of cultural progress in America. Despite the predominance of orthodox clerical influence, this colonial scholar was not without liberty in the examination of truth according to the modern method. He found his way by setting aside any metaphysical controversy and sought freedom by the enlightened scientific methods of Bacon, Locke and Newton. Having thus far secured his fundamental understanding of Newton's principles of celestial mechanics through secondary sources, he soon secured for himself the original. He acquired this the year after receiving his professorship. At the age of twenty-five, we find Winthrop assiduously engaged in mastering the Principia which he so brilliantly applied to all his long years of subsequent work in astronomy and natural philosophy and in research and class instruction.

Winthrop was more than interested in ascertaining the correctness of Newton's laws of motion from celestial phenomena for he prepared and established the first laboratory of experimental physics in this country in order to test the laws of gravitation of bodies on the earth. In conjunction with these experiments, he demonstrated to his students the motions of planets and comets, and illustrated the problems of eclipses, and so on. Far more significant than this, however, was the first practical demonstration and experiment in electricity and magnetism in a laboratory in America. This was on May 10th, 1746, some twenty years earlier than was designated by the historians of Harvard College. Of course these lecture experiments had to do also with problems of the elements of mechanics, hydro-statics, optics, heat, and the theory of light and prisms according to Newton. These experimental lectures which were given by Winthrop himself before the class, were conducted much as are those in a modern laboratory—except that today the students perform the work themselves.

Winthrop's best known public work were two lectures upon comets, one in particular on the return of the comet (1682), better known as Halley's comet, which he was fortunate to observe, since it was the first predicted return of a comet. This lecture was also read in the Chapel of Harvard College, 11th of April, 1759, as a part of the regular and assigned duty of the Hollis professorship. Winthrop first observed this comet on April 3rd, after it had passed perihelion and like similar celestial phenomena, had caused much anxiety and speculation as to its meaning. In his second discourse before the college on April 18th, 1759, he discussed the true theory of comets according to the work of Newton's *Principia* and also according to the laws formulated by Kepler, with the predictions of Halley. Like all his previous papers or lectures, Winthrop shows a profoundness of learning and authority. This is further evidenced by his mathematical computations connected with the solution of the orbital elements, and the origin of periodic comets, according to Halley.

It has recently come to light that the first introduction into our colleges of the elements of fluxions now known as the calculus, was in connection with the theses required of the students under Winthrop, beginning about 1751. This marks a definite epoch in mathematical studies which has interested students of history for some time.

At the peak of his fame, John Winthrop, scholar, scientist, and astronomer, passed away in Cambridge, on the third of May, 1779, at the age of 65.

This brief survey has shown what the dominant force has been in early mathematical history in the colonies. That this young country should have accepted Newton's philosophy so readily, at the same period of its acceptance by the older countries of the Continent, is indicative of the fertile minds among the intellectuals of early America. Many were not especially prepared to reach this higher realm of mathematical analysis, nevertheless, many knew that Newton's work completed the theories of Copernicus, Galileo and Kepler concerning the laws of motion of the planetary system. That the facts concerning the celestial bodies, their motion, period and so forth can be accurately defined; and that these laws of Nature defined by Newton, are indications of an orderly cosmos, and are a divine expression. With the firm establishment of Newton's fundamental laws of celestial motion and theory of fluxions, a new science of mathematics and astronomy was created — namely celestial mechanics.

This gave many Colonial preachers a theme to ponder upon. They too were not prepared to understand this rationalization against the Puritanic Calvinism that had been established for so long. Newton's work brought forth sermons and philosophical arguments of the most vehement type. In the end Newton prevailed and science gave to the colonial people, a philosophy of rationalism and empiricism never before experienced. This may be said to be the beginning of the making of the modern mind in America.