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# Piety, politeness, and power: Formation of a Newtonian culture in New England, 1727--1779

Frances Herman Lord
*University of New Hampshire, Durham*

# PIETY, POLITENESS, & POWER: FORMATION OF A NEWTONIAN CULTURE IN NEW ENGLAND 1727-1779

BY

FRANCES HERMAN LORD
A.B., Mercyhurst College, Erie, Pa., 1965
M.A., University of New Hampshire, 1991

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This dissertation has been examined and approved.

Dissertation Director, Jan Golinski
Professor of History

Charles E. Clark, Professor Emeritus of History

Eliga H. Gould, Associate Professor of History

Richard M. Candee, Professor of American and New England Studies
Boston University

I. Bernard Cohen, Professor Emeritus of History of Science
Harvard University

Date

**For my parents, Francis Joseph and Anna Hoffman Herman,**
**who inspired my love of learning,**

**and for my husband, Robert Anthony Lord,**
**who inspired my love of history.**

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## ABBREVIATIONS

### Primary Sources

*AD* — *An Astronomical Diary* (1726-1775) by Nathaniel Ames, Jr., (1726-1764) and by Nathaniel Ames III (1765-1775). Printed in Boston, Ma. by Bartholomew Green and later by John Draper and others; Portsmouth, N.H., by Daniel Fowle; Newport, R. I.; and New Haven, Hartford, and New London, Ct.

*AMHC* — *American Magazine and Historical Chronicle*. Boston: Printed by Rogers and Fowle, 1743-1745.

*BEP* — *Boston Evening-Post.*

| | |
|---|---|
| *BG* | *Boston Gazette.* |
| *BNL* | *Boston News-Letter.* |
| *BPB* | *Boston Post-Boy.* |
| Evans | Charles Evans, *Early American Imprints, 1639-1800 Series*, ed. Clifford K. Shipton. New York: Readex Microprint Corporation, 1963–. |
| *NEC* | *New-England Courant.* |
| *NEWJ* | *New-England Weekly Journal.* |
| *NHG* | *New Hampshire Gazette.* |
| W-W Papers | Warren-Winthrop Papers, Mercy Warren Papers, 1709-1841, Massachusetts Historical Society, Boston, Ma. |

Secondary Sources and Institutions

| | |
|---|---|
| AAS | American Antiquarian Society, Worcester, Ma. |
| AAS *Proc.* | *Proceedings of the American Antiquarian Society.* |
| CSM *Pubs.* | *Publications of the Colonial Society of Massachusetts.* |
| EIL | Essex Institute Library, Salem, Ma. |
| *EIHS* | *Essex Institute Historical Collections.* |
| MHS | Massachusetts Historical Society, Boston, Ma. |
| PA | Portsmouth Athenaeum, Portsmouth, N. H. |
| *SHG* | John L. Sibley et al. *Biographical Sketches of Graduates of Harvard College* [*Sibley's Harvard Graduates*], 17 vols. Cambridge: Harvard University Press, 1873-1975. |

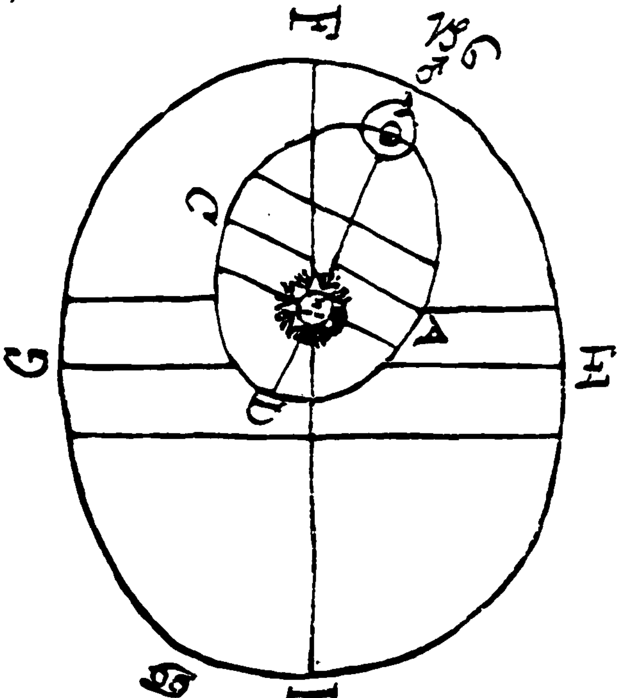

**Fig. 1. A personified sun centers this "geometrical," (i.e., "Newtonian') scheme of planetary motion in Nathaniel Ames's *Astronomical Diary . . . for 1750*—a visual representation of the eighteenth-century conjoining of traditional lore and science.**

## ABSTRACT


PIETY, POLITENESS, & POWER:
FORMATION OF A NEWTONIAN CULTURE IN NEW ENGLAND
1727-1779

by

Frances Herman Lord

University of New Hampshire, September, 2000

This dissertation explores how men and women deployed the mathematical and experimental science of Isaac Newton and the new science based upon his work as the framework for a "Newtonian culture" in New England between 1727 and 1779, which established our modern view of the natural world and the authority of science. Their endeavors often involved co-opting the authority, and the cachet, of Newton's name and redirecting it toward new ends that involved both the affirmation and challenge of prevalent cultural, religious, and social values. This study examines the uses of Newtonian natural philosophy within the context of the cultural transformation, or anglicization, of colonial society as it became rationalized and refined. The Newtonian philosophy was an inclusive and flexible system, explored here according to the behavior and motives of mid-eighteenth-century men and women. Fostering its popularization were other cultural practices: piety (to enhance religious belief and practice), politeness (to evince polite learning and refined living), and power (to reinforce or challenge existing hierarchies).

Investigating how ordinary and elite New Englanders encountered the Newtonian universe through print and material culture, this study finding new faces and sites in the history of early American science. Newtonian science was discussed, disputed, displayed, and demonstrated in front parlors, gentlemen's studies, women's correspondence, and the newspapers, as well as social

libraries, church pulpits, and lecture halls. A new genre of "Newtonian literature" appeared among the core titles of booksellers' and social library catalogues, available for consumption by Anglo-Americans aspiringing to the polite culture of metropolitan London. Available to elite and vernacular audiences were domestic publications (almanacs, sermons, newspapers, demonstration catalogues, and poetry) featuring the new science. Public demonstrations and at-home observations by men and women, inspired by new discoveries in natural philosophy, occurred in a "sociable sphere" that mediated between public and domestic spheres. Although an uneven process often checked by opposing forces, by the end of the 1770s a Newtonian natural philosophy, with an accretion of metaphysical concepts, became a subtle force within the popular culture of New England, much as Newton's "Subtle Fluid" or "aether" permeated the whole of the natural world.

# INTRODUCTION

The death of Isaac Newton (1727) and that of his most prominent advocate in New England, John Winthrop (1779) bracket an age fascinated with the natural world not only because of traditional religious interest in deciphering God's message in "extraordinary" events, but also because of the wonders revealed by the new science of Isaac Newton. This dissertation discusses how men and women of eighteenth-century New England became cognizant of the "new System"of Newtonian natural philosophy and how it assumed meaning in their lives. Informed by the methods, goals, and ideals of Isaac Newton, they accommodated Newtonian philosophy to prevalent beliefs, customs, and institutions, thus forming a "Newtonian culture" in New England which underlies our twentieth-century view of the natural world.[1]

This study explores various aspects of the dissemination of Newtonian science, by focusing on how both ordinary and elite New Englanders encountered Newton and the Newtonian universe through the print and material culture of the mid-eighteenth century, and by examining various sites where natural philosophy was taught, discussed, and displayed. Print culture included an array of imported texts and popularized versions of Newtonian philosophy, while material culture included mezzotints, which celebrated his person, achievements, and "immortality" (fig I.1), and artifacts, such as jewelry, bearing his image. Just as important, and available to a wider audience, composed of ordinary as well as "learned" readers, were colonial publications (primarily sermons, almanacs, and newspapers, but also catalogues for science demonstrations and poetry). Public lectures and demonstrations featured the new science and promulgated it not only on the lecture stage, but also

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[1]This is not a claim that a Newtonian culture was exclusive to New England, especially since networks of trade, print information, and scientific correspondence crossed colonial boundaries. How such a culture developed in other regions of Anglo-America is a subject for further research.

through newspaper advertisements and eyewitness accounts. Hence the popularization of Newtonian philosophy extended far beyond the colonial colleges, where it is usually examined, to sites available to literate men and women. It was read, discussed, observed, displayed, performed, and disputed at church pulpits, classroom podiums, public lecture halls, and social libraries as well as over a bowl of punch in gentlemen's studies and over women's tea tables in front parlors. These endeavors, especially those involving display and dispute often co-opted the authority, as well as the cachet, of Newton's name and redirected it toward new, but not always scientific, ends; this involved the affirmation and sometimes challenge of prevailing cultural and religious values. Influenced by recent works that have articulated a model of "public science," which examines the construction of science and its audiences within their cultural context, this study will explore the significance of natural philosophy and its audience in New England as it spread in the middle decades of the eighteenth century to booksellers' stalls, social libraries, and the public stage, as well as formal parlors and farmers' kitchens.[2] Because these activities occurred at a time when society itself was undergoing change, the uses of Newtonian philosophy occurred within the context of the cultural transformation, or "anglicization," of colonial society as it gradually adapted the "polite" values of upper class English society to colonial beliefs and institutions, thus becoming rationalized and refined.

New Englanders viewed Newtonian philosophy as an inclusive and flexible system, because it provided a framework for both *exploring* the natural world and *interpreting* it, as suggested by the mezzotint that "glorified" Newton and his accomplishments. In the former sense, Newtonian science

[2]For the development of this model, see Larry Stewart, *The Rise of Public Science: Rhetoric, Technology and Natural Philosophy in Newtonian Britain, 1660-1750* (New York: Cambridge University Press, 1992); Jan Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820* (New York, Cambridge University Press, 1992). For a review that provides an historiographical context for their work, see John Money, "From Leviathan's Air Pump to Britannia's Voltaic Pile: Science, Public Life and the Forging of Britain, 1660-1820," *Canadian Journal of History* (Dec. 1993): 521-544.

answered the queries of natural philosophers concerning matter and motion (the *physical means* of the created world), while in the latter, under the guise of Newtonian metaphysics, it answered the questions of clerics, poets, and enthusiasts concerning motive and purpose (the *metaphysical meaning* of creation). How eighteenth-century men and women behaved within these frameworks is the theme of this dissertation, and its purpose is the recovery of the "webs of significance," to use Clifford Geertz's term, they spun around their varous practices of Newtonian philosophy.[3] When viewed as a cultural practice, explored according to the behavior or motives of natural philosophers, *and* enthusiasts and devotees of the new science, it intersected with the cultural practices of piety (to enhance religious belief and practice), politeness (to evince polite learning and refined living), and power (to reinforce existing hierarchies or create new ones). These practices, themselves potent forces within New England society, enabled individuals as diverse as college professors, traveling showmen, and society matrons to adapt the methods and goals of Newtonian natural philosophy to their own ends and hastened the development of a Newtonian culture in New England which bridged learned and popular culture.[4]

Consequently, this study takes a broad view of the elements that defined this culture by employing the terms "Newtonian thought" and "Newtonian philosophy" to represent several different usages of the natural philosophy of Isaac Newton as they were developed from his original works and deployed in the mid-eighteenth century. In the first instance, Newtonian thought refers to

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[3]Clifford Geertz, "Thick Description: Toward an Interpretive Theory of Culture," in *The Interpretation of Cultures, Selected Essays by Clifford Geertz* (New York: Basic Books Inc., 1973), 5. In developing this theme, I have followed Geertz's dictum that "behavior must be attended to, and with some exactness, because it is through the flow of behavior—or, more precisely, social action—that cultural forms find articulation," Ibid., 17.

[4]For a review of new approaches that treat the popularization of science (primarily in England) as "culturally situated," see Roger Cooter and Stephen Pumfrey, "Separate Spheres and Public Places: Reflections on the History of Science Popularization and Science in Popular Culture," *History of Science* 22 (1994): 237-67. Their warning that science assumes its own meaning within popular culture, often different from that intended by its elite popularizers informs Chap. II below.

the natural philosophy set forth by Newton in his *Principia* and *Opticks*, a natural philosophy grounded on evidence obtained from experiment and observation and developed in a mathematical framework without recourse to hypothesis. Newton's own works, imported into New England along with the works of his interpreters and explicators, as seen in Chapter One, promulgated his methodology and inspired the endeavors of science practitioners, such as the natural philosophers introduced in Chapters Three and Four, in the fields of experimental philosophy (physics), astronomy, and optics. The second use of Newtonian philosophy refers to the natural philosophy that developed in the post-Newtonian eighteenth-century, but which bears the imprint of Newton's thought, methods, and results. Hence other branches of natural philosophy, particularly electricity and its demonstrators, find a place in this study, for they were conceived and found their structure under the seal of Newton's science. A related, and still broader, use of Newtonian philosophy or thought denotes a rational outlook and a critical assessment of evidence, characteristic of Newtonian science. This outlook gradually dominated the thinking of men and women in the post-Newtonian decades, even in non-scientific domains, because, as is especially evident in Chapter Five, it provided a way of ordering knowledge and also of perceiving the world and confirming one's place in it.

Newtonian natural philosophy also inspired a galaxy of theological and metaphysical ideas spun out from Newton's *Principia* and *Opticks* by his ardent disciples and spokesmen. These ideas found their way into eighteenth-century discourse as a coherent system of metaphysics, which went far beyond Newton's scientific theories in an effort to explain the workings of the entire universe and God's relation to it.[5] Central to this world view was belief in what is termed "the scientific harmony

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[5]Early 20th-century scholars, such as H. Drennon, have used the term "Newtonianism" to describe this world view, Drennon, "Newtonianism: Its Method, Theology, and Metaphysics," *Englishe Studien* (1933): 397-409. Because this usage distorts the original meaning of Newtonianism, I shall refer to this world view as "Newtonian metaphysics" (in contrast to my use of "Newtonian culture" to describe a more diffuse cultural formation). The 18th-century use of "Newtonianism" embraced several different meanings that were all embodied in the "method or order" employed by Newton and/or the theories explicated by him in the *Principia* and/or the

of the universe," which had been so wonderously revealed by Newton's insights into the laws governing the physical structure of the universe. This concept implies belief in both the inductive approach to empirical knowledge and the demonstrable rationality of world-order (i.e., the world is governed by immutable, mathematical laws).[6] Newtonianian enthusiasts used the tools of induction and rationalism to investigate theological, metaphysical, and even social phenomena. Thus they inflated the scope of Newtonian natural philosophy, pushing it beyond the realm of mathematics and physics to a far wider application especially to the realm of religion and "professors" of religion, that is those men and women who "professed" belief in religion.[7]

The conflation of religion and natural philosophy integral to Newtonian metaphysics raised no eighteenth-century eyebrows, because at that time natural philosophy and theology were not distinct disciplines but simply different branches of "science" (a term used synonymously with "knowledge"). Natural philosophy and religion both delved into the causes of things. For its practioners, whether clerics or educated laity, they were reciprocal avenues of investigation, because knowledge of natural (or secondary) causes within the created world complemented knowledge of the ultimate cause of creation. For Newtonian natural philosophers, as for Newton himself, God was the "Author" and "Governor" of the world and its laws. Theirs was a providential universe, but only

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*Opticks*, I. Bernard Cohen, *Franklin and Newton, An Inquiry into Speculative Newtonian Experimental Science* (Philadelphia: The American Philosophical Society, 1956), 179-82.

6Drennon, "Newtonianism," 402-03.

7Pushing the limits has led scholars to evaluate the social context of Newtonian philosophy. For a controversial application of its social use, i.e., Newtonian philosophy as the basis for Whig politics in 18th-century English political life, see Margaret C. Jacob, *The Newtonians and the English Revolution, 1689-1720* (Ithaca: Cornell University Press, 1976). For a review of the "contextualist" as opposed to the "intellectualist" approach to "Newtonianism," see Steven Shapin, "Social Uses of Science," in *The Ferment of Knowledge: Studies in the Historiography of Eighteenth-Century Science*, ed. G. S. Rousseau and Roy Porter (Cambridge: Cambridge University Press, 1980), 93-107.

in a limited sense: the "divine arm"[8] created and maintained (however mysteriously) the workings of the universe only through "natural" laws: the laws of motion and gravity explicated by Newton. To study creation, whether through the telescope or the microscope, revealed the divine order imposed by those laws *and* the glory, power, and goodness of their Creator. So awesome was this realization that within a decade after his death in 1727, Newton's devotees in England included clerics, poets, and the educated gentry for whom the study of the rational world of nature became both a polite pastime and an act of devotion.

The questions raised by exploring natural philosophy as a cultural practice through the lens of piety, politeness, and power did not concern the early scholars of the history of science in America. Scholars such as Dirk Struik, Brooke Hindle, and Samuel Eliot Morison were concerned with tracing the diffusion of European enlightenment ideas that would produce an atmosphere conducive to scientific observation and experimentation in the colonies, beginning in the late seventheenth-century. Their studies took either a hermeneutic approach, tracing the threat of the new mechanistic world view to orthodox theology, or a biographical approach, placing eminent members of the nascent scientific community within the context of European science. Morison, as well as Theodore Hornberger and Raymond Phineas Stearns, also discussed the scientific endeavors of seminal promoters and practitioners of experimental philosophy, the development of a Newtonian science curriculum at the infant colonial universities, and the establishment of a colonial network with ties to the Royal Society.[9]

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[8]Newton used this metaphor in accounting for the transverse movement of celestial bodies, quoted in Drennon, "Newtonianism," 405.

[9]Standard introductory works include Dirk J. Struik, *The Origin of American Science (New England)* (1948, repr., New York: Cameron Associates, 1957); Brooke Hindle, *The Pursuit of Science in Revolutionary America, 1735-1789* (Chapel Hill: The University of North Carolina Press, 1956); Samuel Eliot Morison, *Intellectual Life of Colonial New England*, 2d ed. (New York: New York University Press, 1956), Chap. 10; Theodore Hornberger, *Scientific Thought in the American Colleges, 1638-1800* (1946; repr., New York: Octagon Books, Inc., 1968); and Raymond

The important role of the colonial colleges in teaching Newtonian science has been addressed in the works of Morison, Hornberger, and I. Bernard Cohen and is not re-visited here, because my purpose is to explore alternate sites of Newtonian science where its practice attracted a more inclusive audience than that embraced by classroom walls.[10] The nucleus of learned men in New England who were graduates of Harvard, Yale, Dartmouth, or Rhode Island College (Brown) had the benefit of systematic instruction in Newtonian natural philosophy. That they provided the fertile ground necessary for the cultivation of a Newtonian culture is tacitly acknowledged throughout this study, for numbered among its protagonists are influential teachers and graduates who brought Newtonian science out of the classroom into the church pulpit, formal parlor, public lecture hall, and social library and also onto the pages of newspapers and almanacs.

Women were not a subject of the early investigations of science in colonial America. With the advent of feminist studies, however, attention did turn to recovering the exceptional few women who, usually under the patronage of a sympathetic or needful male relative, engaged in scientific activities such as botany or astronomy. Joan Hoff Wilson's list of only nine women engaged in science during the colonial period shows just how minimal were female scientific endeavors in pre-Revolutionary America if considered within the traditional definition of "scientist."[11] Aware of the paucity of her investigation, Hoff suggested that what is needed is a new conceptual framework.

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Phineas Stearns, "Colonial Fellows of the Royal Society of London, 1661-1788," *William and Mary Quarterly*, 3d ser., 3 (1946): 208-68; and Ibid., *Science in the British Colonies of America* (Urbana: University of Illinois Press, 1970).

[10]Hornberger, *Scientific Thought*; Morison, *Intellectual Life*; Ibid., *Three Centuries of Harvard* (Cambridge: Harvard University Press, 1936); I. Bernard Cohen, *Some Early Tools of American Science, An Account of the Early Scientific Instruments . . . in Harvard University* (1950, repr., New York: Russell & Russell, 1967), Ibid., *Science and the Founding Fathers* (New York: Norton, 1995), Chap. 4.

[11]Joan Hoff Wilson, "Dancing Dogs of the Colonial Period: Women Scientists," *Early American Life* 7 (Winter 1973): 225-35.

Shifting the focus from "creators" to transmitters" of science, as suggested by Margaret Rossiter, has been fruitful in studies of women and the popularization of science in the nineteenth century, but Rossiter's limited definition of scientist led her to revise Hoff's list downward to only one early American female scientist.[12] Taking a slightly more inclusive view, studies of the "scientific lady" in England from the late seventeenth through the eighteenth centuries have exposed an informal network of women who transmitted scientific ideas through their own investigation, writings, schools, or salons.[13] But the lack of an equivalent, female colonial network and institutions frustrates the seach for any such early American "scientific ladies."[14] Changing focus from institutions to individuals, however, suggests a new approach to the history of science in America. An investigation that proceedes from the viewpoint of the meaning individuals invested in Newtonian natural philosophy as they adapted it to the circumstances of their lives proves a fruitful way to recover the participation of women as well as men hitherto considered outside or on the periphery of science institutions.

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[12]Margaret W. Rossiter, *Women in Science in America: Struggle and Strategies to 1940* (Baltimore: Johns Hopkins Press, 1982). For a review of works dealing with the search for women in science, and an evaluation of traditional and new approaches, see Sally Gregory Kohlstedt, "Women in the History of Science," Paper given at the Annual Meeting of the History of Science Society, Madison, Wis., Oct. 1991. For an approach that takes into account the gendering of science, and the complex interactions between women, science and society, see the collection of essays in *Science and Sensibility: Gender and Scientific Enquiry, 1780-1945*, ed. Marina Benjamin (Cambridge, Ma.: Basil Blackwell Inc., 1991).

[13]Gerald Dennis Meyer, *The Scientific Lady in England* (Berkeley: University of California Press, 1955); Patricia Philips, *The Scientific Lady: A Social History of Women's Scientific Interests, 1520-1918* (New York: St. Martins Press, 1990).

[14]For the sucessful recovery of 19- and 20th-century "scientific ladies" from Britain, the United States, and Canada, see the essays on women popularizers of "vernacular" science in *Natural Eloquence, Women Reinscribe Science*, ed. Barbara T. Gates and Ann B. Shteir (Madison: University of Wisconsin Press, 1997). For the *literary* salons of elite women in Bitish American, starting in the 1750s, see David S. Shields, "Literary Culture in the Eighteenth Century," in *The Colonial Book in the Atlantic World*, ed. Hugh Armory and David D. Hall (Cambridge: AAS and Cambridge University Press, 2000), 461-64.

During the early decades of the eighteenth century in England the world of expanding knowledge and science, of discoverable nature and rational exploration inspired in large part by Newtonian philosophy, intersected with the forces of a "commercial society" to produce fundamental change. This change, signifying the development of a "modern" world view, was hastened by the "commercialization" of society; that is, by the ever-increasing availability of "knowledge and things" and the public's ever-increasing desire and ability to acquire them. In the area of natural philosophy this meant not only the production of books, apparatus, and even toys for entertainment and improvement but also the proliferation of scientific lectures aimed as much at entertaining as at instructing. The forces of ready production, widespread distribution, and inspired marketing of goods and knowledge met in turn with eager consumption, thus extending this transformation from metropolitan to provincial centers, and from elite to middling classes.[15]

As provincial centers in Anglo-America responded to these changes, Newton's philosophy also became current in New England, due initially to the efforts of teachers, preachers, and early almanac makers, and then through imported texts from the shelves of booksellers or social libraries and science demonstrations publicized in the press. Newtonian natural philosophy first entered religious discourse with Cotton Mather's *The Christian Philosopher* (London, 1721) and *Manudutio ad Ministerium* (Boston, 1726).[16] So pervasive was Newton's fame and his

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[15]For the seminal articulation of this view, see Neil McKendrick, "Introduction" in Ibid., John Brewer, and J. H. Plumb, *Birth of Consumer Society: The Commercialization of Eighteenth-Century England* (Bloomington: The University Press, 1982); on science books, see McKendrick, Chap. 1; on instruments, see Gerard L'E. Turner, "The London Trade in Scientific Instrument-Making in the Eighteenth Century," *Vistas in Astronomy* 20 (1976): 173-81; on toys developed from 18th-century demonstration apparatus and popular through the twentieth century, see Turner, "Scientific Toys," *British Journal of the History of Science* 20 (1987): 383-397.

[16]The framework for setting science, including natural philosophy and natural history, in a religious context had been advanced in the late 17th century by Robert Boyle's *The Christian Virtuoso* and John Ray's *The Wisdom of God manifested in the Works of Creation*, both extremely popular among New England learned readers.

investigations of the heavens that children sounded out his name in their spelling books and observed the three wise men in eighteenth-century dress use telescopes to trace the star of Bethlehem in *The History of the Holy Jesus*, an illustrated and versified introduction to the Bible for very young readers (fig. I.2).[17] Men, women, and children employed the telescope themselves to enhance their gaze of the heavens, as portrayed in an illustration of Bostonians clustered around the telescope, prominently erected in a public space to observe the comet of 1744 (fig. I.3). Newtonian philosophy intersected not only with the pious practices of ordinary children and adults, but also with the colonial elite's desire to consume the intellectual as well as material culture of England. Motivated by the desire to participate in the "polite" culture of metropolitan England, they too marveled at the wonders revealed by Newtonian natural philosophy.

Historians have identified certain crucial trends that hastened the "anglicization" of colonial society in this period. The diffusion of British culture from London, the metropolitan capital, to colonial or provincial centers in the British colonies occurred, according to Jack Greene, through the conscious replication of British institutions. According to Richard Bushman, this transformation also took on a class dimension as a newly-emerging colonial "gentry" sought to consolidate their social position and power by emulating the lifestyles and accumulating the trappings of gentility exhibited by British aristocracy. T. H. Breen credits the widespread availability of affordable English-produced goods with the creation of a common consumer mentality that created an Anglo-American "empire of goods."[18] Subsequent scholarship has examined the acquisition and display of

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[17]Thomas Dilworth, *A New Guide to the English Tongue*, 15th ed. (New York, 1754), 66; Anon., *The History of the Holy Jesus*, 5th ed. (Boston, 1748); the following inscription written on the illustration of a woman reading to an infant in a cradle opposite the injunction to "diligently read, / And ponder every Verse" denotes the *History's* longevity: "Elizabeth Sangers Book / Given Her by her mother / September *1900*," (italics mine). See also, *The History of the Holy Jesus: A list of editions of this once popular Children's Book*, comp. Albert Carlos Bates (Hartford, 1911).

[18]Jack P. Greene, *Pursuits of Happiness: The Social Development of Early Modern British Colonies and the Formation of American Culture* (Chapel Hill: University of North Carolina Press,

various kinds of "goods" traded within this empire including clothing and portraits in order to determine the "changing lifestyles"of the colonial elite.[19]

A concurrent explosion of print culture, as described by David Hall, and the creation of "communication networks" based on print rather than word of mouth, as delineated by Richard Brown, fostered the transmission of new information.[20] Due to the widespread availability of books, "extensive" reading of new forms of polite literature, including novels and journals, gradually replaced the "intensive" reading of a relative few, but perennially popular, religious texts. The hegemony of "learned" culture over "vernacular," or common culture, remained incomplete, however, due to the persistance of orthodox piety evinced in the continued popularity of "standard" devotional works well into the nineteenth century. Indeed, as Hall has probed deeper into the seeming dichotomy of "learned" versus "vernacular," it has become apparent that the two cultures were not mutually exclusive; instead, they interacted, as individuals made their own personal accommodation of polite learning and popular piety.[21]

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1988); Thomas H. Breen, "'Baubles of Britain': The American and Consumer Revolutions of the Eighteenth Century," in *Of Consuming Interests, The Style of Life in the Eighteenth Century*, ed. Cary Carson, Ronald Hoffman, and Peter J. Albert (Charlottesville: University Press of Virginia for the United States Capitol Historical Society, 1994), 444-82; Richard L. Bushman, *The Refinement of America: Persons, Houses, Cities* (New York: Vintage Books, 1993).

[19]See, for example, Karin Calvert, "The Function of Fashion in Eighteenth-Century America"and Margaretta M. Lovell, "Painters and Their Customers: Aspects of Art and Money in Eighteenth-Century America," in *Consuming Interests*, 252-283 and 284-306. These and other essays in *Consuming Interests* comprise an overview of colonial shopping habits.

[20]David D. Hall, "The Uses of Literacy in New England, 1600-1850," in *Printing and Society in Early America*, ed. William L Joyce, David D. Hall, Richard D. Brown, and John B. Hench (Worcester: AAS, 1983), 1-47; Ibid., "Books and Reading in Eighteenth-Century America," in *Consuming Interests*, 354-72; Richard D. Brown, *Knowledge is Power: The Diffusion of Information in Early America, 1700-1865* (New York: Oxford University Press, 1989).

[21]David D. Hall, "Learned Culture in the Eighteenth Century," in *Colonial Book*, 430-33. Hall's insights into the existence and persistence of a vernacular, Protestant, or "low" book culture, the development of a refined, "literary" or "high" book culture," and the resultant tensions as well as the establishment of a middle ground where they co-existed, can be traced in his collected essays in

Hall's seminal work provided the impetus for a new body of scholarship that has examined the multi-faceted colonial book trade from the perspective of book publishers and wholesale dealers in England and the colonies, the importation and distributions of books, and the development of a "book culture."[22] Charles Clark's analysis of another aspect of this print culture— the colonial newspapers or "public prints"—shows how newspapers were the vehicle for drawing ordinary readers into the belief system of the "upper-class, cultivated, . . . patriotic, . . . ethnocentric, Protestant English male." Hence his analysis has enriched our understanding of the development by the mid-century of an inclusive, genteel "Anglo-American" print culture and the importance of newspapers in disseminating "virtually unquestioned assumptions" concerning social, political, religious, and moral values."[23] Most recently, the concept of "politeness," has nuanced the model of anglicization. American historians have drawn on the insights Lawrence Klein articulated after exploring the importance of discourse in the formation of a "culture of politeness" and in the exhibition of civility in English society.[24] Most notably, David Shields has looked at the role of private society in British America, focusing on "belles lettres" as the source of social exchange and civility in the public sphere. His work brings to light the discursive practices integral to private associations such as taverns, coffeehouses, social libraries, clubs, salons, and tea tables where, he

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*Cultures of Print: Essays in the History of the Book* (Amherst: University of Massachusetts Press, 1996).

[22]See, for instance, studies of the book trade, "bibliocultural" printing, and the impact of printing, in the chapters so named in *Printing and Society*; for the definitive treatment, based on the most current and comprehensive scholarship, of the context, cultural meaning, and impact of publishing, writing, and reading in Anglo-America through 1790, see *Colonial Book*.

[23]Charles E. Clark, *The Public Prints: The Newspaper in Anglo-American Culture, 1665-1740* (New York: Oxford University Press, 1994), quote 221.

[24]Lawrence E. Klein, *Shaftesbury and the Culture of Politeness: Moral Discourse and Cultural Politics in Early Eighteenth Century England* (Cambridge: Cambridge University Press, 1994).

contends, a vision of civility emerged that defined American culture into the early Republic.[25]

Hall, Clark, and Shields have all treated an acquaintance with Newtonian natural philosophy as a marker of learned society, but it has had only a peripheral place in their studies of cultural institutions. Although Hall cites natural philosophy as an important influence on eighteenth-century literary culture, his work has not focused on the specific sources, including imported texts, of that influence.[26] Clark cites the "belief in science and reason . . . combined in varying degrees with the continued belief in the providential governance of both natural and human affairs" as one of the underlying assumptions of Anglo-American culture. More specifically, he casts the "orderly" laying out of the news within the framework of the "rationalistic currents of time" and the eighteenth-century fascination with time and duration "compatible with the newly explained universe of Newton."[27] Shields has noted the influence of Newton's "messianic science" on the "cosmopolitan" writers of the religious sublime poetry of the 1720s, viewing it as one example of the attempt by colonial writers of belles lettres to reconcile the Christian view of supernatural power with the social virtues of politeness. He has also recognized the role of social libraries as sites where local discourse "vivified" the subject matter of the books upon their shelves, which afforded readers the opportunity to become familiar with, among others, "learning from the universities, professional treatises, . . . [and] approved European authors and critics"—in short, books supplied by the Anglo-American book trade.[28] These scholars' explorations of the dynamics of colonial print culture, its participants, and its discursive practices underlie this study.

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[25]David S. Shields, *Civil Tongues & Polite Letters in British America* (Chapel Hill: University of North Carolina Press, 1997).

[26]See, for instance, Hall, "Learned Culture in the Eighteenth Century," in *Colonial Book*, 432-33.

[27]Clark, *Public Prints*, 216-17.

[28]Shields, *Civil Tongues*, 231, 236; Ibid., "Literary Culture," in *Colonial Book*, 476.

This study views the incorporation of Newtonian thought (including Newton's own thought and the later thought based on the intellectual foundation he provided) as a central element in the cultural shifts occurring in mid-eighteenth-century Anglo-American society. Chapter One establishes how New Englanders "trafficked" in Newton, that is, how they encountered Newton, face-to-face through imported mezzotint portraits, and ideologically through imported books that introduced and popularized Newtonian astronomy and experimental philosophy. It first examines the popularity of Newton as a icon and his appeal to science devotees by looking at representations of Newton in the material culture of New England. It then analyzes catalogues of booksellers and social libraries to establish the availability and appeal of imported "Newtonian literature," which comprises academic texts, physico-theological works, and philosophical poetry, as well as "polite" and "easy" introductory texts and science reference works. The significant presence of the various types of Newtonian literature on booksellers' and social library shelves suggests it should be viewed as a genre in itself—equally important to the Anglo-American book trade and to the reconciliation of polite and religious cultures as the novels and standard works of piety that Hall has considered. Concluding with an examination of the cultural and community context of a specific social library, that of Portsmouth, New Hampshire, Chapter One sets forth the use of natural philosophy in the service of both religious conviction and cosmopolitan aspirations.

Nature's and Newton's newly revealed wonders—the cause of planetary motion, the explanation of tides, the return of comets, and the refraction of light in a rainbow—revealed a beneficent God, awesome in his goodness, who himself acted according to the laws he had created to govern the natural world. Holy Scripture, on the other hand, revealed a different God, described by the young country cobbler, Samuel Lane, as the God of "Remarkable Providences . . . Death, Thunder and Lightning, Lights in the Air." This was an entirely providential God, terrible in his goodness, who could act outside the laws he had created to govern the universe, setting aside merely secondary causes (natural laws) to intervene directly through the agency of a thunderstorm or earthquake to chastise, instruct, or reward his people. Here arose the tension between orthodox piety embedded in revealed religion and the new, rational belief spearheaded by Newtonian natural philosophy. Because the celestial world was the especial province of almanac makers and because their audience comprised vernacular as well as learned readers, almanacs are telling records of the accommodation of these two beliefs. Chapter Two surveys the almanacs produced first by Dr. Nathaniel Ames, Jr., and then by his son, Dr. Nathaniel Ames III, over the course of nearly fifty years for a readership that by the 1760s numbered between 50,000 and 60,000 men and women annually.[29] In addition to showing how the Ameses introduced various elements of astronomy, often set in a Newtonian context, to their readers, it shows how the elder Dr. Ames struggled to reconcile the rational explanation of extraordinary events with his own belief in providentialism overlaid with astrological implications. Complicating his resolution was the necessity to respond to the changing expectations of his readers as they mirrored societal changes during his forty-year career.

Chapter Three re-examines the conflict that erupted after Thomas Prince, the co-pastor of Boston's South Church, and John Winthrop, the professor of natural philosophy and mathematics at Harvard, were shaken from their beds by the earthquake of 1755. This experience jarred them, as well as many of New England's ministers and lay persons conversant with natural philosophy, into a debate over the role of natural versus providential causes of extraordinary events. Both intellectual historians as well as historians of science have remarked upon this well-publicized controversy played out in the Boston newspapers, which embodied some degree of bifurcation of the original Newtonian philosophy that had united theology and science in a harmonious whole. Seeing the claims of revealed religion as well as Prince, a venerable cleric, on one side of a metaphysical divide with reason and an enlightened Winthrop, Anglo-America's foremost astronomer, on the other,

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[29]Hugh Amory, "Reinventing the Colonial Book," in *Colonial Book*, 52.

some scholars have identified it as the critical point in the rationalization of American religion and science.[30] Hence, the new science, spearheaded by the natural philosophy of Isaac Newton, broke through the twin barriers of strict, orthodox Calvinism and providentialism.[31] Yet, as David Hall, in particular, has shown, what formerly was viewed as a divide between science and religion is more properly regarded as a shifting continuum. This view of the reciprocal relationship between natural philosophy and religion and the view of science as knowledge that can be appropriated by an individual to enhance one's own scientific theories as well as one's power and position, developed in the work of Simon Schaffer,[32] provides a new and fruitful perspective for investigating this power play in the public prints..

Chapter Four observes the scene as the young gentleman-scientist, Edward Bromfield, whose own research was grounded in Newtonian methodolgy, entertained a gathering of friends in 1745 at his wealthy family's Boston mansion house by demonstrating the powers of his solar microscope. A young woman in attendance later put her recollections of the afternoon in poetry, published after Bromfield's death, lauding him for revealing the "glories" of creation and their Creator. This incident reveals a hitherto unexamined facet of the popularization of science in the American colonies, namely that practitioners of "polite science"[33]—ladies and gentlemen alike—could have a meaningful and visible role in this social transformation. Bromfield's

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[30]See, for example, Charles E. Clark, "Science, Reason and an Angry God: The Literature of an Earthquake," *New England Quarterly* 38 (1965): 340-62.

[31]Struik, *Origin of American Science*, 30-32; (Struik also sees this a divide between credulous countryfolk and the "wordly learning" of town merchants). Cf. Hindle, *Pursuit of Science*, 95.

[32]Simon Schaffer, "Natural Philosophy and Public Spectacle in the Eighteenth Century," *History of Science* 21 (1983): 1-43.

[33]For the development of this concept and its use in English society, see Alice Nell Walters, "Conversation Pieces: Science and Politeness in Eighteenth-Century England," *History of Science* 35 (1997): 121-54.

performance of natural philosophy provides a contrast for the public performances mounted by lecturers and demonstrators of experimental philosophy, astronomy, electricity, and pneumatics, who were motivated either explicitly or implicitly by the theories or methods of Newtonian science as well as by entrepreneurial impulses. Advertisements in the public prints, occurring from the 1720s through the 1770s, reveal the demonstrators' manipulation of natural philosophy according to their own educational, religious, and commercial agendas and according to their anticipation of the audiences' aspirations.

Bromfield's young woman guest provoked this study of Newtonian culture in New England. There are clues, as diverse as they are tantalizing, of female interest in natural philosophy in eighteenth-century New England. They range from images of the Newtonian universe in women's own devotional and "philosophical" poetry; to entries in booksellers' and social library catalogues for popularized versions of Newtonian science for "young Gentlemen and Ladies"; to newspaper advertisements for jewelry bearing Newton's image and for public demonstrations of natural philosophy seeking the patronage of ladies; as well as clues in women's correspondence of their participation in the "domestic" practice of science. Not until the implications of the anonymous young woman's attendance at Bromfield's optical demonstration and her poem became apparent, however, did the larger issue of the meaning of science in women's lives begin to emerge. This incident suggested a new approach to recover women's role in early American science. Chapter Five, building on the correspondence between Hannah Winthrop and Mercy Warren as well as that between Elizabeth Stiles and her father Ezra Stiles, answers the long-standing challenge to develop a new conceptual framework for evaluating women's role in science. It suggests the home itself be considered a site where the ideals of Newtonian science informed women's "rational" discourse and their domestic practices of science, simultaneously drawing them out of the prescribed "domestic" sphere to a "sociable" sphere where, like Bromfield's female guest, they engaged with others in scientific discourse and observation.[34] Thus, by looking at science in women's lives, rather than women "in science," this study concludes by delineating yet another "web of significance" among those devised by eighteenth-century practitioners and devotees of Newtonian natural philosophy.

Two hundred years after the men and women in this study encountered Newton, Alexandre Koyré observed that most of us have been "bred" into the Newtonian world in that we "have accepted the idea of the Newtonian world machine as the expression of the true picture of the universe and the embodiment of scientific truth."[35] As this study shows, we can look back to the six middle decades of the eighteenth century for the genesis of the "Newtonian world" that we, as twenty-first-century Americans, have inherited. Impelled by the forces of piety, politeness, and power, men and women—natural scientists, science devotees, and lay persons alike—accommodated the methods, goals, and ideals of Newtonian natural philosophy to their own needs and to orthodox beliefs and institutions of New England culture. Although this was an uneven process, often checked by opposing intellectual, theological, and social forces, by the end of the 1770s, Newtonian natural philosophy with its accretion of metaphysical concepts became a subtle force within New England permeating the whole of its culture, much as Newton's "Subtle Fluid" or "aether" permeated the whole of the natural world.

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[34]For the concept of "domestic spheres", see Chap. V below; for "sociable spheres," see Lawrence E. Klein, "Gender and the Public/Private Distinction in the Eighteenth Century: Some Questions about Evidence and Analytic Procedure," *Eighteenth-Century Studies* 29 (1995):103.

[35]Alexandre Koyré, "The Significance of the Newtonian Synthesis," in *Newton: Texts, Backgrounds, and Commentaries*, ed. and selected I. Bernard Cohen and Richard S. Westfall (New York: W. W. Norton & Co., 1995), 59. Koyré initially articulated this view in 1948, Ibid., 58.

## CHAPTER I

## BOOKSELLERS, SOCIAL LIBRARIES, AND SCIENCE DEVOTEES: TRAFFICKING IN NEWTON'S IMAGE AND NEWTONIAN LITERATURE

"The person who so ingeniously borrowed Sir Isaac Newton's works out of my printing office is earnestly desired to return them speedily, they being none of my property," read the notice in a 1749 issue of a New York newspaper.[1] The printer's consternation is evident: an unknown party has snitched a valuable set of books in his care. Yet bound up with his concern over the illegal trafficking in books are a number of issues that have engaged social, cultural, and intellectual historians: the printer's office as a locus of the booksellers' trade; reading tastes in mid-eighteenth America and the would-be appropriation of knowledge; and the diffusion of Anglo-American culture.[2] But I take as the entry point to this incident two hitherto unexamined issues: first, the availability of Newtonian science texts in a distinctly non-academic colonial milieu and, second, the desirability of possessing those texts.

One of the measures of the diffusion and desirability of Newtonian science in provincial society is the availability of Newtonian reading materials directly from colonial booksellers. Another measure is access to Newtonian literature through the collections of social libraries. Still another measure is the display of Newton's portrait or his works in one's own library; while yet another, and

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[1]Quoted in Esther Singleton, *Social New York Under the Georges, 1714-1776,* (New York: D. Appleton and Company: 1902), 339.

[2]See, for instance, Stephen Botein, "The Anglo-American Book Trade before 1776: Personnel and Strategies," in *Printing and Society in Early America*, William L. Joyce, David D. Hall, Richard D. Brown, and John B. Hench, eds., (Worcester: AAS, 1983); Richard D. Brown, *Knowledge Is Power: The Diffusion of Information in Early America, 1700-1865* (New York: Oxford University Press, 1989); and Richard Bushman, *The Refinement of American: Persons, Houses, Cities* (New York: Vintage Books, 1993), and for an overview, see essays on these subjects in *The Colonial Book in the Atlantic World*, ed. Hugh Armory and David D. Hall (Cambridge: AAS and Cambridge University Press, 2000).

perhaps the ultimate, measure is the use of visual references to Newton in one's own portrait. This chapter will look first at the potency of Newton's works and image through the examples of several devotees of the new science who exhibited the "public badge" of Newtonian science in their own portraits. It will briefly describe the body of Newtonian literature (original texts, scholarly and popular interpretations, physico-theological sermons and poetry, and various digests of eighteenth-century science) that sought to interpret, explain, and promulgate the natural philosophy of Isaac Newton. It then will look at bookseller and social library catalogues to determine the extent of Newtonian literature available to New England readers and also examine the Portsmouth, New Hampshire Social Library to situate the availability of Newtonian literature in a community context.

The number and diverse character of Newtonian titles reveals the appeal of the new science to the religious sentiment, genteel aspirations, and practical needs of New England readers—a multiplicity of interests well satisfied by the literary interpreters and promoters of the Newtonian system. Of course there was no invisible boundary that neatly separated eighteenth-century readers' interests. Hence their desire to gain scientific information often intersected and overlapped their desire to reinforce religious belief, and both in turn could be incorporated into the pursuit of polite science. By looking at the trafficking in both Newton's image and Newtonian literature, this chapter begins the investigation of the development of a Newtonian culture in New England—a culture made especially persuasive because it incorporated the forces of piety and politeness within the framework of natural philosophy, and particularly desirable (as will be evident in subsequent chapters) because it enhanced the personal power of those who claimed its mantle.

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## Trafficking in the Image of Isaac Newton

In the colonies, as has been observed in England, an acquaintance with the new science of Isaac Newton became one of the measures of gentility, a "public badge" sought by members of provincial society in assimilating metropolitan values and culture, especially the Enlightenment value of rational politeness.[3] On an individual level, a taste for polite literature was a way to "invoke civility";[4] such behavior manifested itself in the display of a Newtonian text in one's secretary-bookcase which may have been borrowed from a social library, or in an allusion to Newtonian science in rational disourse, physico-theological sermons, and philosophical poetry, or in the genteel pursuit of scientific endeavors. A taste for polite literature also could determine the identity one chose to present to posterity. After sitting for his portrait in 1771, the Rev. Ezra Stiles (Fig. 1.1), then minister of the Second Congregational Church in Newport, Rhode Island and the secretary of Newport's Redwood Library Company, had the painter add what he described as "Emblems" that were "more descriptive of my Mind, than the Effigies of my Face."[5] Along with works of theology and history, Stiles displayed Newton's *Principia,* for, he related, "I possess & have read all Newtons Works & his Principia often : and am highly delighted with his Optics & Astronomy." Stiles also instructed the painter to inscribe the pillar to his right with "one Circle with one Trajectory around a solar point," emblematic, he explained, "of the Newtonian or Pythagorean System of the Sun & Planets & Comets. It is pythag so far as respects the Sun & revolv$^{g}$ Planets : it is newtonian so far as it respects the Comets moving in parabolic Trajectories, or long Ellipses whose Vertexes are nigh a parab. Curve." Stiles chose to be portrayed in "a Teaching Attitude, with the right hand on the Breast, and the left holding a preaching Bible,"—a reminder to the portrait's viewers of a minister's

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[3]Roy Porter, "Science, Provincial Culture, and Public Opinion in Enlightenment England," *The British Journal for Eighteenth-Century Studies* 3 (1980): 29-30.

[4]David Shields, *Civil Tongues & Polite Letters in British America* (Chapel Hill: University of North Carolina Press, 1997), xv.

[5]For this and Stile's comments which follow, and a description of all the books and emblems in his portrait, see 1 Aug., 1771, *The Literary Diary of Ezra Stiles*, ed. Franklin Bowditch Dexter (New York: Charles Scribner's Sons, 1901), I:131-32. For a biography, see Edmund S. Morgan, *The Gentle Puritan: A Life of Ezra Stiles, 1727-1795* (New Haven: Yale University Press, 1962).

potent role in disseminating both religious and scientific truths.[6] Stiles pursued this role in Portsmouth, New Hampshire during the two years he spent there as minister of the First Congregational (North) Church after the evacuation of Newport in 1776 and before he assumed the presidency of Yale College in 1777 where his "delight" with Newton enabled him to deliver extempore lectures on Newtonian subjects such as gravity.[7]

Throughout his life, Stiles engaged in various scientific pursuits including astronomical and meteorological observations and corresponded with science practitioners in the colonies and abroad, including John Winthrop, Professor of Natural Philosophy and Mathematics at Harvard College and a correspondent and Fellow of the Royal Society, and Benjamin Franklin, the Pennsylvania diplomat cum natural philosopher whose discovery of the properties of electricity and lightning established his renown in both England and America.[8] Stiles finally laid aside his elaborate plan, formulated between 1763 and 1767, to establish a society of colonial intellectuals (tentatively named in 1766 "The Newtonian Academy of Sciences in America") whose purpose would be "to transmit important occurrences of natural phenomena" only a sampling of which included, "celestial observations, . . . Meteorological Registers of the Thermometer and Barometer, Effects of Lightning and whatever may assist toward perfecting the Theory of the Electrical pointed Rods and . . . the Botany and

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[6]For an example of Stiles's use of Newtonian theory to elucidate the wonders of divine creation, see Sermon 19 (4 Dec. 1755), "Psalm 100:4-5," Ezra Stiles Papers, Yale University Colls. (Microfilm Edition, 1978), Ser. 5, 1-32, esp. 14-17. Hall has also recognized the cultural potency of Stiles's portrait in representing Stile's "learned" union of piety and rationality, Hall, "Learned Culture in the Eighteenth Century," in *Colonial Book*, 433.

[7]See, for instance, 2 July 1778, *Literary Diary*, 2:277.

[8]Winthrop viewed Stiles, whose scientific correspondence was the most extensive in the colonies, as the "a sort of clearing house" for the informal exchange of information, and in Jan., 1763 eschewed Stile's suggestion to formalize colonial endeavors by founding an American philosophical society, Morgan, *Gentle Puritan*, 159. For the scientific activities of Winthrop and Franklin, see Chaps. III and IV respectively.

Mineralogy of America."[9] Yet Stiles tirelessly promoted and participated in inter-colonial scientific endeavors such as the observation of the Transit of Venus in 1761, and also promoted the efforts of individual natural philosophers such as John Winthrop, whose candidacy for membership in the Royal Society he suggested to Benjamin Franklin.[10]

Newton's image as well as his works could also adorn the walls of an eighteenth-century study or social library—a source not only of inspiration but also of authentication of one's intellectual pursuits. In fact, *The American Magazine and Historical Chronicle* (a Boston periodical with a readership throughout the northern colonies) advised readers in an article of November, 1745 reprinted from the *London Magazine*, as to the correct furnishings of a gentlemen's literary "Club-Room." They were instructed that displaying the "Heads" (i.e, mezzotint portraits) of authors including that of Newton was an indication of the "Taste" of club members.[11] Newton's portrait could have been among the "Six Mezzotinto Pictures, containing Heads of Illustrious Englishmen" acquired by the Salem, Massachusetts Social Library in 1762.[12] Mezzotint reproductions of portraits of popular English figures were available for purchase from colonial booksellers such as Robert and Thomas Kennedy of Boston. In 1768 they listed prints of

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[9]Morgan, *Gentle Puritan*, 159; Stiles Papers, Misc. Vols. and Papers, Reel 16, # 417:7. In 1767 Stiles settled on the "The Selden Academy of Sciences in New England in America," and outlined 15 "Classes of learned and public merit"; the first class he denoted "The Newtonian—comprehending Natural Philosophy and Chronology," Ibid.

[10]Morgan, *Gentle Puritan*, 153-57, 159.

[11] "An Account of a Northern Club," *AMHC* (Nov. 1745): 530. The edifying effect of such display was deliberate, as the anonymous contributor made explicit: "As we take care, in particular, to be inform'd of the Life of our Author and the Character of his Works, we can sometimes imagine ourselves as intimately Acquainted with all his Perfections, as if he were in Person dictating what he wrote," Ibid.

[12]An Alphabetical Catalogue of the Books belonging to the Social Library in Salem: Taken the Twenty-eighth Day of May — Anno Domini 1761 To which is sujorn'd An Account of Donations to the Library," Salem Athenaeum Coll., EIL.

"ILLUSTRIOUS personages" among the wares at their print shop which they would have imported from a London firm, such as that of Sayer and Bennett who published a book-length catalogue of prints, maps and charts, and artists' books available for "Merchants for Exportation, and Shopkeepers to sell again."[13] Newton's portrait would have been among the mezzotints the Kennedys advertised not only for the Boston market but also as "very saleable and cheap for country chapmen."[14] Their appeal to country retailers is indicative of the role they and other urban colonial shopkeepers played as middlemen in the Anglo-American trade and the diffusion of English material culture.[15] The broadside advertisement, circa 1763, of the New Haven druggist-bookseller, Benedict Arnold, illustrates that the selling of books and prints was not always a specialized business restricted to shops with a large stock. Along with a full line of drugs, Arnold advertised "A very elegant Assortment of Mezzotinto Pictures,"and also listed 150 books, imported via New York,

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[13][Robert Sayer and James Bennett], *Sayer and Bennett's Enlarged Catalogue of New and Valuable prints,* . . . (London, 1775, repr. London: Redwood Press Limited, 1970). The "Posture Size" (14" x 10") portrait of "Sir *Isaac Newton,*" was entered under the heading "*Statesmen,* . . . *&c. Who have distinguished themselves, to the present Time*" and cost 1 shilling [or 20 shillings colonial currency, at the exchange rate of 20 to one shilling sterling], Ibid., 16.

[14]*BNL*, 12 Dec. 1768. Although no Boston ads indentified the "personages" by name, Newton was undoubtedly among any collection of English heroes as verified by a New York jeweller who in 1775 advertised the cutting of cameos and engraving of "ladies' trinkets" with the "heads" of English worthies including Newton, Lord Chatham, Shakespeare, Milton, and Pope, quoted in Singleton, *Social New York*, 254. Bound collections of prints accompanied by biographies of the subjects were also available as described by the New York firm of Garrat Noel and Company who advertised a set of 180 "Heads of Illustrious Persons of great Britain . . . engraved by Mr. Houbraken and Mr. Virute, with their Lives and Characters by Thomas Birch, D. D., Secretary to the Royal Society," quoted in Ibid., 92.

[15]For shopkeepers' role in the development of "genteel" markets and clientele, see Richard L. Bushman, "Shopping and Advertising in Colonial America," in *Of Consuming Interest: The Style of Life in the Eighteenth Century*, ed. Cary Carson, Ronald Hoffman, and Peter J. Albert (Charlottesville: University Press of Virginia, 1994), 233-51; for the trade in imported prints as evidence of colonial participation in the consumer revolutions, see Margaretta Lovell, "Aspects of Art and Money in Eighteenth-Century America" in Ibid., 297-306 .

which included three of the most fashionable titles available in natural philosophy.[16]

A mezzotint image of Newton did in fact preside over the endeavors of the young Boston gentleman-scientist, Edward Bromfield, who exhibited a mezzotint of the"glorification," or apotheosis, of Newton in his study (fig. I.1).[17] Bromfield paid homage to Newton in his own portrait (fig. 1.2) by including a visual reference to *The Opticks*, which presumably had informed the young man's investigations of light and his production of original optical instruments.[18] Displayed next to Newton's work on the bookshelves behind Bromfield is the Bible. His prominent display of both books silently informed eighteenth-century viewers of Bromfield's own learned and pious conjoining of natural philosophy and religion.

The mezzotint portrait of Newton by John Faber after the portrait painted in 1725 by John Vanderbank for the Royal Society inspired an apparently amateur colonial painter to reproduce an exact copy in gouche, or opaque watercolors, (fig. 1.1a); at first glance only the inscription, hand-lettered rather than printed, and the signature, "W: Taylor del: / Ex Mezzotinto," differentiate it from its model, probably Faber's mezzotint or a engraved copy of the mezzotint included in a popular

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[16]These were *The Philosophical Grammar* and *Philosophia Britannica* by Benjamin Martin and *Astronomical Dialogues between a Gentleman and a Lady* by John Harris listed, respectively, as "Martin's Philosophical Grammar, and Philosophia Britannica," and "Harris's Astronomical Dialogues," "Benedict Arnold, has just imported . . . ," [New Haven, 1763].

[17] Justin Winsor, ed., *Memorial History of Boston*, (Boston: James Osgoode and Company, 1881) 1:510; Brandon Brame Fortune with Deborah J. Warner, *Benjamin Franklin & His Friends: Portraying the Man of Science in Eighteenth-Century America* (Washington, D. C.: Smithsonian National Portrait Gallery, 1999), 113. Two generations later, the mezzotint came into the possession of Josiah Quincy who displayed it in his Harvard College room in the 1780s, Winsor, *Memorial History*, I:510. Quincy was the grandson of Abigail Bromfield Philips, sister of Edward Bromfield.

[18]*SHG*, 6:134-35. Bromfield's portrait (c. 1746, att. John Greenwood) is in the Harvard University Portrait Collection, Cambridge, Ma. Only three of the books in the background were identified by title; the labels read "NEWTON'S OP[TICKS]; "BI[B]LE,"; the third is illegible. I thank Sarah Grindlay, Curator, Harvard University Portrait Collection, for confirming these titles.

biographical dictionary of distinguished English natural philosophers (fig. 1.1b).[19] That Newton was one of the subjects chosen for this exercise—the copying of a mezzotint model usually by young gentlemen and ladies under the direction of a drawing teacher—suggests his image evoked widespread popularity.[20] Faber's mezzotint also provides a more indirect, but just as telling, example of the popularity of Newton and his image. The art historian Waldron Belknap has pointed out a succession of colonial American portraits, starting with the circa 1730 painting by Nathaniel Emmons of the Boston diarist and jurist, Samuel Sewall (Fig. 1.4), which depict their subjects with the "Newtonian" pose and general composition of Faber's mezzotint. Belknap opines that Faber's mezzotint of Kneller's portrait (which depicted Newton at age eighty-four, one year before his death) served as a model of "resigned and philosophic old age" for both male and female subjects.[21] Their appropriation of Newtonian portraiture attributes also may have subtly suggested the appropriation of a measure of the immortality accorded Newton after his death.[22]

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[19]Taylor's painting has a history of ownership in Connecticut, suggesting a Conn. origin, perhaps the amateur painter of miniatures and landscapes, William Taylor (1764-1841). Taylor was a 1785 graduate of Yale College and teacher in Milford, Conn. before becoming a merchant, Franklin Bowditch Dexter, *Biographical Sketches of the Graduates of Yale College . . .* (New York: Henry Holt and Company, 1907), 4:442. His 1790 portrait by Ralph Earl depicts him at a easel, George C. Groce and David H. Wallace, *The New York Historical Society Dictionary of Artists in America, 1564-1860*, (New Haven: Yale University Press, 1957), 621.

[20]Imported mezzotint portraits were used as a source of instruction by both professional artists and young students who had limited access to original works, E. McSherry Fowble, *Two Centuries of Prints in America, 1680-1880* (Charlottesville: University Press of Virginia, 1987), 13-14. In 1748 the dealer James Buck advertised "fine Mezzotintoes pick'd out for the Ladies to paint," *BEP*, 27 July 1747, quoted in Dow, *Arts & Crafts*, 34.

[21] Waldron Phoenix Belknap, Jr., *American Colonial Painting: Materials for a History* (Cambridge, Harvard University Press, 1959), 288-89; see Plates XVII and XVIII for additional examples through 1750 by artists including John Smibert and Joseph Badger; quote, 289-90.

[22]Lovell views the "borrowed body syndrome" in the use of prints as evidence of the human body as a subject of fashion and commerce, "Painters and Customers," 300. I have extended this concept to include the appropriation of intangible attributes closely associated with the subject of the original print.

Trafficking in Newtonian Literature

The bestowal of immortality upon Newton, albeit symbolic, reflected the popular reception as well as the amplification of Newton's natural philophy as derived from his two seminal works, the *Principia* and the *Opticks*, and as promulgated by numerous interpretations, adaptations, and popularizations.[23] An assessment of science books and their readers has concluded that from a bibliographical point of view, the years from 1690 to 1790 in England should be called "the century of Newton"; during this time the print culture responded to the demand for information about the "new science"—which from roughly 1680 to 1750 "*meant* Newton"—with the publishing not only of translations and academic interpretations but also of physico-theological sermons, university lectures, and coffee house demonstrations as well as science dictionaries and periodicals, and even poetry informed by natural philosophy.[24] As an integral part of the Anglo-American "empire of goods" whose buyers consumed the latest imported wares, intellectual as well as material, New Englanders also participated in the print culture's dissemination of Newtonian science.[25] Fertile materials for locating imported Newtonian literature in New England are the extant catalogues of booksellers and social libraries dating from the 1720s through the 1770s, which represent ten booksellers (including one bookseller-circulating library) and four social libraries (App. I, below).[26]

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[23]For a brief exploration of the foundation and various facets of Newton's popularity and the extension of his philosophy into the realms of theology, philosophy, medicine, physiology, and social science, see Derek Gjertsen, "Newton's Success," in *Let Newton be!*, ed. John Fauvel, Raymond Flood, Michael Shortland, and Robin Wilson (New York: Oxford University Press, 1988), 20-41.

[24]G. S. Rousseau, "Science books and their readers in the eighteenth century," in Isabel Rivers, ed., *Books and Their Readers in Eighteenth Century England* (Leicester: Leicester University Press, 1982), 215-16, quote, 215.

[25]For readers as consumers of science, see Ibid., 211.

[26]See App. I for a chart of booksellers and social library catalogues and a numerical summary of their holdings, App. II for specific titles in each catalogue, and App. III for a bibliographical checklist of titles. To arrive at a preliminary estimate of Newtonian literature outside the university setting, I have examined all extant, separately printed bookseller, auction, and social

Boston's preeminence as the book selling center of the colonies emerged early in the colonial period, positioning it as the leader in the Anglo-American book market that began to grow in the thirty years following the peace established by the Treaty of Utrecht in 1713. By 1724 Boston booksellers were strong enough to form a trade association to regulate trade and set prices. Growth and prosperity in the book trade throughout this period paralleled the growth in other sectors of the economy, expanding significantly in the 1750s and 1760s as more imported goods, especially luxury items, appeared in the market place. But the recession that followed the end of the Seven Years' War also caused a slump in the book market that was aggravated by the non-importation agreements. Lifting of trade restrictions in 1771, however, occasioned a brief resurgence of Anglo-American trade until cut off by the impending war. The New England book trade reflected these trends in a modest surge of advertisements in 1772 and 1773 followed by a cessation of advertising that lasted until 1785.[27]

Although not as numerous as the myriad of titles available in England, American imports of Newtonian literature, as seen in the booksellers' catalogues, varied in nature from academic texts, to

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the university setting, I have examined all extant, separately printed bookseller, auction, and social library catalogues, published in New England from 1725 to 1779 by using Winans' descriptive checklist as a guide to catalogues reproduced in Evans' microprint series. See Robert B. Winans, *A Descriptive Checklist of Book Catalogues Separately Printed in America 1693-1800* (Worcester, Ma.: AAS, 1981), #s 9, 12, 46, 52, 54, 59, 66, 79, 87, and 90, and Evans, #s 39828, 3765, 41515, 41516, 10069, 41642, 11051, 42336, 12424, and 42505, and App., I, #s 1, 2, 6, 7, 8, 9, 10, 12, 13, and 14, respectively. I have supplemented these with the manuscript catalogues of the Redwood (Newport, R.I.), Salem, Ma., and Portsmouth, N.H. social libraries and the probate inventory of the bookseller Jeremiah Condy; see App. II. for bibliographical information.

[27]For the view that ties the book boom to 1718, see Jesse H. Shera, *Foundations of the Public Library: The Origins of the Public Library Movement in New England, 1629-1855* (Chicago: The University of Chicago Press, 1949), 46-47; for a dissenting view, see Stephen Botein, "Anglo-American Book Trade," 50-51; for the difficult 1760s , see Elizabeth Carroll Reilly, "The Wages of Piety: The Boston Book Trade of Jeremy Condy," in *Printing and Society*, 85-88; on the Non-Importation Agreements, see Worthington Chauncey Ford, "Henry Knox—Bookseller," MHS *Proceedings* 61 (1927-1928), 228-29. For an overview of the volume of imported books, dealer networks, and social dimensions of the colonial book trade, see James Raven, "The Importation of Books in the Eighteenth Century," in *Colonial Book*, 183-97.

popularized works, to physico-theological sermons and poetry. Academic textbooks based on podium and public lectures comprised both direct translations and theoretical interpretations of Newton's *Principia* and *Opticks*, aimed at serious science practitioners and scholars, while popular texts, which de-emphasized mathematical language by stressing experimental proofs, were aimed primarily at educated gentlemen readers rather than scholars. Physico-theological sermons and poetry comprised works aimed at devout readers interested in the scientific reinforcement of religious truths. The appeal of the new science crossed not only educational boundaries but also those of gender and age. Mid-century England saw a proliferation of natural philosophy books "made easy" for young gentlemen and ladies as well as their younger siblings which soon became available in New England. Provincial as well as metropolitan readers of more general literature also found the new science explained, referenced, and even touted in dictionaries, almanacs, literary and scientific periodicals, and compendia of general knowledge.

Consumers of imported books included members of social libraries as well as customers of colonial booksellers. A phenomenon that started in the 1730's with the Library Company of Philadelphia, social libraries proliferated up and down the Atlantic seaboard and numbered at least sixty-four before the Revolutionary War, including twenty-eight in New England, twenty-three in the middle colonies, and three in the south.[28] Generally known as "proprietary" or "subscription" libraries, they were based upon a social contract between the members who "had united through the purchase of stock, to form and maintain a library for their common benefit."[29] Most often they were associations of elite gentlemen with the means to indulge in what the Portsmouth, New Hampshire Social Library members described as their "Taste for polite Literature . . . [and] whatever is curious

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[28]C. Seymour Thompson, *Evolution of the American Public Library, 1653-1876* (Washington, D.C.: The Scarecrow Press, 1952), 54-55.

[29]Thompson, *American Public Library*, 41-42.

& entertaining . . . to have always a good Collection of Books at hand . . . for their Amusements at leisure Hours."[30] Social libraries are evidence of the "cultural potency" of eighteenth-century print media; as institutions of private society, their members gathered not only to select, collect, and maintain collections of books and periodicals, but also to discourse upon them, thus bridging oral and print culture.[31] The various kinds of natural philosophy books produced in England found a ready market among the members of New England social libraries who were eager to display their polite taste for the latest in imported intellectual wares. The extant catalogues of four New England social libraries—the Redwood Library founded in Newport, Rhode Island in 1747, the Portsmouth Social Library founded in Portsmouth, New Hampshire in 1750, the Salem Social Library founded in Salem, Massachusetts in 1760, and the Providence Social Library founded in Providence, Rhode Island in 1768—reveal what place their members accorded Newtonian literature upon their bookshelves and what books they discoursed upon.

In order to assess the appeal and impact of Newtonian literature upon colonial reading preferences, it is helpful first to briefly examine the various categories of Newtonian reading material imported from England as indicated in both bookseller and social library catalogues (see App. II for specific titles listed by category in each catalogue). The following section will present such an overview under the broad and sometimes overlapping categories discussed below: original texts (the *Principia* and the *Opticks*), "podium" texts or scholarly interpretations, "pulpit" or physico-

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[30]"Proposals for Beginning a Social Library in Portsmouth" in "The First Book of the Records and Proceedings of the Library Society in Portsmouth in the Province of New Hampshire . . . 1750," Small MS Colls., PA, [1], (hereafter PL Proposals and PL Records, respectively). Although the terms "subscription" and proprietory" to describe early social libraries were often used without distinction, members of subscription libraries paid a fee for services rather than stock; true subscription libraries were characteristic of later (post-Revolutionary) libraries such as mercantile libraries and young men's associations, Thompson, *American Public Library*, 42. For the legal distinction, see Shera, *Foundations of Public Library*, 57-58. Subscription libraries appealed to a general, and often young, clientele and were "consciously democratic," Ibid., 59.

[31]Shields, *Polite Letters*, 322.

theological works, "philosophical" or physico-theological poetry, texts "a La Mode" or popular interpretations including "polite" and "easy" texts, and various reference works.[32] The subsequent sections will then look specifically at the holdings of the various booksellers and social libraries and examine, in particular, the Portsmouth, New Hampshire Social Library in order to place the availability of Newtonian literature in a community context.

The Source of Newtonian Literature: The *Principia* and the *Opticks*

Newton's work, *Philosophiae Naturalis Principia Mathematica*, written in Latin, the international language of scholars, was written at the urging of the astronomer Edmond Halley, under imprimatur of the Royal Society in 1687.[33] Three years earlier Halley had urged Newton to pursue studies he had undertaken earlier, because these provided an answer to the long-perplexing problem of why the orbital motions of the planets follow Kepler's laws as they revolve around the sun. Newton's greatest achievement in the *Principia* was the formulation of the law of universal gravity and the explanation of why the Copernican universe embodies Kepler's laws of planetary

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[32]While I have relied principally upon Rousseau's distinction between "scholarly" and "popular" science in defining the categories for analysis, I have also drawn upon David M. Knight, *Natural Science Books in English 1600-1900* (London: Portman Books, 1989), Chaps. 2-5; Margaret M. Jacob, *The Cultural Meaning of the Scientific Revolution* (Philadelphia: Temple University Press, 1988), Chaps. 4, 5; and for "polite" texts, Alice N. Walters, "Conversation Pieces: Science and Politeness in Eighteenth-Century England," *History of Science* 35 (1997): 123-25. For bibliographic sources, I have relied upon Peter Wallis and Ruth Wallis, *Newton and Newtoniana, 1672-1975, A Bibliography* (Kent, England: Dawson, 1977) and *A Descriptive Catalogue of the Grace K. Babson Collection of the Works of Sir Isaac Newton* (New York: Herbert Reichner, 1950).

[33]David C. King in collaboration with John R. Milburn, *Geared to the Stars: the Evolution of Planetariums, Orreries, and Astronomical Clocks* (Buffalo: University of Toronto Press: 1978), 168; I. Bernard Cohen, *A Guide to Newton's Principia*, in Isaac Newton, *The Principia, Mathematical Principles of Natural Philosophy*, trans., I. Bernard Cohen and Anne Whitman assited by Julia Budenz (Berkeley: University of California Press, 1999), 11-12; hereafter, *Guide* and *Principia*, respectively. For the origins of the *Principia* and its early publishing history as well as major 18th- and 20th-century translations, see Cohen, *Guide*, Chaps. 1-2. For the authoritative biography, see Richard S. Westfall, *Never at Rest: A Biography of Isaac Newton* (New Haven: Yale University Press, 1970).

motion. This endeavor, as Newton himself wrote in the "Author's Preface" to the first edition, extended to reducing the phenomena of nature to the laws of mathematics and, through the application of "rational mechanics," "to discover the forces of nature from the phenomena of motions and then to demonstrate the other phenomena from these forces."[34] The first book of the *Principia*, entitled "The Motion of Bodies," deals with the mathematical demonstration of these forces of nature in "free spaces" (i.e., spaces "devoid of resistance"), and the second book deals the motion in resisting mediums. The third book, entitled "The System of the World," applies the mathematical propositions from books one and two to "derive from celestial phenomena the gravitational forces by which bodies tend toward the sun and toward the individual planets" and from these forces to deduce, by additional "mathematical propositions," the motions of the planets, comets, moon, and sea.[35] Within the next four decades another two Latin editions of the *Principia* were published, both revised under Newton's direction: the second edition in 1713 by Roger Cotes, his friend and academic colleague, (upon the urging of Richard Bentley), and the third edition in 1726 by his protégé, Henry Pemberton.

Because Newton had extensively employed mathematical analysis, the *Principia* was inaccessible to all but a relative handful of scholars. Newton himself was aware of both the speculation regarding the basis of his mathematical analysis in the *Principia* and the burden it put on his readers. Nevertheless, among other mathematicians and natural philosophers, the *Principia* was recognized as an "epoch-making" work, and in England Newtonian natural philosophy quickly became the reigning orthodoxy.[36]

Although the first direct English translation—*The Mathematical Principles of Natural*

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[34]Newton, *Principia*, 381-82.

[35]Cohen, *Guide*, 13; Newton, *Principia*, 382.

[36]Westfall, *Never at Rest*, 472.

*Philosophy* (1729) by Andrew Motte—may have broken the language barrier, the hurdle erected by the *Principia's* mathematical underpinnings remained. Yet the persuasiveness of Newton's theory and the elegance of the Newtonian universe generated intense interest. For therein the motion of all terrestrial as well as celestial bodies not only could be explained but, even more significantly, could be predicted according to the "universal" law of gravitation. Indeed, Newton's Law of Gravity provided a new paradigm, a new way of elucidating the natural world that caught the imagination of poets and clerics as well proponents of science. Hence, the tenets and images of Newton's "new system" of natural philosophy entered religious and poetic discourse, for Newton himself had pointed the way in the "General Scholium," or conclusion to the *Principia*, added to his second (Latin) edition. Although exposed to the lay person through the seeming legerdemain of Newton's mathematics, the mechanically-perfect and hierarchically-ordered universe (what Newton described as "this most elegant system of the sun, planets, and comets" arising from "the design and dominion of an intelligent and powerful being), was proof of the "supreme" God's "wisest and best construction of things and their final causes." Furthermore, Newton instructed his readers, "to treat of God from phenomena is certainly a part of natural philosophy."[37]

An even greater level of interest followed the publication of *The Opticks, or a Treatise of the Reflections, Refractions, and Colours Of Light*, Newton's seminal work on the nature of light and color, published in 1704. Because it was written in English and relied on experimental rather than mathematical proof, the *Opticks* was immediately accessible to a much wider and more general audience.[38] As Newton himself explained in the introduction, his intent was to proceed "not by

[37]Newton, *Principia*, 940, 942-43.

[38]For the classic study of the *Opticks* as the genesis of non-mathematical empiricism in contrast to the mathematical empiricism of the *Principia*, see I. Bernard Cohen, *Franklin and Newton: an inquiry into speculative Newtonian experimental science and Franklin's work in electricity as an example thereof* (Philadelphia: American Philosophical Society, 1956); for an elaboration of the two separate strains of Newtonianism, see Robert E. Schofield, *Mechanism and*

hypothesis" but "to prove by reason and experiment."[39] Two and one half centuries of repetition have rendered Pope's epigram, "Nature, and Nature's Laws lay hid in Night. / God said, *Let Newton be!* and all was *Light*," a cliché. In the eighteenth century, however, it captured the essence of Newton's achievement in the *Opticks* and the *Principia*. Pope's epigram appealed to the imagination of generations of readers whose view of nature, as Marjorie Nicolson has demonstrated, was literally "colored" by the revelations of Newton's prism.[40] Among them was Ezra Stiles who, as a young Yale graduate destined to become one of Newton's greatest enthusiasts, copied Pope's epigram under the heading "Epitaph on S^r^ Isaac Newton" at the end of a manuscript draft of a funeral oration he delivered in December 1750.[41] Newton's original works were available to New England readers who did not have access to college libraries through social libraries rather than booksellers (except for Henry Knox). The Providence Social Library was the only institution to list the *Principia* in Latin, while the Redwood Library owned a translation by Motte as well as the *System of the World*. Newton's *Opticks* and/or *Optical Lectures* appeared in the Salem and Providence Social Libraries, while bookseller Knox advertised the *Opticks*.

Scholarly Interpretations: Academic Texts Derived from Podium and Public Lectures

In the first two decades of the eighteenth century, the *Principia* spawned a steady flow of scholarly interpretations by colleagues, correspondents, and disciples of Newton who were eager to

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*Materialism: British Natural Philosophy in An Age of Reason* (Princeton: Princeton University Press, 1970).

[39]Isaac Newton, *The Opticks, or a Treatise of the Reflections, Refractions, and Colours of Light*, 4th, corr. ed. (London: for William Innys, 1730), 1.

[40]Marjorie Hope Nicolson, *Newton Demands the Muse, Newton's Opticks and the Eighteenth Century Poets* (Princeton: Princeton University Press, 1946).

[41]'Stiles, draft of "Oratio Funebris [for Jonathan Low]," Stiles Papers, Misc. Vols. and Papers, Reel 13, # 102:16; the sermon was published in 1750. Obviously prompted by his reflections on death, Stiles first entered the following epitaph on Newton: "Look on the Grave, and on the Skies, you'll find / The measure of his Body and his Mind," Ibid.

establish the primacy of Newtonian experimental philosophy and astronomy. Even before their appearance, Samuel Clarke's annotated version (1697) of the soon-outmoded university text, Rouhault's *Physica* incorporated Newtonian theory in extensive footnotes that contradicted the Cartesian world view of Rouhault. Institutional resistance to change determined that many a student in the colonies as well as England first met the Newtonian system of the world in the Clarke's Latin version or in one of three "Englished" editions that were published between 1723 and 1730. Only the two earliest bookseller catalogues (S. Gerrish and T. Cox, App. II, #'s 1and 2) and the Redwood Library, however, list Rouhault's work, presumably because "first-hand" explications of Newtonian philosophy published by the "first generation" of Newtonian popularizers also were available early on in New England, as the catalogues indicate.

Like Clarke, the "first generation" of Newton's promoters were colleagues or correspondents of Newton, and their explanatory texts were "mathematical in character"as pointed out in one analysis of the experimental content of Newtonian texts.[42] Typical of the circle of academics, or "mathematical Newtonians,"[43] was David Gregory, a professor of mathematics at Edinburgh who assumed the Savilian chair of astronomy at Oxford in 1691; within three years he published a Latin text explaining the "gravitational principles" of the *Principia*. In 1715 Gregory's work was translated as *The Elements of Astronomy, Physical and Geometrical* and published with a re-issue of Edmond Halley's influential work on comets which drew on Newtonian theory to predict the return of the Comet of 1698 (an event that occurred in 1758). As an early proponent of

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[42]King, *Geared to the Stars*, 169. I have drawn extensively on King in this section; except as otherwise noted, my description of the texts mentioned in this section relies upon his analysis; see Chap. 10, 168-169, *passim*. The authors and works I cite do not, by any means, comprise a complete list of all interpreters of Newtonian theory, or their works, but refer only to those who appear in the catalogues cited.

[43]For a full discussion of the "first generation" of "mathematical" Newtonians versus the "second generation" of "experimental" Newtonians, see Schofield, *Mechanism and Materialism*, Chap. 2

Newtonian science, Halley also had reviewed the *Principia* in the Royal Society's *Philosophical Transactions* upon its initial publication in 1687, presenting its conclusions in non-mathematical terms.[44] Gregory's work, along with Halley's treatise on comets, was popular among New England social library readers, appearing in three out of the four social library catalogues, as well as that of the bookseller, Thomas Cox.

John Keill, Gregory's pupil and successor to the Savilian chair of astronomy at Oxford published two Latin works that enjoyed lasting popularity as introductions to the *Principia: Introductio ad Veram Physicum* (1702), translated as *An Introduction to Natural Philosophy* in 1720, and *Introductio ad Veram Astronomian* (1718), translated as *An Introduction to the True Astronomy* in 1721. Although Keill recommended mathematical literacy in geometry and trigonometry as a prerequisite for the study of astronomy, he gained recognition as the first professor actually to demonstrate the new science with the use of experiments, albeit "in a mathematical manner." The effectiveness of this approach elicited the admiration of his student, J. T. Desaguliers who credited Keill's methodology for introducing "the Love of Newtonian Philosophy."[45] Keill was equally popular among New Englanders; his works appear in three out of four social library and six out of ten of bookseller catalogues, appearing twice as frequently as the next-popular author of podium texts, Willem Jacob 'sGravesande, the professor of mathematics at the University of Leyden, whose work appeared in three social library and four bookseller catalogues.

Influenced by Desaguliers, 'sGravesande had incorporated the use of mechanical apparatus in his lectures on the *Principia,* which he published in Latin in 1720 in homage to Newton, whom

[44]Knight, *Natural Science Books*, 64.

[45]Quoted in King, *Geared to Stars*, 169.

he addressed as "the Prince of Philosophers."[46] 'sGravesande's publication was translated into English in three different versions: Desaguliers' two-volume, *Mathematical Elements of Natural Philosophy Confirmed by Experiments, or An Introduction to Sir Isaac Newton's Philosophy* (1720); John Keill's, *Mathematical Elements of Physics, prov'd by Experiments: Being an Introduction to Sir Isaac Newton's Philosophy* (1720), and a translation by a "Fellow of the Royal Society" (identified as Edmund Stone) as *An Explanation of the Newtonian Philosophy* (1735). New England readers preferred Desagulier's translation: at least four of the seven catalogues entries were his two-volume translation.[47] Appearing only once in the catalogues (Redwood Library) was an explanatory text produced in English, John Clarke's *A Demonstration of Some of the Principal Sections of Sir Isaac Newton's Principles of Natural Philosophy* (1730).

These academic texts may be termed "podium lectures" in that they were published from lectures originally delivered in Latin from the classroom podium. Initially published in Latin, most of them were "Englished" within a few years, thus drawing upon a readership that extended beyond the university setting. They depended, however, on mathematical literacy as a prerequisite for the study of both Newtonian astronomy and mechanics (physics). Hence the market for academic texts was limited to those who had the advantage of higher education. In New England, with the exception of those by Keill and 'sGravesande, academic texts appeared almost exclusively on the shelves of social libraries rather than booksellers. Two other teachers who produced academic texts in English only which became "standard" texts for serious students were William Emerson and

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[46]Quoted in J. T. Desaguliers, "Preface," *A Course of Experiment Philosophy*, vol. 1, (London, 1734), unpaged.

[47]The short-title format of most of the catalogues makes identification difficult; it appears the bookseller, T. Cox, and the Redwood, Providence, and Salem social libraries listed Desagulier's 2-volume translation; circulating library/bookseller, J. Mein (1765 and 1766) listed Stone's translation, while bookseller J. Condy's five copies may have been by any one of the three translators.

Robert Smith; these works dealing with both Newtonian optics and experimental philosophy were imported by two social libraries and two booksellers.[48]

Another type of podium lecture was produced by the earliest demonstrators of the new science. This first generation of science demonstrators came out of the privileged halls of the university, transporting Newton's natural philosophy from the classroom to the public settings of the lecture hall. Thus Newtonian science appeared in secular settings frequented by broader audiences and changing character along the way from a theoretical to an experimental science. Chief among the early science demonstrators was Desaguliers who enriched the mathematical explanation of Newtonian philosophy with the significant addition of "the Mechanicks," or hand-on experiments, which he described as "the Explanation of mechanical Organs [i.e. machines], and the Reason of their Effects."[49] Alert to the value "by Way of Amusement" of experimental demonstrations, Desaguliers devised a series of "publick Courses" using "Machines . . . contriv'd to explain and prove experimentally what Sir Isaac Newton has demonstrated mathematically."[50] His text, *A Course of Experimental Philosophy* (1734), which was based on these lectures, directly appealed to those "not born with a genius for Mathematicks." Reviewing his success in delivering 121 courses in more than twenty years of public demonstration-lectures, Desaguliers credited "the Help of Experiments" for the general reception of the Newtonian Philosophy "among Persons of all Ranks and Professions, and even the Ladies" and to the fielding of eight of the twelve other demonstrators of experimental philosophy active in England and "other parts of the World."[51] Among these

[48]Robert Smith, *A Compleat System of Opticks*, . . . 2 vols. (Cambridge, 1738) and William Emerson, *Principles of Mechanics* (1758) and *The Elements of Opticks* (1768), Knight, *Natural Science Books*, 76.

[49]Desaguliers, "Preface" to *Experimental Philosophy.*

[50]Ibid.

[51]Ibid.

scholars was the Bostonian, Isaac Greenwood, who would become Harvard College's first professor of natural philosophy and mathematics. After studying with Desaguliers in the 1720's, Greenwood imported his mentor's brand of experimental philosophy to colonial America with a public lecture course he first taught in Boston in 1726.[52]

Desaguliers was the most prominent of the academics who in the early 1700s offered a "dozen or so" science courses in London, spreading Newtonian philosophy to wider spheres.[53] They lectured on astronomy and experimental philosophy (physics) in both private academies and public settings. One popular public setting was the Censorium; built in the second decade of the eighteenth century for Sir Richard Steele (the London pundit and co-author of the *Spectator*), the lecture hall, as the press noted , was "conveniently fitted for Ladies as well as Gentlemen."[54] Mixed audiences also followed science demonstrators on the coffee house circuit. Dubbed "penny universities" by modern scholars, coffeehouses were becoming potent sites for the dissemination of learning to men and women of the middle and upper classes.[55] Members of this new audience were "unlearned" in the traditional sense of not having a classical, i.e., Latin education, or in the practical sense of not knowing higher mathematics. They were, nevertheless, anxious to acquire an acquaintance with the new science and constituted a ready audience for science demonstrators.

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[52]See Greenwood's course outline, *An Experimental Course of Mechanical Philosophy* (Boston, 1726) which closely follows Desagulier's method. For Greenwood's role in the promotion of Newtonian natural philosophy, see Chaps. III and IV below.

[53]Patricia Phillips, *The Scientific Lady: A Social History of Women's Scientific Interest, 1520-1918* (New York: St. Martin's Press, 1990), 125.

[54]Gerald Dennis Meyer, *The Scientific Lady in England, 1650-1760* (Berkeley: University of California Press, 1955), 75-77; quote from the *London Daily Courant*, 3 Mar. 1716, Ibid., 75; Philips, *Scientific Lady, A Social History*, 125-26. For Steele's promotion of and guide to science education for women in his 3-volume work, *The Ladies Library* (London, 1714), see Meyer, 71-77.

[55]Rousseau, "Science books and readers," 207-08. For the development of coffee houses as sites of learning, see A. Ellis, *The Penny Universities: A History of the Coffee Houses* (London: Secker & Warburg, 1956).

Among other academics who joined Desaguliers on the demonstration circuit were William Whiston and Humphrey Ditton, while Francis Hauksbee's participation marked the entry of instrument makers and sellers on the lecture circuit.[56] Their printed lectures also resulted in texts aimed at a popular readership. The result was a first generation of science manuals that, while still relatively heavy on theory, took a "hands-on" approach and utilized a "plain style" and a "short, practical format."[57] The demonstrators or entrepreneurs of natural philosophy, especially exemplified by Desaguliers, brought science into the realm of public culture and the ken of the untutored particularly by the "production of the artifactual—or the mechanical manufacturing of philosophic facts within the laboratory."[58] As a sub-set of academic texts, the texts produced by the "experimental Newtonians," such as Hauksbee (one listing), Ditton (one), and Whiston (four), occur in New England bookstores or social libraries relatively infrequently. As noted, Desaguliers was known indirectly in New England through his translation of s'Gravesande's work and through the public science endeavors of his student Isaac Greenwood.

Physico-Theological Works Derived from Pulpit Lectures

Newtonian philosophy spread to wider audiences when, with Newton's approval, it entered religious discourse as a defense of revealed religion. "This most elegant system of the sun, planets, and comets," Newton had asserted in the "General Scholium," "could not have arisen without the

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[56]William Whiston, *Astronomical Lectures* . . . (1715) and *Sir Isaac Newton's Mathematick Philosophy More Easily Demonstrated* (1716); Humphrey Ditton, *The General Laws of Nature and Motion; . . . Being a Part of the Great Mr. Newton's Principles* (1705); Francis Hauksbee, *Physico Mechanical Experiments on Various Subjects* (1709).

[57]Rousseau, "Science books and readers," 210-11. Rousseau characterizes the demonstrators' publications as "science manuals," a characterization also based on mid-century publications of "easy" texts, explained below.

[58]Larry Stewart, *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain, 1660-1770* (Cambridge, Cambridge University Press, 1992), xxiv. For the entrepreneurs' importance in the development of utilitarian science in the public domain, see Ibid., Chap 4.

design and dominion of an intelligent and powerful Being. . . . He rules all things, not as the world soul but as the lord of all. And because of his dominion he is called Lord God *Pantokrator*."[59] Asked to give the first in a series of monthly lectures endowed by Robert Boyle (an early and influential proponent of experimental philosophy and founder of the Royal Society), which commencing in 1692, Richard Bentley corresponded with Newton before delivering a Newtonian "demonstration of God's Existence from the Origin and Frame of the World."[60] Bentley argued the regular functioning of the universe, "could in no-wise be attain'd without the power of the Divine Arm." Equating that power to "universal gravitation," he showed through various examples, such as planetary orbits, that gravity is "a thing certainly existent in Nature, [that] is above all Mechanism and material Causes, and proceeds from a higher principle, a Divine energy and impression."[61] Bentley's Boyle lectures addressing Newtonian natural philosophy (which were the last two of Bentley's series of eight) have special importance, because they were the first popularizations of the *Principia*; published in 1793, they predated both the revised Latin and the English translations and scholarly interpretations of the *Principia*.

Bentley's use of Newtonian natural philosophy in religious discourse established the tone of subsequent Boylean lecture series. Women as well as men were urged to attend, because—as that sophisticated arbiter of taste, the *Spectator*, advised—they inculcated both religion and learning.[62] Bentley also established a tradition that was followed by Anglican and dissenting (Puritan) divines

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[59]Newton, *Principia*, 940. Newton defined *Pantokrator* as "universal ruler," Ibid.

[60]Richard Bentley, *A Confutation of Atheism from the Origin and Frame of the World* (London, 1693), 3; Knight, *Natural Science Books*, 50. For Boyle's encouragement of women's interest in science and women's attendance at the Boylean lectures, see Philips, *Scientific Lady: A* History, 122-24. For the Boylean lectures as a Whig strategy linking natural order and harmony to political stability, see Jacob, *Scientific Revolution*.

[61]Bentley, *Confutation of Atheism*, 35, 32.

[62]Philips, *Scientific Lady: A History*, 124.

well into the eighteenth century; these "clerical Newtonians," to use Margaret Jacob's term, included some authors who wrote in both the academic and clerical genres. Although they wrote to demonstrate the existence of God and "to arouse a sense of wonder at God's intelligence and ingenuity as it is revealed in the intricacies of nature," the clerical Newtonians dealt extensively and knowingly with the natural world viewed in the light of Newton's discoveries rather than merely with the religious conclusions that could be drawn from their considerations.[63] These included Samuel Clarke who turned his pen to the wedding of science and religion in *A Demonstration of the Being and Attributes of God . . .* (1705) and *A Discourse Concerning the Unchangeable Obligations of Natural Religion . . .* (1716) and to the defense (by correspondence published in 1717) of Newton's philosophy against the charges of the continental philosopher, Leibniz, who argued the Newtonian world precluded the intervening presence of God.[64] Other clerical Newtonians whose popularity extended to New England readers were William Whiston, *Astronomical Principles of Religion* (1717), George Cheyne, *Philosophical Principles of Natural Religion . . .* (1705); William Wollaston, *The Religion of Nature Delineated* (1722); and William Derham, *Physico-Theology; or, A Demonstration of the Being and Attributes of God from his Works of Creation* (1713) and *Astro-Theology: or, A Demonstration of the Being and Attributes of God from a Survey of the Heavens* (1715), as well as the Dutch theologian, Bernard Nieuwentyt, *The Religious Philosopher* (1715).[65]

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[63]Claude M. Newlin, *Philosophy and Religion in Colonial America* (New York: Philosophical Library, Inc., 1962), 32.

[64]Samuel Clarke, *A Collection of Papers . . . between . . . Mr. Leibnitz, and Dr. Clark . . . Relating to . . . Natural Philosophy and Religion*, (London, 1717).

[65]On the Newtonian content of the Bentley lectures, the Clarke-Leibniz correspondence, and Derham's works, see Knight, *Natural Science Books*, 48-53. For Derham's influence on Cotton Mather's *The Christian Philosopher* (London, 1721) and *Manudutio ad Ministerium* (Boston, 1726), see Newlin, *Philosophy and Religion*, 32-38.

By far the most popular clerical Newtonians among New England readers were Derham and Wollaston, whose pulpit lectures were found in seventy-five percent of social library catalogues and sixty percent of bookseller catalogues. Equally popular among social library readers was Nieuwentyt, whose *Christian Philosopher* also occurred in seventy-five percent of the social library catalogues, but in only thirty percent of bookseller catalogues. With the exception of the smallest book dealers, Benedict Arnold and Andrew Barclay, all social libraries and all booksellers imported pulpit lectures—equaling the number of importers of podium lectures (imported by all four social libraries and all booksellers except Arnold, Barclay and Smith & Coit). New Englanders exhibited slightly less interest in pulpit lectures compared to podium lectures, importing four pulpit lectures for every five podium lectures (forty-one listings of physico-theological works compared to fifty listings of academic texts). Nevertheless, pulpit lectures may have attracted a more general audience, since the percentage of physico-theological works available through booksellers (fifty-six percent) was significantly higher than that of academic texts (thirty-eight percent).

Philosophical Poetry

Related in tone and pious intent to pulpit lectures was an extensive genre of devotional poetry that defended Christianity by employing Newtonian science as the "rational ally of revelation."[66] Physico-theological poetry, or "philosophical poetry" as it was commonly called, became an endeavor of many eighteenth-century "scientific" poets whose work was often as informed (and footnoted) by Newtonian theory as that of the early encyclopedias of science.[67] Major works of four of the scientific poets became standard among American readers. The earliest of these book-length poems is Richard Blackmore's publication of 1715 whose title indicates the poet's

[66]Douglas Bush, *Science and English Poetry: A Historical Sketch, 1590-1950* (New York: Oxford University Press, 1950), 70.

[67]Nicolson, *Newton Demands the Muse*, 56. Nicolson deals exclusively with the influence of the *Opticks*. On that of the *Principia*, see Bush, *Science and English Poetry*, esp. Chap. 3.

physico-theological intent: *The Creation, a Philosophical Poem, Demonstrating the Evidence and Providence of God.* Like other contemporary scientific poets, James Thomson invoked ideas and images of color and light derived from Newton's *Opticks* and of the order, harmony, and design of the universe derived from the *Principia* in his book-length poem, *Seasons* (1726-30). Edward Young's *Night Thoughts on Life, Death and Immortality* (1742-45), which apostrophized astronomy as "the Daughter of Devotion" and addressed angels as "Ye searching, ye Newtonian angels," completes the trinity of devotional poems whose popularity persisted among both male and female readers in England and in the colonies throughout the eighteenth century.[68] The poets' blatant use of images of the Newtonian universe, ensured that readers otherwise unfamiliar with Newtonian literature, would imbibe the "truths" of the new science along with the "truths" of orthodox religious doctrine.

The lone appearance of the early eighteenth-century poem *The Creation* (in Thomas Cox's bookseller catalogue of 1734) belies its widespread popularity and its influence on the "aesthetic of the religious sublime" that characterized the philosophical poetry of a small group of New England poets.[69] The numerous entries for Thomson's and Young's philosophical poems, written several decades later, however, do reflect the overwhelming popularity of their work. All twelve catalogues complied in 1750 or after listed *The Seasons* published either separately or in Thomson's complete

[68]Quoted in Bush, *Science and English Poetry*, 68. For additional "poet-scientists" and their specific appeal to women readers, as well as female authors of scientific poems, see Philips, *Scientific Lady: A Social History*, 119-121. For the religious underpinnings of Blackmore, Thomson, and Young, see Hoxie Neale Fairchild, *Religious Trends in English Poetry* (New York: Columbia University Press, 1939), I:189-201, I: 509-34, and II:131-49, respectively.

[69]Blackmore, for instance, inspired the devotional poetry of Jane Turrell, the daughter of the Boston minister, Benjamin Coleman. For Blackmore's influence on her verses as well those as other New England "philosophical" poets, see David S. Shields, "The Religious Sublime and the New England Poets of the 1720s," *Early American Literature*, 19 (1984/85): 231-48. Blackmore's poetry was frequently quoted in the almanac verses of the elder Nathaniel Ames, the first author of the long-running, New England almanac series, *An Astronomical Diary*, see Chap. II below.

works, while in the same period seventy-five percent of both social libraries and booksellers offered either *Night Thoughts* or Young's complete works. Three out of four social libraries and five out of ten booksellers also offered Alexander Pope's *Essay on Man* (published separately or in his complete works). Although critical of the excesses of science and philosophy, Pope made compelling use of Newtonian images of the celestial world and man's place in it, particularly the beneficence of divine wisdom, the great chain of being, and the harmonious order of the universe.[70]

"Science a La Mode": "Polite" and "Easy" Popular Introductions to Newtonian Philosophy

Hints of the fashionable appeal of natural philosophy or "Science a La Mode" (as Benjamin Martin termed it in the introduction to one of his popularizations)[71] began nearly as soon as the science demonstrators took Newtonian science into the coffee houses and Desaguliers recognized the "amusement" it afforded "ladies and gentlemen." By mid-century writers, lecturers, and instrument makers—many impelled by the great burst of adulation for the "immortal" Newton after his death in 1727—had produced numerous popularized versions of Newtonian astronomy and experimental philosophy. These were specifically designed to appeal to a non-scholarly audience motivated either by fashionable aspirations or by practical interests. Literary magazines such as the *Spectator* often mentioned Newtonian natural philosophy, in a serious as well as satiric vein, which helped established the validity of Newtonian natural philosophy as a polite pastime among its metropolitan and colonial readers.

John Harris, the founder of an academy noted for its science education, produced several significant science works that crossed the bounds of polite science and science made "easy" for practical use. The earliest, *The Descriptions and Uses of the Celestial and Terrestrial Globes*

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[70]Nicolson, *Newton Demands the Muse*, 133-35; Bush, *Science and English Poetry*, 62-63. For the tension between Christian doctrine and deistic "implications" in *Essay on Man*, see Fairchild, *Religious Trends*, II: 498-508.

[71]Quoted in Philips, *Scientific Lady: A History*, 129.

(1703), described the Newtonian universe for the use of his gentlemen students. Sixteen years later Harris invited ladies to join the scientific discourse with a work that identified the accouterments of polite science in its title: *Astronomical Dialogues between a Gentleman and a Lady. Wherein the Doctrine of the Sphere, Uses of the Globes and the Elements of Astronomy and Geography are explained in a pleasant, easy, and familiar Way. With the Famous Instrument called the Orrery* (1719). The secondary title indicates in part what determined its long-term popularity as a polite text: a dialogue format between two persons of quality of the opposite sex, with classical and poetic allusions (often borrowed from contemporary English poets);[72] the use of apparatus particularly suited to female study; and a style that was "easy" and "familiar"—the clue that knowledge of mathematics was not required.[73] Harris's production of a volume especially aimed at ladies as well as gentlemen is evidence of the marketing of science to women—a "key strategy," as Alice Walters has proposed, to introducing natural philosophy into polite culture.[74]

An important transition from scholarly texts to mid-century "polite" and "easy" texts specifically based on Newton's works were works by Henry Pemberton, Colin Maclaurin and Voltaire. Like Maclaurin's popularized version, *An Account of Newton's Philosophical Discoveries* (1728), Pemberton's *View of Sir Isaac Newton's Philosophy* (1728) was designed for the readership of educated gentlemen. In this artistically illustrated, quarto-sized volume, Pemberton summarized

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[72]Aileen Douglas, Popular Science and the Representation of Women: Fontenelle and After," *Eighteenth-Century Life* 18 (May 1994), 7.

[73]Walters, "Conversation Pieces," 128; on the "canon" of polite science texts and their role in promoting the "social agenda" of polite science, see 123-35, *passim*. For the roll of polite texts in the development of cultures, see Douglas, "Science and Representation of Women," 1-14. For an interpretation of their gendered meaning, see John Mullan, "Gendered Knowledge, Gendered Minds: Women and Newtonianism, 1690-1760," in *A Question of Identity, Women, Science, and Literature*, ed. Marina Benjamin (New Brunswick, N. J.: Rutgers University Press, 1993): 44-56. For Bernard Fontenelle's, *The Plurality of Worlds* (1686, trans., 1715) as the source of subsequent scientific dialogues for women, see Meyer, *The Scientific Lady*, Chaps. 2-3.

[74]Walters, "Conversation Pieces," 130.

and explained the *Principia* and the *Opticks* under three headings: Book I, entitled "Motion of Bodies," Book II, entitled "The System of the World, and Book III, entitled "Concerning Colours and Light." Pemberton prefaced his text with one of the numerous versified tributes to "the incomparable Newton" which poured from the pens of the English scientific poets. Richard Glover's panegyric praises Newton in the diction employed in polite discourse:

> Newton who first the almighty works display'd
> And smooth'd that mirror in whose polish'd face
> The great creator now conspicuous shines who opened nature's adamantine gates,
> And to our minds her secret powers expos'd. . . .[75]

No bookseller catalogues, but all the social library catalogues listed Pemberton's work, while only the Redwood Library also listed that of Maclaurin. Three of the social libraries as well as the booksellers John Mein (circulating library and sale catalogues) and Cox and Berry listed Voltaire's *Letters concerning the English Nation* (trans. 1733) that included a general introduction to Newtonian natural philosophy.[76] None of the booksellers or libraries, however, listed Voltaire's transitional text popular in England, *Elements of Sir Isaac Newton's Philosophy* (trans. 1738).[77] Nor did any New England catalogues list the one text written specifically for women, Francesco Algarotti's *Sir Isaac Newton's Philosophy explain'd for the Use of the Ladies* (1737), translated soon after for English readers by Elizabeth Carter (1739), although there is evidence of Algarotti's text in the southern colonies.[78]

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[75] *A View of Sir Isaac Newton's Philosophy*, London, 1728.

[76] Knight, *Science Books in English*, 67.

[77] Although the separately printed, booksellers' catalogues considered here did not list Voltaire's *Elements*, it did occur in newspaper advertisements, see below, p. 65-66.

[78] Copies of Carter's translation of Algarotti's text were imported privately by William Byrd and Robert Carter of Virginia for their daughters, and it was advertised in the *South Carolina Gazette* in August, 1752, Kevin J. Hayes, *A Colonial Woman's Bookshelf* (Knoxville: The University of Tennessee Press, 1996), 29.

The small showing of transitional texts in booksellers' catalogues was compensated, nevertheless, by the occurrence of many popular texts that appealed to both men and women. Both Benjamin Martin and James Ferguson, the London-based public lecturers, instrument makers, and indefatigable science promoters, adapted Harris's inclusive model, but added the mid-century concept that engagement in polite science was not just "a matter of emulating one's social betters, but . . . a part of growing up."[79] Martin's *Young Gentleman and Lady's Philosophy, in a Continued Survey of the Works of Nature and Art;* . . . (1759/63), presented Newtonian philosophy in the guise of a dialogue between the college student Cleonicus and his curious sister Euphrosine, while in Ferguson's *The Young Gentleman's and Lady's Astronomy*, the undergraduate Neander instructs his sister Eudosia in the "morally-uplifting" study of natural philosophy.[80] Although only a few of the many works produced by the two science entrepreneurs, they illustrate the positioning of Newtonian science at the intersection of gentility and piety, as Ferguson elucidated in a reference to the study of astronomy that concluded with a quotation from Young's *Night Thoughts*. "Our very faculties are enlarged with grandeur of the ideas it conveys," Ferguson instructed readers,

> our minds are exulted . . . and our understandings clearly convinced, and affected with the conviction, of the existence, wisdom, power, goodness, immutability, and superintendency of the SUPREME BEING. So that without an hyperbole, "*An*

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[79]Walters, "Conversation Pieces," 124. For Martin's and Ferguson's works in social and private libraries in Philadelphia, New York, Virginia, and South Carolina, see Hayes, *Woman's Bookshelf*, 129, esp. n. 32.

[80]Walters, "Conversation Pieces," 130. For specific examples and literary merit of their scientific dialogue, see Meyer, *Scientific Lady*, 37-43. For general content and publishing history, see John R. Milburn, *Benjamin Martin: Author, Instrument-Maker, and 'Country Showman,'* (Leyden: Noordhoff International Publishing, 1976), 70-78, and Ibid., in collaboration with Henry C. King, *Wheelwright of the Heavens: The Life & Work of James Ferguson, FRS* (London: Vade Mecum Press, 1988), 218-222. For a comparison of their careers and lecture style and content, see Milburn, "The London Evening Courses of Benjamin Martin and James Ferguson, Eighteenth-Century Lectures on Experimental Philosophy," *Annals of Science* 40 (1983): 437-455.

*undevout astronomer is mad.*"[81]

Children, too, were targeted as potential consumers of Newtonian science in several polite texts. *Nature display'd,* an English translation of Antoine Pluche's multi-volume work, *Spectacle de la Nature: or, Nature displayed: Being a Discourse on . . . Natural History . . . to excite the Curiosity, and form the Minds of Youth*, appeared in various editions throughout the century. Pluche took a conversational tone to explain such topics as the heavens, light, colors, vision, and experimental physics, according to ancient and modern authors, including Newton, while cautioning, "experimental Truth is useful . . . when it prudently makes use of God's Favours.[82] Popular in its own right throughout the century, it was one of the early works that helped shape polite science as an elite activity in the first half of the century.[83] Pluche's compendium of natural history occurred consistently in the catalogues from 1765 on, appearing in five booksellers' (including Mein's circulating library) and the Providence Library catalogues. By mid-century "Tom Telescope, A. M." had produced a small volume devoted entirely to Newtonian philosophy interpreted for a youthful audience, *The Newtonian System of Philosophy Adapted to . . . young Gentlemen and Ladies*, which appeared in the catalogues of John Mein (1766) and of Cox and Berry.[84]

In addition to their polite texts for young ladies and gentlemen, both Martin and Ferguson published numerous other introductions to Newtonian science whose titles, which nearly all incorporate the terms "easy" and 'familiar," indicate their authors' intent in providing texts for an

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[81]Ferguson, *Astronomy Explained upon Sir Isaac Newton's Principles*, . . . 2nd American ed., rev., corr., imp. Robert Patterson (Philadelphia, by Matthew Carey, 1809), 31.

[82]Pluche, *Nature Display'd*, 7th ed. (London, 1759), 4:343.

[83]Walters, "Conversation Pieces," 125.

[84]This work is attributed to John Newberry, the publisher of many "little books" for children printed in duedicimo size in contrast to the octavo or quarto size of adult science books. For its educational merit, see James A. Secord, "Newton in the Nursery: Tom Telescope and the Philosophy of Tops and Balls, 1761-1838," *British Journal for the History of Science* 23 (1985): 127-51.

audience hitherto devoid of mathematical instruction. Martin's *The Philosophical Grammar;* . . . (1735), *A Course of Lectures in Natural and Experimental Philosophy, . . . explain'd on the Principles of the Newtonian Philosophy* (1743), *Philosophia Britannica: or a New System of the Newtonian Philosophy, Astronomy and Geography* (1747), as well as Ferguson's *Astronomy Explained upon Sir Isaac Newton's Principles and Made Easy to Those Who Have Not Studied Mathematics* (1756) and *Lectures on Select Subjects in Mechanics* (1760) appealed to colonial and metropolitan audiences alike. Three out of the four social libraries and all booksellers except for Mein (1765, circulating) and Barclay imported at least one of Martin's works, while three booksellers imported at least one of Ferguson's works.

The cleric, Isaac Watts, familiar to readers in both old and New England as a writer of sermons and hymns, designed *The Knowledge of the Heavens and the Earth Made Easy:* . . . (1725) "to entertain younger Minds and entice them . . . on to the higher Speculations of the great Sir Isaac Newton and his Followers on this Subject." Watts acknowledged he was venturing outside his "peculiar [i.e., religious] Studies." He explained, however, that "some Acquaintance with this Mathematical Science" not only led to a clearer "Conception of . . . the Scriptures" but also raised a student's "Ideas of God the Creator" to a higher "Pitch." Such an explanation illustrates the appeal Newtonian science held for many devout lay persons as well as clergymen in joining what Watts identified as "mental culture and vital piety."[85] Many young readers also found Newtonian mechanics and astronomy explained in Edward Wells's *The Young Gentleman's Course of Mathematicks* (1712) and his *Course of Astronomy*, while others perused Robert Dodsley's *The Preceptor, or a general Course of Education and Polite Learning, for the Instruction of Youth*

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[85]Isaac Watts, *The Knowledge of the Heavens and the Earth Made Easy; or, The First Principles of Astronomy and Geography*, 3d ed. (London, 1736), vi. G. P. Brooks identifies and traces this theme as Watt's educational and religious agenda, propounded in this work and in his equally popular work, *The Improvement of the Mind* (1741), "Mental Improvement and Vital Piety: Isaac Watts and the Benefits of Astronomical Study," *Dalhousie Review* 65 (1985-86): 551-64.

(1758)—all of which introduced the Newtonian universe to a polite audience with the use of globes, microscopes, and telescopes. Popular throughout the eighteenth century, at least one of the works of these three authors appeared in all the social libraries and also in sixty percent of the booksellers' catalogues.

Another work that took a practical approach to the apparatus most closely associated with Newtonian astronomy was *The Description and Use of the Globes, and the Orrery* (1731) by Joseph Harris which went through twelve printings by the 1780s. In New England Joseph Harris's work equaled in popularity John Harris's earlier work. By mid-century Daniel Fenning produced *A New and Easy Guide to the Use of the Globes* (1769), that comprised yet another introduction to the instruments that visually illustrated the principles and penetrated the wonders of the Newtonian universe, while Henry Baker produced *The Microscope Made Easy* (1742) an equally popular introduction to the microscope, an instrument enhanced by the fascination with Newton's optics.[86] By mid-century, polite and practical science existed side-by-side as illustrated by the activities of the science entrepreneurs Benjamin Martin and James Ferguson and the proliferation of easy introductions that inculcated elements of both genres of scientific writing. As the titles of the various works indicate, their authors sought to create and respond to both polite and practical markets for Newtonian natural philosophy and astronomy, by siting their works at the intersection of the market place and science.

The extant catalogues indicate that Newtonian science was indeed "a La Mode" in New England: overall, eight out of the ten booksellers (including Mein's circulating library) and all social

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[86]The popularity of Baker's work also reflected the increasing fascination with the small wonders of the natural world, as the study of natural history (botany and biology) gained importance and gradually supplanted the primacy of natural philosophy during the later half of the eighteenth century. For its fashionable appeal, see William Powell Jones, "The Vogue of Natural History in England, 1750-1770," *Annals of Science* 2 (1937): 345-52. Women's use of both the microscope and telescope is a theme of Meyer, *Scientific Lady*.

libraries stocked popular texts. Considering all categories of texts "a La Mode" among these booksellers, popular texts were twice as numerous as academic texts—an average of six popular to an average of three academic texts among the (seven) booksellers who stocked academic texts. On the other hand, among social libraries with their more highly educated readership, popular texts were slightly less in demand than academic texts, as overall the libraries stocked an average of six academic texts for every five popular texts.

Reference Works: Newtonian Science in Digests and Dictionaries

Other treatments of Newtonian natural philosophy occurred in scientific and bibliographic dictionaries and in scientific and literary periodicals. The dictionaries include John Harris's *Lexicon Technicum*, a two-volume encyclopedia of arts and sciences (1704 and 1710), which quoted Newton extensively under headings such as Attraction, Colour, Comets, and Light, and also Ephraim Chambers's *Cyclopedia, or an Universal Dictionary of Arts and Sciences* (1728), whose copious entry on Newton was copied throughout the century in other dictionaries, including *A New and Complete Dictionary of Arts and Sciences* (1764) and the second edition of the *Encyclopedia Britannica* (1772).[87] The sub-title of the four-volume *New and Complete Dictionary*—which touted information in "all the Branches of useful Knowledge, with accurate Descriptions, as well of the various Machines, Instruments, Tools, and Schemes necessary for illustrating them"—indicates the scope of the early science dictionaries. Biographical dictionaries such as the 1738 edition of Bayle's *Historical and Critical Dictionary*, Benjamin Martin's *Biographica Philosophia* (1764), the *Biographical Britannica* (1760), and *A New and General Biographical Dictionary* (1761) also familiarized readers with Newton and his scientific achievements. Serious students of Newton's science could turn to the *Philosophical Translations* of the Royal Society or to the review of science books in the eighteen-volume *Review or Annals of Literature, exhibiting a succinct Plan of*

[87]Wallis, *Newtoniana*, 253, 251.

*every Book published since the Beginning of the Year 1756.*[88] All social libraries and all but three of the ten booksellers carried at least one reference work. Fifty percent of social libraries and forty percent of booksellers carried either the *Philosophical Transactions* or the *Critical Review*. Seventy-five percent of libraries stocked both scientific and biographical dictionaries, while among booksellers twenty percent stocked biographical dictionaries and sixty percent stocked science dictionaries. The social libraries averaged between two and three reference books each, while the seven booksellers who dealt in reference works averaged just over two reference works each.

Newtonian Literature on New England Booksellers' Shelves

Boston booksellers account for all extant New England book sale and auction catalogues except for those of Benedict Arnold of New Haven, Connecticut, who was in trade as a bookseller and druggist from 1763 to about 1767, and of Solomon Smith and Joseph Coit, booksellers and druggists in business from 1763 to about 1775 in Hartford, Connecticut.[89] Although the catalogues vary greatly in number of titles from 150 advertised in Arnold's 1763 catalogue and in Andrew Barclay's 1765 broadside to 1,741 listed in John Mein's fifty-two-page catalogue of 1766, four out of the ten booksellers handled nearly 700 to 850 books, while an additional two stocked over 1400 titles (App. I).[90] The sale catalogues all tout the "rare," "curious," or "choice" and "valuable" character of their collections, but more pertinent to the assessment of literary tastes and the anglicization of cultural values, the catalogue advertisements for new book sales assured potential

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[88]The *Memoirs of the Academy of Sciences, History of the Royal Society*, and *Philosophical Transactions* were reviewed in Vols. III, IV, and X and XII, respectively, *A Catalogue of Mein's Circulating Library* (Boston, 1765), 25-26.

[89]Isaiah Thomas, *The History of Printing in America,* (1810), 2d, corr. ed. (Albany, NY: AAS, 1984), 2: 234.

[90]Catalogue format varies from short to full author and title entries; they are listed alphabetically or by subject, by size, or by no apparent order.

buyers the stock offered was imported from London or from England. To the extent, however, that most colonial booksellers' stock depended on selections determined by their London suppliers, many titles listed in such catalogues may have represented "the detritus of eighteenth-century English culture."[91] Even a book bearing a recent publication date may have been a re-issue of an earlier work or an old work merely disguised by a new title page.[92] Although London wholesalers were not adverse to "dumping" out-of-date books—known in the trade as "rum" books—on colonial retailers, the careful ordering by American importers, evident in the records of Henry Knox and Jeremy Condy, indicates by and large they escaped this sharp practice.[93] The occasional inclusion of genuinely new titles in the exant catalogues examined here demonstrates colonial booksellers' attempt to respond to or even shape new and fashionable trends in reading.

Despite the small number of extant catalogues, an examination of the natural philosophy titles imported from London book dealers yields specific information on the variety of books dealing with the new science that actually were available in the colonial marketplace. Samuel Gerrish, established in business in 1712 as a bookseller and occasional book publisher, published seven sale catalogues between 1717 and 1725, which included two bookseller (retail) and five auction sales.[94] Although Gerrish had featured "Choice English books" and imported books on "divinity, philosophy, history, mathematicks, poetry, plays, voyages and travels" in his sales of 1720 and 1723

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[91]Botein, "Anglo-American Book Trade, p. 49.

[92]On the "dumping" of "rum" books, i.e., unsalable titles, on the colonial market and colonial booksellers' efforts to resist this practice, see Ibid., 73-79.

[93]Raven, "Importation of Books," 187-88.

[94]Thomas, *History of Printing*, 2:216. Gerrish sales of 1717, 1718, 1718, 1719, 1720, 1723, and 1725; Winans, *Checklist*, #s 2-7 and Evans #s 1921, 1953, 1984, 39701, 39722, 39784 and 39828, respectively. Gerrish's 1717 sale of the library of the Rev. Pemberton was exceptional in that it included 3 reference books (*Rarities of the Royal Society*, Harris's *Lexicon Technicum*, and Bayle's *Historical and Critical Dictionary*), plus both of Derham's physico-theological works and one of Whiston (*New Theory of the Earth*).

respectively, not until his auction sale of 1725 were Newtonian podium lectures (academic texts) advertised for sale on Boston bookshop shelves.[95] The 1725 sale, comprising the libraries of two New England ministers and "a considerable number of choice new books, lately imported from London" for a total of 695 books, included John Keill's *Introduction to Natural Philosophy,* in both English and Latin editions, and Samuel Clarke's Newtonian gloss of Rohault's *Physica* in the original Latin, as well as a pulpit lecture by George Cheyne (App. II, #1).

In the 1730s Thomas Cox advertised to a readership sophisticated enough to respond knowingly to the description "books in all arts and sciences." Although Cox established himself as a bookseller in Boston between 1733 and 1744, he conducted most of his business from London and employed an agent to oversee his Boston endeavors.[96] Cox's 1734 catalogue suggests he was able to avoid the problems of supply that beset colonial sellers dealing with English suppliers. Unlike Gerrish, Cox did deliver the best authors ancient and modern: his science books cross the spectrum from the mid-seventeenth to the mid-eighteenth centuries, include works by the foremost natural philosophers of Newton's generation as well as those immediately before and after, and comprise a variety of science genres. Cox's catalogue advertised 856 titles; of the twenty-two science titles, sixteen deal with Newtonian science, including eight academic texts, five physico-theological works, one popularization, and two digests of general or scientific knowledge (App. II, #2). In addition Cox listed Richard Blackmore's philosophical poem, *Creation.*

Some thirty years later, John Mein—advertising books "in most branches of polite

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[95]Although the 1720 and 1723 sales featured "imported" books, neither listed any Newtonian texts; the 1723 sale did have an early version of the compendium of polite learning for children, Pluche's *Nature Display'd.* However, the 1718 auction sale of the Rev. Mr. Curwin's library listed Derham's *Physico-Theology*, while the 1717 auction of the Rev. Henry Pemberton's library included Derham's *Physico-Theology* and 3 science digests: Harris's *Lexicon Technicum,* and both the *History* and the *Rarities of the Royal Society.*

[96]Thomas, *Printing in America,* 2:225.

literature, arts and sciences" for circulation as well as sale—found it necessary to satisfy his readers' desire for genteel taste as well as intellectual stimulation. A year after Mein arrived in Boston from his native Edinburgh, he advertised the opening of Boston's first "Circulating Library" open to both men and women where books were "lent out" upon payment of an annual, semi-annual or quarterly fee.[97] The separately printed, fifty-seven-page catalogue lists 750 titles for lending or sale. Newtonian literature comprised fourteen titles (nearly 1.5 percent of all titles): one podium lecture; three pulpit lectures; two philosophical poems; five texts "a La Mode" that included one each of transitional, polite, and easy texts as well as one introduction to apparatus; and two reference works, (App. II, #7). Mein advertised the collection would be "doubled in less than a twelvemonth" if he met with "due encouragement." Some encouragement must have been forthcoming, for in the following year Mein issued a catalogue of 1741 titles. Yet he apparently abandoned the plan for a circulating library, since this collection of "curious and valuable" books was advertised for sale only. The 1766 catalogue listed an additional four Newtonian titles comprising one academic text and three texts "a La Mode." The latter included an easy introduction to Newtonian philosophy, a guide to Newtonian apparatus, and a polite text for children, respectively, Fenning's *Use of the Globes*, Martin's *Philosophical Grammar*, and "Tom Telescope's" polite text for young readers listed as "Newton's Philosophy adapted to the Youth of both Sexes," attributed to its publisher, John Newberry (App. II, #8). In the newspaper advertisements that promoted the circulating library, Mein noted he had selected his books "to amuse the Man of Leisure; to afford and elegant and agreeable relaxation to the minds of Men of business, and to insinuate knowledge and instruction, under the veil of entertainment to the FAIR SEX."[98] Encoded in his appeal is evidence of changing

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[97]For Mein's status as the forerunner of other Boston circulating libraries, see Charles K. Bolton, "Circulating Libraries in Boston, 1765-1865," CSM *Pubs.* 11 (1906-07): 196-200.

[98]*Massachusetts Gazette*, 31 Oct. 1765.

cultural values as well as the gendering of reading itself. Men and women, so Mein insinuates, may both read for diversion, but women's reading must be surreptitiously directed to a purposeful end.

During the economically expansive decade of 1760s, three other New England booksellers produced sale catalogues. In New Haven, Benedict Arnold produced a broadside advertisement of 150 books imported via New York, while Andrew Barclay also advertised 150 books for sale at his shop in Boston.[99] Arnold's patrons could chose among three polite or easy versions of Newtonian natural philosophy as well as Thomson's *Seasons*, while Barclay's patrons were limited to Chambers *Cyclopedia* and the philosophical poems of Thomson and Blackmore (App. II, #s5 and 6, respectively). Bostonians, Harvard College students, and more distant readers who were interested in the new science also could patronize the shop of Jeremiah Condy. A Boston bookseller and occasional publisher, Condy distributed his books to other Boston merchants and small shopkeepers as well as hundreds of individual account-holders spread along established trade routes throughout New England.[100] His catalogue, published in 1766, listed 160 books, although it is now missing. Nevertheless, the inventory of his estate taken two years later establishes that his stock of books then numbered 308 titles of which thirteen (4.2 percent) dealt with Newtonian science: five copies of an English version of 'sGravesande's academic text, one copy of Nieuwentyt's and twelve copies of Wollaston's physico-theological lectures, a total of nine copies representing three of Martin's popular interpretations (*Philosophical Grammar*, *Philosophia Britannica*, and *Use of the Globes*) and eighteen copies of Ferguson's popular text, *Astronomy Made Easy*, plus one science and one bibliographic dictionary, and a single copy of Thomson's *Seasons* (App. II, #9).[101] Although his

[99]For Barclay's professional activities in Boston, New York, and Royalist Canada, see Hannah D. French, "The Amazing Career of Andrew Barclay, Scottish Bookbinder of Boston," *Studies in Bibliography* 14 (1961): 145-66.

[100]Reilly, "Wages of Piety," 107-09.

[101]For the complete inventory of Condy's books, see Ibid., App. II.

estate inventory does not include the eighteen "optical instruments" listed in the 1766 catalogue, in 1762 Condy advertised "Telescopes of various Sorts, Microscopes, *Hadley's* Quadrants for double and single Observation; Cases of Mathematical Instruments; Maps, [and] a great Variety of fine Prints for the Camera Obscura"—apparatus that he obtained from the London workshop of Benjamin Martin which could be used by both polite and practical devotees of Newtonian science.[102]

In the early 1770s an additional three New England booksellers produced catalogues of book sales, all of which show a decrease or absence of scholarly texts, a corresponding increase in popular texts, and the persistent appeal of physico-theological works. In 1772 Edward Cox and Edward Berry advertised "a large assortment [1400 titles] of the most esteemed books in every branch of polite literature, arts and sciences" for sale at their King Street store in Boston which included twenty-seven Newtonian titles: one academic text, four pulpit lectures, ten popular texts including three for young students, nine reference works, the physico-theological poems of Thomson and Young, and Pope's *Essay on Man* (App. II, #12). Young readers could choose Pluche's *Nature Display'd*, Watts' *Astronomy*, and Tom Telescope's *Newtonian System of Philosophy*, listed as "Telescope's Philosophy of Tops and Balls" under the heading, "Little BOOKS for the Instruction and Amusement of Children, adorn'd with a Variety of Cuts, and bound in Gilt Paper." In 1773 the firms of both Henry Knox, stationer and bookseller in Boston, and Solomon Smith and Joseph Coit, booksellers and druggists in Hartford, produced catalogues of "imported" books. Among Knox's 800 titles were seventeen that comprised Newtonian literature, while among Smith and Coit's 375 titles were ten. Knox's titles were weighted toward interpretations "a La Mode" (seven); other categories numbered two or three entries, although he offered no reference works (App. II, #13). Smith and Coit did offer the *New and Compleat Dictionary of Arts and Sciences*, four popular

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[102]*BNL*, 29 Apr. 1762; Reilly, "Wages of Piety," 94. On a 1761 trip to England Condy apparently had established professional relations with Martin which extended through 1767, Ibid.

works (two polite texts by Martin and two books for young readers), and two pulpit lectures, but no podium lectures (App. II, #14). Both listed the philosophical poems of Thomson, Young, and Pope.

Henry Knox also advertised a full line of philosophical apparatus suitable for either the practical or polite use of science listed as follows: "Refracting Telescopes, Gun[t]er Scales and Dividers, Protractors, Sectors, Cloth Reflecting Microscopes. Magic Lanthorns, Pocket ditto, Pocket Compasses" as well as "a Pair of 18 Inch Globes with Proper Apparatus." That his line of books, stationary, and apparatus was available "on the most reasonable Terms" to "Gentlemen in the Country who want to Originate or compleat Social Libraries, Country Merchants, Traders and others" is evidence of the pursuit of leisure activities among the elite in pre-Revolutionary New England as well as the spread of genteel reading tastes from urban centers to country outposts. Knox's appeal to a "gentlemanly" audience fits the pattern of the "transforming relationship" created by mid-eighteenth century retailers' emphasis on the "genteel" nature of their goods and their exchange, in which "in the very act of seeking and serving customers, shopkeepers recruited for a cultural style."[103]

Although the total number of titles varied widely among the three booksellers active in the 1770s, the percent of Newtonian titles listed in their catalogues varied by only one percent (a high of 2.67 percent to a low of 1.64 percent). Overall in the booksellers' catalogues of the 1770s, as in those of the 1760s, Newtonian literature comprised just over two percent of all titles. Popular texts in both decades out-numbered academic texts by a ratio of nearly six to one. The number of physico-theological texts and of philosophical poems was approximately double that of academic texts, while combined they numbered about eighty percent of popular texts. Thus in the second half of the eighteenth century, the general reading public that patronized booksellers followed two main avenues to the principles of Newtonian natural philosophy both of which tended to conflate

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[103]Bushman, "Shopping and Advertising," 251.

Newtonian truths with other tenets reflecting both religious beliefs and polite aspirations.

## Newtonian Literature in New England Social Libraries

When New Englanders looked for a model for the establishment of social libraries, they usually looked to the the Library Company of Philadelphia, publicized throughout the northern colonies by an article in *The American Magazine and Historical Chronicle.*[104] The Library Company had its origins in the Junto, the reading and discussion club formed by Franklin and most of his "ingenious Acquaintances" in 1727. Although Franklin cited no actual model for the Junto, he had participated in literary discussions in London coffee-houses and taverns, had observed Cotton Mather's neighborhood benefit societies in Boston, and had read John Locke's " Rules of a Society which met once a Week for the Improvement of useful Knowledge, and the Promoting of Truth and Charity"—all of which contributed to the establishment of the Junto whose purpose was the "mutual Improvement" of its members. Within a few months of the demise of the Junto in 1731, Franklin had put forth his "Scheme" for the Library Company, a subscription library whose purpose, like that of the Junto, was the acquisition of "useful" knowledge and self-improvement.[105] Included in the Library Company's initial order of forty-five titles, filled with the help of a London patron—the Quaker merchant and Fellow of the Royal Society, Peter Collinson—were two Newtonian texts, listed as "Keill's *Astronomical Lectures*" and "'sGravesande's *Natural Philosophy*" (i.e. *Introduction to True Astronomy* and *Mathematical Elements of Natural Philosophy*, translated by Desaguliers, respectively). These were supplemented by Collinson's personal donation of a text

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[104]"An Address of the Directors of the Library Company of Philadelphia," *AMHC* (Jan. 1744), 210-11.

[105]Margaret Barton Korty, *Benjamin Franklin and Eighteenth-Century American Libraries*, vol. 55, *Transactions of the American Philosophical Society*, new ser. (Philadelphia: The American Philosophical Society, 1965) , 5-8. Locke's essay is in *A Collection of several Pieces of Mr. John Locke, never before printed nor extant in his Works*, . . . (London, 1720), a copy of which Franklin donated to the Library Company, Ibid. 19.

recorded as "Sir Isaac Newton's Philosophy"—identified in the first printed catalogue of the library as Pemberton's *A View of Sir Isaac Newton's Philosophy*.[106]

In Franklin's view, as he recounted in his autobiography, the Library Company became "the Mother of all the N. American Subscription Libraries now so numerous." The widespread establishment of subscription libraries, he believed, not only caused reading to become "fashionable" but also "improved the general Conversation of the Americans."[107] Social libraries, as Franklin's remark suggests, are evidence of the "cultural potency" of the eighteenth-century print media; as institutions of private society, their members gathered not only to select, collect, and maintain collections of books and periodicals, but also to discourse upon them, thus bridging oral and print culture.[108] Although, as Marion Korty has cautioned, Franklin's claim to parenthood of "all" subscription libraries is overstated, she has found that Franklin and other members of Library Company of Philadelphia, or their associates, directly influenced the establishment of thirteen subscription libraries in towns in Pennsylvania, New Jersey, South Carolina, and Rhode Island.[109] The mere knowledge of the Philadelphia Library Company, promulgated in *American Magazine*, and of the Library Company's progeny undoubtedly spurred the residents of still other towns to found libraries. Such was the apparent impetus for the Portsmouth Social Library whose proprietors cited the example of "Rhode Island, & Philadelphia & other Places on this Continent [that] have

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[106]Ibid., 8; Edwin Wolf, 2nd, "The First Books and Printed Catalogues of the Library Company of Philadelphia," *Pennsylvania Magazine of History and Biography* 78 (1954), 1; *A Catalogue of Books Belonging to the Library Company of Philadelphia* (1741; repr. Philadelphia: Printed for the Library Company of Philadelphia, 1956), 16. For an annotated edition of the 1741 catalogue, see Wolf, "Printed Catalogues," 54-70.

[107]Quoted in Korty, *Franklin and Libraries*, 21.

[108]Shields, *Polite Letters*, 322.

[109]Ibid., 21-25. Cf. Shera, *Foundations of Public Library*, 56-7.

reap'd great Benefit from such public Libraries" in their founding statement.[110]

The Library Company founded by Franklin and his mechanic and tradesmen friends is the most notable exception to the genteel character of the early social libraries. Their use of the resources of their library for "mutual Improvement" would yield, however incidentally, the knowledge necessary to fulfill the subscribers' aspirations to higher economic and social status—the elite status that typified the founding members of other pre-Revolutionary social libraries.[111] The proprietors of the Portsmouth Social Library, for instance, represented the wealthy merchant, professional, and governing classes of the town, as did the founders of the Salem Social Library, while the Redwood proprietors were men of "opulence, learning, science, and liberal leisure."[112] For the most part, only men could exercise membership privileges.[113] This was a circumstance due more, perhaps, to legal restrictions than social preference, since membership depended on the purchase and ownership of a tangible asset—a right denied eighteenth-century married women. Nevertheless, a

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[110]PL Proposals, [1]; for the names of the 33 founders, see Ibid., [1-2].

[111]For the modest backgrounds of members of the Junto and the Library Company, see Korty, *Franklin and Libraries*, 6-7.

[112]Quoted in Arthur S. Roberts, "Redwood Library: Two Centuries," in *Redwood Papers: A Bicentennial Collection*, ed. Lorraine Dexter and Alan Pryce-Jones (Newport, R. I.: The Redwood Library and Athenaeum, 1976), 15. The "Town and Province Tax List for 1757" (repr. in *The Portsmouth Project*, ed. and comp. Charles E. Clark and Charles W. Eastman [Somersworth: New Hampshire Publishing Company, 1974], 24-37), includes 27 of the 33 founders of the Portsmouth Social Library among Portsmouth's 513 rate payers. All were in the top 33% of the rate payers, while nearly half (44.8%) were in the top 6%. I thank Jim Pietsch for these figures. The founders (among whom were one Yale and 9 Harvard graduates) included 21 merchants, 3 attorneys, 2 ministers, and one physician. The majority were associated by blood, marriage, or politics with the royal governor, Benning Wentworth and his "clan." For their ties to Wentworth, see Jere R. Daniell, *Colonial New Hampshire: A History* (Millwood, New York: KTO Press, 1981), 66, n. 69, and Ibid., *Experiment in Republicanism: New Hampshire Politics and the American Revolution, 1741-1794* (Cambridge: Harvard University Press, 1970), Chap. 1, esp. 5, 15-19. For Salem Social Library members, see Harriet Silvester Tapley, *Salem Imprints, 1768-1825* (Salem, Ma.: Essex Institute, 1927), 220-28.

[113]For women's participation in *circulating* libraries, see Ross W. Beales and James N. Green, "Social Libraries and their Users" in *Colonial Book*, 403-04.

few women did become members of at least the Portsmouth and Salem social libraries when they inherited the shares of their deceased husbands or fathers.[114]

The Portsmouth library proprietors' deliberate reference to their "Taste for polite Literature" reveals their conscious desire to use the social library as a means to exhibit their gentility as much as a practical means to amass a ready collection of books "without the Expense of procuring a Library."[115] Their effort to acquire civility, an effort they shared with members of mid-century British American society, was tied to the internalization rather than the mere imitation of manners and taste.[116] Thus their selection of books is an exercise in the conscious display of good taste as well as an endeavor to reinforce their gentility with the acquisition of specific hallmarks of "polite Literature." The statement of these goals, accompanied by the names of the founding members of the Library Society and recorded in the "Library Proposals," becomes a self-validating act. The actual choice of reading material, which they will discourse upon as well as read, then becomes paramount in carrying out the goals they have displayed in writing. The catalogue of the Portsmouth library, like those of the social libraries in Newport and Providence, Rhode Island, and Salem, Massachusetts, shows that Newtonian science books comprised a small but significant percent of what was selected and displayed by their patrons as polite literature.[117] While the catalogues of the four libraries are valuable in providing evidence of the availability of Newtonian literature away from

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[114]The Salem Social Library had at least 7 widowed-women members by 1784, while the Portsmouth library had one woman member who had inherited her father's proprietary share, "The [Salem] Social Library's Book of Votes, &c. 1761," Salem Athenaeum Collection, EIL, *passim*; PL Records, 2 Mar. 1785.

[115]PL Proposals.

[116]Ibid., 39.

[117]Similar statements of purpose are incorporated in the catalogues or founding documents of the other three libraries. For specific holdings of the social libraries, see App. I, #s 3 (Redwood), 4 (Portsmouth), 5 (Salem), and 10 (Providence).

the metropolitan center and its desirability as a tangible hallmark of learning; the details emerge through an exploration of the cultural and community context of the Portsmouth Social Library.

Established during the era of Portsmouth's greatest prominence as the colonial capital of the province of New Hampshire and a northern center of Anglo-American trade, greatest wealth as the exporter of products from its lumber and fishing industries, and greatest efforts to replicate the genteel lifestyle of cosmopolitan centers, the Portsmouth Social Library provides an opportunity for establishing the community and cultural context of social libraries in New England.[118] The science books purchased in 1750 and 1755 by the thirty-one members of the Portsmouth Social Library, who subscribed 12 Pounds each to the purchase fund, constitute a fairly typical mix of the various kinds of Newtonian literature available on the shelves of New England social libraries by the middle decades of the eighteenth century. Although the Portsmouth Social Library collection numbered only 102 titles, it included eight works that can be considered within the genre of Newtonian literature. Five of these dealt specifically with Newtonian astronomy or experimental philosophy; one took a physico-theological approach; while an additional two titles represented poetical works whose authors were moved by the scientific muse of Newtonian philosophy. Gregory's *The Elements of Astronomy, Physical and Geometrical* represents the first generation of academic texts and scholarly interpretations of the *Principia*, as does Whiston's *Astronomical Lectures*. Nieuwentyt's *The Religious Philosopher* represents a physico-theological work, although the Portsmouth Library was unique in that it did not have the two most popular pulpit lectures of the colonial era, Derham's *Physico-Theology* and *Astro-Theology*. The library also owned a copy of

[118]For a contemporary view of Portsmouth, see James Birket, *Some Cursory Remarks Made by James Birket in his Voyage to North America 1750-1751* (New Haven: Yale University Press, 1916), 3-13. For a historical and political perspective, see Daniell, *Experiment in Republicanism*, Chaps. 1-2; for a cultural view, see James L. Garvin, "Portsmouth and the Piscataqua: Social History and Material Culture," *Historical New Hampshire* 26 (Summer 1971): 3-48; for material culture, see *Portsmouth Furniture, Masterpieces from the New Hampshire Seacoast*, ed. Brock Jobe (Hanover, N.H.:The Society for the Preservation of New England Antiquities, 1993).

Thomson's philosophical poem, *The Seasons,* and a complete set of Pope's works wherein readers would have encountered the Newtonian world view in *The Essay of Man*. Library members also owned the transitional polite text, Pemberton's *View of Sir Isaac Newton's Philosophy* and an easy introduction for young gentlemen, Well's *Introduction to Mathematicks*. Those library patrons who wanted a short introduction to Newtonian natural philosophy could consult the first volume of Harris's *Lexicon Technicum.*

In 1755, library proprietors had commissioned one of their members to deal directly with the London book dealer, Thomas Osborne, for the purchase of several books apparently ordered from the wholesale dealers's catalogues, among which were Pemberton's *View of Newton's Philosophy.*[119] Although the practice of dealing directly with a London wholesaler was one followed by other early social libraries, they could have dealt directly with Boston booksellers. Henry Knox, as noted above, promoted the social library market, while Jeremiah Condy, who had an extensive stock of Newtonian science titles at his Boston bookstore, acted as the agent for the Salem Social Library, procuring their orders directly from London.[120] Just a year later the Portsmouth proprietors could have enlarged their collection by simply walking to the printing office of Daniel Fowle, who had arrived from Boston in 1756 to establish the colony's first newspaper. Fowle had brought with him a large parcel of books, no doubt acquired when in the printing and publishing business in Boston with his brother, James Fowle. The list of books advertised in the October, 1756 issues of the *New Hampshire Gazette* includes an "*Account of Newton's Philosophical Discoveries*," the transitional

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[119]PL Records, 3 Mar. 1762; 8 Mar. 1762. The catalogues are identified in the inventory of books and buyers for the auction sale of the library's holdings held upon its dissolution in 1786, "John Parker Account Book," 135, Small MS Colls., PA. The library purchsed their initial collection from the Rev. Arthur Browne, the Anglican minister of Portsmouth, PL Proposals, [2-3]. For an account of London wholesale dealers, colonial retailers, and Osborne's activities, see Botein, "Anglo-American Book Trade," 62-73.

[120]Talpey, *Salem Imprints*, 229-30; see also "Condy to [Proprietor] Stephen Higginson," 5 Nov. 1760, quoted in Ibid.

polite text by Colin Maclaurin. Fowle also offered Pluche's *Nature Display'd* for young readers and the philosophical poems, Thomson's *Seasons* and Young's *Night Thoughts*. Fowle also listed the *American Magazine*, a three-volume collection of the monthly periodical which featured "all the Parts of polite and useful Learning" published by Fowle and Rogers in the early 1740s. Distributed from Boston to New York, Philadelphia, New Haven, Connecticut, and Newport, Rhode Island, the *American Magazine* announced that it aimed for a broad audience so that "Tradesmen, Husbandmen and even their Wives and Children may gather much Learning as well as much Entertainment." During its three-year life, its editors imitated the cosmopolitan models of London journals and featured extracts from the best authors in "*Great Britain* and the Plantations" on history, politics, poetry, divinity and natural philosophy. The latter included articles on Newtonian science as well an extensive account of Newton's life, discoveries, and publications, extracted from Bayle's *Historical and Critical Dictionary*.[121]

Two subsequent notices advertising books for sale at public auction or through the printer listed Harris's *Lexicon Technicum*, Young's poetical works, Thomson's *Seasons* and the *American Magazine* among assortments of religious, historical, practical, and fictional works.[122] In 1769 the merchant William Appleton advertised "a very large and compleat Assortment of BOOKS in Law, Physic, History, Anatomy, Novelty, Surgery, Navigation, Divinity, Husbandry, and Mathematicks," which numbered 215 titles, for sale at his Portsmouth store.[123] His collection included nine works

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[121]*AMHC*, Sept, 1743, ii-iii.; "An Account of the Life of Sir Isaac Newton : Extracted from Mr. Bayle's Historical and Critical Dictionary," Ibid., Jan. 1745, 9-18. Newton as a personage is depicted in "The Characters of Worthies at Stowe . . .," Aug. 1746, 348-49, while Newtonian natural philosophy is referenced in "An Account of Comets," Jan. 1744, 207-09, and even parodied in "Of Philosophical Systems," Nov. 1745, 495-99.

[122]*NHG*, 26 Apr. 1765.

[123]*NHG*, 16 June 1769. The list included 214 titles comprising 24 law; 21 medicine; 14 biography, history, and geography; 45 belles lettres (novels, poems, literary magazines), 48 divinity (but only six authors of devotional "steady sellers"; see note 123 below), 15 math, science,

(4.2 percent) that represented all categories of Newtonian literature and actually surpassed the percentage of Newtonian titles found in the sale catalogues of Boston booksellers (with the exception of Jeremiah Condy). These were one academic text (Desaguliers's translation of s'Gravesande's *Elements*), one physico-theological work (Nieuwentyt's, *Christian Philosopher*), two philosophical poems (Young's *Night Thoughts* and Pope's *Essay on Man* in his collected works), four texts "a La Mode," (Martin's *Philosophical Britannica*, Doddsley's *Preceptor*, and Voltaire's *Letters Concerning the English Nation* and *Elements of Newton's Philosophy* in his collected works) and one reference work (*The Dictionary of Arts and Sciences*). Appleton's advertisement, in particular, with its eclectic and cosmopolitan assortment of imported titles suggests that no assortment of books could indeed be "compleat" (i.e., offering a choice in quality and style of "fashionable" goods)[124] without a representative selection of Newtonian texts.

The occasional advertisements in the *Gazette* are a reminder that Newtonian literature was available beyond the relatively exclusive bookshelves of the social libraries through the agency of printers and booksellers as well as individuals who shared their own private collections. Just over the Piscataqua River in the Maine towns of Kittery and York, a "Revolving Library," numbering under three hundred books, circulated among the houses of the parish ministers from 1751 to 1790 and benefited the first and second parishes in Kittery, and one in York.[125] The library itself benefited in large part from a bequest of Sir William Pepperrell to the the pastor of Kittery's First Congregational Church, the Rev. Benjamin Stevens, for the purpose of establishing a "Social library for the congregational ministers and their successors in said office," as Stevens noted in his own will

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navigation and husbandry; 9 music; and various miscellaneous titles, plus an unspecified number of untitled bibles, primers, testaments, and spelling and school books.

[124]Bushman, "Shopping and Advertising," 245.

[125]Horace E. Scudder, *Public Libraries in the United States: Their History, Condition, and Management* (Washington, D. C.: Government Printing Office, 1876), 20.

that apparently formalized the library's long-standing existence.[126] The collection included four Newtonian science books owned by Pepperrell's son, Andrew, in 1740 and 1741, before he entered Harvard College.[127] These included the fifth edition (1737) of William Whiston's physico-theological work, *A New Theory of the Earth* (1697), and a first edition of Pemberton's *View of Newton's Philosophy*. Also represented was the second edition (1729) of John Harris's *Astronomical Dialogues between a Gentleman and a Lady*. Young patrons of the revolving library could also learn Newtonian philosophy from Isaac Watt's *Astronomy*.

Following his death, an advertisement in the local newspaper solicited the return of books "borrowed of Sir WILLIAM PEPPERRELL, Bart., now deceased."[128] Hence Sir William's bequest, which included the books of his son Andrew who had predeceased him, may have grown out of Pepperrell's apparent practice of the ready loan of books from his personal library and also his friendship with the Rev. Stevens. That the Pepperrell library contained a significant number of Newtonian natural philosophy books may have been due to the scientific interests of Stevens. The Kittery minister, who had advised Sir William in the stocking of his library, was a Harvard graduate, a friend as well as student of John Winthrop, the college professor of mathematics and natural philosophy, and a member of the Portmouth Social Library.[129] Known to be "engaged with ardor,

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[126]Will of Benjamin Stevens, 4 Aug. 1791, John Eldridge Frost, *Maine Probate Abstracts*, vol. 2, (Camden, Me.:Picton Press, 1991), 16:1003.

[127]The remnants of this library, including the four Newtonian texts with Andrew Pepperrell's signature are in Kittery First Congregational Church Coll., PA. For biographical information, see *SHG* 11:290-93.

[128]*NHG*, 3 Oct. 1761.

[129]A native of Charleston, Mass., Stevens was a fellow at Harvard for 10 years following his graduation in 1740; he served as pastor in Kittery from 1751 until his death in 1790, *SHG*, 10:535-59. Under the terms of his will, he left "any benefit from my interest in the old Social Library at Portsmouth" to his son-in-law, the Rev. Joseph Buckminster, who had succeeded Stiles as the pastor of the First Congregational Chuch in Portsmouth Frost, *Maine Probate Abstracts*, 16:1003-04.

and great diligence in the pursuits of science," the Kittery pastor also maintained a correspondence with Ezra Stiles with whom he exchanged data on astronomical observations as well as news of theological import.[130] The Kittery Revolving Library, supplied with scientific as well as religious books, demonstrates that Newtonian literature could cross the bounds of merely polite readership to serve the interests of a diverse group of church members.

When Portsmouth Social Library patrons chose their "good Collection of Books," Newtonian literature comprised nearly eight percent of what they determined was desirable for the "Advancement of Learning & the Increase of all useful Knowledge . . . of great Importance both to the Civil & Religious Welfare of a People."[131] Although the smallest of the four New England social libraries in terms of library holdings, the Portsmouth library actually possessed the highest percentage of Newtonian literature titles. Newtonian literature in the Redwood Library with approximately eight times the total titles comprised nearly four percent of all titles, while it comprised approximately six percent of the Salem and Providence libraries' titles whose holdings were roughly three-and-one-half times that of Portsmouth. The three other institutions owned a similar mix of academic, physico-theological, poetical, popular, and reference works. Overall the libraries owned at least an even number of academic and popular works (Portsmouth and Providence), or fifty to seventy-five percent more academic than popular works (Salem and Redwood, respectively), which may be attributable to the generally high educational level of the library proprietors. The inverse ratio of Newtonian literature to total titles and also the diverse mix of Newtonian titles in the social libraries suggest that by the middle of the eighteenth century, educated readers' "Taste for polite Literature" demanded a minimum repertoire of Newtonian literature. As such, the incidence of Newtonian literature titles compares favorably to the incidence

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[130] *SHG*, 10:536; quote from John Eliot, *Biographical Dictionary* (1809), Ibid.

[131] PL Proposals

of historical and religious texts that constituted the "core readings" of social libraries after 1790.[132] The catalogues of the Portsmouth, Salem, Providence, and Redwood social libraries are evidence that a "good Collection" of books would of necessity include those core readings that imparted the new science by way of scholarly, pious, and polite works.

The use of Newtonian science by the Portsmouth library proprietors, as well as by their peers in Salem, Providence, and Newport, is of a piece with the change in reading habits discernable by the middle of the eighteenth century. The "social correlations of literacy" were changing as elite, cosmopolitan reading tastes were developing distinct from the hitherto shared culture of "traditional literacy."[133] This new taste in reading reflected the goals of polite learning—genteel display and civil discourse—rather than religious improvement which was the theme of "steady sellers" and their vernacular readers. This is apparent not only in the taste for novels, as Hall and other scholars have shown, but also in the taste for the newest science books. The significant presence of Newtonian literature on booksellers' and social library shelves suggests it should be considered as one of the new literary genres that infiltrated the previously monolithic hold of devotional and religious books that had leavened seventeenth-century New England society. By mid-eighteenth century, the introduction of new genres, especially of novels and journals, precipitated the gradual fracture of the

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[132]This term is borrowed from David Lundberg who identified 94 titles (primarily historical and religious works) that occurred at least five times in 12 social libraries from the 1790s, "Hall, Books and Readers," 362. Using as a conservative measure, an occurrence of 3 times in the 4 social libraries, works by the following authors, which represent all types of Newtonian literature, would constitute core readings: 'sGravesande, Gregory, Keill, Whiston, Derham, Nieuwentyt, Wollaston, Pope, Thomson, Young, Pemberton, Voltaire, Martin (various works combined), Harris (reference).

[133]David D. Hall, "Introduction: The Uses of Literacy in New England, 1600-1850," in *Printing and Society*, 45. Of the approximately 52 theological titles, only one is by any of the 26 writers Hall has identified as authors of "steady sellers," Ibid., 28-21, and Hall, *Worlds of Wonder, Days of Judgment, Popular Religious Belief in Early England* (Cambridge: Harvard University Press, 1989), 48-52. The majority of theological works comprised biblical history and chronology (21 titles); the remainder were devotional titles (8), collected works and sermons (9), polemics dealing primarily with natural versus revealed religion (11), and church polity (3).

religiously-based world view whose fullest effects were not apparent until late in the 1780s into the 1830s. But there is a caveat here: Newtonian science may have contributed to a mid-century fracture, but not the demise, of a religious world view. In this regard, because imported Newtonian literature incorporated elements of piety and politeness, especially in physico-theological works and polite texts, it acted as a bridge between "genteel culture" and the "vernacular tradition," hence ameliorating the tensions between these two strands of readers.[134] The popularity of the various kinds of Newtonian texts among both the elite readers served by social libraries and general readers served by booksellers indicates that genteel reading tastes could in fact grow out of the religious impulses that had produced the steady sellers of the prior generation. Thomson's *Seasons* and Watts *Astronomy* are particularly significant—the former became a steady seller in its own right well into the nineteenth century, while the latter's popularity no doubt was enhanced by the "steady seller" publication of Watts's devotional hymns and poetry.[135]

Just as the categories of Newtonian literature crossed the bounds of natural philosophy, religion, and polite literature, the works themselves within those categories —especially physico-theological works, philosophical poetry, and polite texts—recrossed those bounds often integrating the cosmopolitan goals of polite literature and the orthodox goals of religious piety. Hence, just as steady religious sellers had provided a common Christian language that embraced men and women of elite and vernacular cultures, so the language of Newtonian texts provided a new "philosophical" vocabulary common to men and women of both traditions with which they could express their relationship to the Newtonian universe. Ezra Stiles may simply be the most prominent figure who

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[134]For the conflicted nature of the relation between these two traditions, see Hall, "Books and Reading," 370-77; for their reconciliation through the establishment of a learned culture, see Ibid., "Learned Culture in the Eighteenth Century," in *Colonial Book*, 411-33, esp. 430-33.

[135]For late 18th- and early 19th-century American publications of Thomson's *Seasons* and Watts's works which qualify them as "steady sellers," see Hall, "Uses of Literature," 30.

reconciled the tensions marking mid-eighteenth-century culture within a unified framework of Newtonian philosophy, enabling it to serve both religious convictions and cosmopolitan aspirations. Certainly there were other, less public figures, other Edward Bromfields, for instance, who trafficking in Newton, used natural philosophy in the service of both piety and politeness.

## CHAPTER II

## THE *AMES'S ALMANACK*: ACCOMMODATING NEWTONIAN METAPHYSICS AND TRADITIONAL LORE

The young man pocketed his penknife and, applying the newly-sharpened quill to the blank paper laid before him, started the cover page of his diary (fig. 2.1):

*A new Fashioned*
*Almanack*
*or a Journal for the year*
*1738.*

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Pausing, he recollected the almanacs that came year in and year out to the family home, then confidently continued:

*wherein is contained or pen'd*
*down Some Remarkable*
*Providences: as Death: Thunder*
*and Lighting. Lights in the air:*
*together with a general course of*
*the weather.*

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*by me: Samuel Lane*

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*(not) master of art (nor yet)*
*Student in Physic & astronomy*

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*Hampton: in New Hampshire.*
*Whose Latitude is about 43 Degrees*
*15 min. - north &c. as I call it*[1]

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The twenty-year old Samuel Lane, who just the previous year had learned "to Cypher & Survey,"[2]

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[1]Samuel Lane Papers, New Hampshire Historical Society, Concord, NH; I thank Jerald Brown for bringing Lane's diaries to my attention.

[2] Charles Lane Hanson, ed., *A Journal for the Years 1739-1803 By Samuel Lane of Stratham, New Hampshire* (Concord: New Hampshire Historical Society, 1937), 1.

here not only reveals a fine sense of humor but also graphically displays the pervasive influence the almanac exerted in the lives of its eighteenth-century readers. Lane was destined to become a successful tanner, farmer, and surveyor rather than a doctor of medicine or astronomy.[3] Yet he typifies the middling sort of colonial society who turned not to textbooks or learned societies for their knowledge of the natural world but to those annual publications, at once ephemeris (i. e., an "astronomical almanac") and ephemeral, produced by "almanack makers" who perforce were actual students of astronomy. By the third decade of the eighteenth century, when Lane catalogued his list of celestial phenomena, almanac writers commonly were explaining those events according to "the Great Sir Isaac Newton."[4]

In this chapter, this study turns from the imported Newtonian texts that stood upon the shelves of social libraries and in the secretary-bookcases of learned and affluent New Englanders to the homely almanac—the annual compendium of astronomical science, lore, and advice that found its way into homes throughout New England. Comprised of one printer's sheet folded into eight leaves (sixteen pages), this product of the colonial press— these "little Books," as they were familiary known—entertained and instructed readers across class and geographic lines. By introducing the rudiments of Newtonian astronomy to that segment of its audience who had little or no other contact with formal instruction, almanacs became an effective means of popularizing the new science and incorporating it into venacular culture. The almanac series of Dr. Nathaniel Ames, Jr., and his son, Dr. Nathaniel Ames III, *An Astronomical Diary, or, an Almanack . . . for . . .* (referred to by it readers and advertised as *Ames's Almanack*) spans the years from 1726 to 1775.

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[3]For a short introduction to Lane's life and a severely edited version of his diary, see Hanson, *Journal . . . By Samuel Lane;* for a biography, see Jerald Brown, *The Years in the Life of Samuel Lane, 1718-1806: A New Hampshire Man and His World* (Hanover, N. H.: University Press of New England, 2000).

[4]Nathaniel Ames, Jr., *AD . . . 1740.*

Thus the series coincides with the period of formation of a Newtonian culture in New England which promoted a rational explanation of the natural world and celebrated the newly discovered wonders of that world. As such, the *Ames's Almanacks* present a unique opportunity to examine how Newtonian thought was adapted and presented for the use of a diverse audience and what individual accomodations this required of its writers, the two Dr. Ameses, father and son.

The natural world—the world of celestial movement, tidal ebb and flow, and seasonal change—was the special province of almanac makers whose own world view influenced their interpretation of the wider world. Evident in the *Astronomical Diary* is the gradual and sometimes reluctant transition from the "old" providential-astrological to the "new" rational world view as the Ameses incorporated Newtonian natural philosophy into their explanations, while always keeping an eye to their their readers' expectations. Because they were writing for an audience whose belief systems represented the spectrum from traditional to new, the Ameses mediated between what David Hall has identified as the two worlds of print: "the world of slow and repetitious rhythms, and that concerned with the new and critical."[5] In negotiating between these two worlds, the Ameses presented the new science in a variety of guises (essays, poetry, and illustrations) to meet the needs and expectations of their audience thus effecting an accomodation between traditional lore and Newtonian natural philosophy.

Almanac makers played a unique role in New Englanders' exposure not only to the basic scientific theory of Newtonian astronomy, but also to the galaxy of theological and metaphysical ideas spun out from Newton's writings that conjoined religion and science.[6] Newtonian metaphysics explained the workings of the universe and God's relation to it in terms of "the

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[5]David D. Hall, "The Chesapeake in the Seventeenth Century" in *Cultures of Print: Essays in the History of the Book* (Amherst: University of Massachusetts Press, 1996), 89-90.

[6]For a fuller explanation of Newtonian metaphysics, see Introduction above, 4-6.

scientific harmony of the universe" which implied belief in Newton's methodology (including an inductive approach to empirical knowledge) and his rational explanation of the universe (i.e., the governance of the world by immutable, demonstrable, mathematical laws). Investigation of the natural world revealed a beneficent God, awesome in his goodness, who himself acted rationally, that is, in accordance to the laws he had created to govern the natural world. In contrast, Samuel Lane's God, the God of Holy Scripture, could set aside natural laws by intervening directly through the agency of "Remarkable Providences . . . Death, Thunder and Lightning [and], Lights in the Air." This was an entirely providential God who was terrible in his goodness. Because their proper subject matter was thunder, lightning, and lights in the air, almanacs often reflected the tensions that arose between conservative belief, grounded in orthodox piety, and the new, rational belief, grounded in Newtonian philosophy. These tensions preoccupied the elder Dr. Ames in particular as he sought over his forty-year career to accommodate his own beliefs to the new science, on the one hand, and to the beliefs of his readers, on the other.

* * *

What could Samuel Lane, the resident of rural New Hampshire, find when he turned to his almanac? The likely model for Lane's diary cover, *An Astronomical Diary, or an Almanack For the Year. . . 1736. . . . by Nathaniel Ames, jun. Student in Physick and Astronomy* (fig. 2.2), suggests the answer can be found in the almanac series produced by the Dedham, Massachusetts physician and tavern keeper, Dr. Nathaniel Ames, Jr., from 1726 until 1764, and continued by his son, Dr. Nathaniel Ames III from 1765 to 1775. Initially printed in Boston, the almanacs produced by the Ameses were printed and sold by bookseller-printers throughout all the regions of New England. In 1756 Daniel Fowle began printing the *Ames's Almanack* in Portsmouth, New Hampshire, followed four years later by Timothy Green in Hartford, Connecticut, and then by printers in New Haven and New London. Such was their popularity that by the 1760s, readers numbered from 50,000 to

60,000 men, women, and children a year.[7]

As the specific phrases Samuel Lane borrowed from his model indicate, the primary information readers sought from their almanacs was the "general course of the weather" and meteorological information. The title page of the elder Dr. Ames's sixteen-page ephemeris for 1736 is a succinct summary of the information conveyed in his and most American almanacs as they had developed by the eighteenth century. Serving as cover, table of contents, and advertisement for the information within, the title page promised the following straight forward information necessary for the daily business of country folk, as well as mariners, merchants, and magistrates:

> Wherin is contained Eclipses of the Luminaries, the Lunations, mutual Aspects, Sun's and Moon's Rising and Setting, Time of high Water, Courts, Spring Tides, Weather, &c.

As Ames's summary indicates, astronomical data contained in the calendar (which comprised twelve pages of the typical sixteen-page almanac) and in the essays (which took most of the remaining space) was the "major component" of the almanacs.[8] Bearing in mind the value of advertising, Ames also added a teaser or hint of a novel topic or promotional piece. In 1736 he featured a "Poem on the Day of Judgment; to be read of the Head of each Month succedaneously."

Thereafter followed a standard line both informational and self-serving as the doctor assured his readers of the "great care" he took in producing the calculations for the meridian of Boston,

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[7]Charles Nichols, "Notes on Massachusetts Almanacs," AAS *Proc.*, n. s., 22 (1912): 30-31; Albert Carlos Bates, "Checklist of Connecticut Almanacs 1709-1850," AAS *Proc.*, n. s., 24 (1914): 97-101; Samuel Briggs, *The Essays, Humor, and Poems of Nathaniel Ames, Father and Son, of Dedham, Massachusetts, from their Almanacks 1726-1775* (1891; repr., Johnson Reprint Corporation: New York, 1970), 20; Isaiah Thomas, *The History of Printing* (1810), 2d, corr. ed. (Albany: N. Y.: AAS, 1984), I:126.

[8]John T. Kelly, *Practical Astronomy during the Seventeenth Century, Almanac-Makers in America and England* (New York: Garland Publishing, Inc., 1991), 13; although a study of the use and history of computational astronomy in 17th-century American and English almanacs, Kelly includes statistical analysis of the content of Massachusetts almanacs from 1639-1775, see 12-14. For a general history of the development of American almanacs, see Marion Barber Stowell, *Early American Almanacs: The Colonial Weekday Bible* (New York: Burt Franklin & Co., Inc., 1977).

"whose Lat. is 42 deg[rees,] 25 min[utes] North." This was of special interest for the maritime community and for those who planned to observe any of the current year's celestial phenomena. Advised of the latitude of Boston, readers at a distance could adjust Ames's calculations to their own location. Centered on the title page was Ames's by-line; after 1736 with his reputation well established, Dr. Ames abandoned the tag "Student in Physick and Astronomy." Below his by-line, Ames usually included several lines of verse, of his own composition or borrowed from contemporary authors, which often introduced the subject that emerged as the theme of the current almanac. At the bottom of the page was the place of publication, the printer, and bookseller, and sometimes the price. The collaboration between the compiler of the astronomical calculations and the printer on the literary content (essays, poetry, humor, general information) of each almanac series varied widely, but Ames and his son both appear responsible for selecting all the material "[to] fill up [the almanac] with useful and entertaining things."[9]

Both the elder and the younger Doctors Ames were skilled in the mathematical and astronomical techiniques necessary to compute the astronomical data (the daily position of the sun and the moon in the zodiac and the positions of the planets relative to each other, especially the times of solar and lunar eclispes and planetary transits) contained in the almanacs. They made use of ephemerides produced in England, which were compilations of astronomical data calculated for the coordinates of a given location, adpating them for the coordinates of Boston. Between 1740 and 1767, however, when English ephemerides were not available, the Ameses had to rely solely on

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[9]Diary entry by Nathaniel Ames III for Oct. 18, 1767, quoted in Briggs, *Essays, Humor,and Poems*, 34. Occasional remarks by both Ameses throughout their almanacs indicate their authorship of various literary essays and poetry. Stowell points out the difficulty of documenting the non-astronomical content, especially in the instances where compilers furnished only the astronomical data to the printer, and the printers or their own editors chose the literary and miscellaneous material, Stowell, *Weekday Bible*, 25-30. My examination of the internal content, including calendar page information, of the almanacs produced by the various *authorized* printers of the *Astronomical Diary*, however, shows a uniformity of content as well as layout.

planetary-tables, a tedious process that required the knowledge and use of logarithms and proportion, principles of computational astronomy, and various astronomical tables. Both the Ameses checked the accuracy of their astronomical predictions, often foretold to the minute, by following up with observations of the actual celestial events. When measured against predictions made by the Harvard College "mathematical-practioners," Thomas Robie and John Winthrop, the Ameses' "keen interest in accuracy" resulted in a "remarkable achievements of computational astronomy. Almanac makers who lacked the necessary compuational skills, purchased their astronomical data from mathematical practitioners, some of whom also produced their own almanacs.[10]

As did his peers and rivals, Ames usually addressed his "Kind Readers" on the first page with a prefactory essay introducing the particular year's *Astronomical Diary*. Ames often reminded his readers of the "much Labour and hard study" required "to trace the rambling Moon, and wandering Planets, in all their intricate Paths" which preparation of the almanac required.[11] He might also include the sources for his poetic headings and the circumstances that may have prompted each year's essay. The essays were of didactic nature and often thematically tied to the poetic headings—a practice apparently unique to Ames. Occasionally Ames here indulged in accounts of his legal and financial problems and of his problems with the printers who produced the authorized

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[10]Kelly, *Practical Astronomy*, 266; 245, 37, 245-56, 273. Kelly based his assessment on the comparison of the elder Dr. Ames's predictions of 32 visable lunar eclipses (1726-1764) to those of Robie and Winthrop, Ibid., Table, 267-70. Among almanac writers who purchased astronomical data is Benjamin Franklin, who purchased the data for *Poor Richard's Almanack* (1733-1758) from the Philadelphia Academy professor of mathematics, Theophilus Grew, who himself published almanacs in Maryland, New York, Pennsylvania, and Virginia, Ibid., 273-74; 274, n.10.

[11]*AD for . . . 1759*. Ames, however, never voiced his complaints as satirically as did "Poor Robin" (James Frankin) who lamented, "It cannot be supposed that the Sons of Art would lie stretch'd on their Backs whole Nights together, stare at the Stars with all the Eyes they have in their Heads, expose themselves to Frosts and Dews, an thereby shorten their own Lives to qualify themselves for predicting long Life and Happiness to others, if they were not compelled to it by the Stars," *The Rhode-Island Almanack for . . . 1734* (Newport, 1734).

editions of the almanacs as well as those who produced pirated or spurious editions.

With the use of a introductory essay addressing his readers, Ames and other almanac makers were using a literary device carried over from seventeenth-century religious texts wherein the reader was instructed how to understand—how to "digest," "chew over," and "meditate upon"— the material that followed.[12] Thus almanac readers, who came from a vernacular tradition of intensive reading of religious texts, were likely to bring the same practice to their perusal of the almanac. That Ames took advantage of this tradition is evident in his introductory remarks to the *Astronomical Diary . . . 1740* when he advised readers to "expect something that may serve to stimulate the Ideals of the Ingenious to make a more accurate Improvement of such a thought [concerning the topic at hand]."

Ames also followed tradition in labeling the page following the preface with heading, "Of the Eclipses this Year" which introduced the eclipses of the sun and/or moon and other celestial phenomena (e.g., comets, transits of Venus or Mercury) usually followed by a brief description of time, place, and visibility. Depending on the custom and scientific interest of the respective almanac makers, this varied from a mere list of dates of the expected eclipses to explanations accompanied by astronomical diagrams. To "please my Country men thereby," as Ames said in introducing the "Man of Signs" in his almanac for 1729 almanac, this page also contained either the crude wood-cut figure surrounded by the signs of the Zodiac pointing to that part of the body supposedly governed by its respective sign as the moon passed through the heavens, or a table labeled "The Anatomy of a Man's Body." Ames used the woodcut between 1729 and 1734, then substituted the table in 1735. In 1734 he had disclaimed any use of astrology—the prediction, or conjuring, of future events based upon a secret knowledge of the conjunction of celestial bodies. After alluding to and protesting the

[12]Hall, "Readers and Reading in America: Historical and Critical Perspectives," in *Cultures of Print*, 178.

practice of astrology, Ames proclaimed his own use and defense of rational science: "I use no Charms, nor filthy Conjurgation / But sublime Geometric Demonstration." Like most of his fellow almanac makers, Ames protested the hold "the ways they'r brought up in" had on those readers they characterized as "Country People."[13] But this editorial posturing, especially in Ames' case, often hid a deeper ambivalence tied to the persistence of the old world of wonders of which the "old Anatomy" with its astrological implications was a part.[14]

The twelve calendar pages followed, printed in columns listing the day of the month, day of the week, setting and rising sun, phases of the moon, tides, and planetary aspects. These were placed below a header that contained the phases of the moon and verses pertaining to the seasons. Ames reserved the widest column for "Courts, Tides, Events, &c." Here readers found the dates and places of court days in all the New England colonies, high and low tides, snippets of poetry, proverbs, historical chronologies, and humorous sayings, as well as anniversaries of English and European royalty. The content of this column varied among the other mid-eighteenth-century almanac makers, seemingly dictated by literary ambitions and presumed audience. Some makers printed only the court days and a few remarks on weather; others added Church of England holy days, while still others included more specific references to agriculture.

When Ames noted in the *Astronomical Diary . . . 1744*, "This little Book serves well to help you date / And settle many petty worldly things," he referred to the implied use of the calendar pages as a marker of time in homes that lacked clocks and watches. Readers could also estimate the time of day from the practical astronomical data contained in the almanacs, such as the rising and setting of

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[13]For a sampling of other almanac makers' disclaimers, see Stowell, *Weekday Bible*, 19-25.

[14]David Hall treats the persistence of this world view in *Worlds of Wonder, Days of Judgment, Popular Belief in Early New England* (Cambridge, Harvard University Press, 1989), see esp. Chap. 2.

the sun and moon.[15] For many, the almanac became a sort of silent "timepiece" used for checking the passage of time and also for permanently recording daily events as the survival of almanac diaries attests.[16] Extant almanac diairies, their calendar pages written over, or interleaved, with the minutiae of everyday events in the lives of even the the most scholarly devotees of Newtonian science, including the ministers Thomas Prince of Boston and Ezra Stiles of Newport, Rhode Island, and the Harvard College professor of natural philosophy, John Winthrop, attest to the diverse readership of Ames's little book.[17]

On the last page of the *Astronomical Diary*, Ames exercised his editorial privilege to introduce an "essay"of his choice.[18] These brief essays he devoted to subjects related to astronomy, natural history, medicine, and current affairs, and, only rarely, to agriculture, humorous anecdotes, or household receipts. Other makers featured a combination of these topics, again depending on their perceived audience and own inclination. It is to these essays that those few critics who have investigated the intellectual and literary content of early American science have turned.

In what remains the only published treatment of the development of early American almanacs and their literary content, Marion Stowell presents an overview of the "general science"

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[15]Kelly, *Practical Astronomy*, 255.

[16]A generation earlier, the Pennsylvania printer William Bradford recorded in his initial almanac (1686) that he started the almanac series in answer to "The People generally complaining that they scarcely knew how the Time passed, or that they hardly knew they day of Rest, or Lords Day, when it was for want of a Diary, or Day Book, which we call an Alamanack,"quoted in Hall, "The Chesapeake," 122.

[17]See, for example, diary entries from Prince's *Ames's Almanack* for 1737 reprinted in CSM *Pubs*. 19 (1916-17): 233-64; from Ezra Stiles's for 1748-1767 and 1771 in Misc. Vols. and Papers, Ezra Stiles Papers, Yale University Colls. (Microfilm Edition, 1978); and from Winthrop's for various years (174391779), Harvard University Archives, Cambridge, Ma.

[18]After Ames expanded the almanac in 1759 by a "half-sheet" that allowed 8 additional pages, the format changed somewhat providing space for a two to -three-page essay, as well as information on stagecoach routes and roads to New York, New Jersey, New Hampshire, and Maine and also tables of interest and of value of coins and currency.

topics of both seventeenth- and eighteenth-century almanacs. She concludes that by the end of the seventeenth century, the "philomath" almanacs, which were produced by Harvard scholars, effectively brought Copernican science to the common reader. Commercialism and competition, however, diluted the scholarly and didactic tone of the previous century as eighteenth-century makers turned to the "popular" science, ( i.e., astrology) demanded by common readers. Nevertheless, despite the generality of makers who yielded to their readers' belief in astrology, Stowell pointed out that the "informed" and "fortunately prolific" makers, namely Nathaniel Ames and Benjamin Franklin, managed to bring Newtonian science to the common man.[19]

More pertinent are studies by Chester E. Jorgenson and Robert Sidwell. Jorgenson briefly examines Newtonian science in the almanacs of the first Doctor Ames and of Benjamin Franklin. He cites material from seven of Ames's almanacs produced between 1726 to 1743 as evidence of the diffusion of "scientific deism" as well as Newtonian science through Ames's pen. Based on a viewpoint that implies an inherent conflict between revealed religion and rational belief, Jorgenson concludes Ames is "almost deistic in his neglect of Scriptural revelation" and in his "exultation of reason and science as the avenue to God" at the exclusion of the "theological machinery" of his native Calvinist, New England religion.[20] In evaluating the "non-institutional" educational content of colonial almanacs, by looking at their "scholarly scientific monographs" (i.e., essays), Robert Sidwell identifies the 1730s as the critical period during which almanac makers conveyed the "spirit

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[19]Stowell, *Weekday Bible*, 162-69. The primary value of Stowell's work is its identification and categorization of almanac makers and almanac series (see Apps. A -C, 315-323) and its general overview, rather than critical analyses, of almanac content That almanacs reflect "the scientific, literary and political growth of the years of their production" was initially proposed by Nichols who identified three periods of production: (1) from 1639 to 1700 characterized as "distinctly religious," (2) from 1700 to 1800, as "practical instruction and literary entertainment," and (3) 1800-1850, as concerned with "various national movements, Nichols, "Massachusetts Almanancs," 17-18.

[20]Chester E. Jorgenson, "The New Science in the Almanacs of Ames and Franklin," *New England Quarterly* 8 (1935), 558-59.

and letter of Newton to the common people." Although Sidwell sees almanac makers as the "allies" of New England ministers in uniting reason and science, he echoes Jorgenson's praise of Ames's and Franklin's "scientific deism" and "secular spirit."[21] There is no doubt that Ames was an enthusiastic proponent of the new science, but a contextural analysis of his essays and poetry in the *Astronomical Diary* reveals his ambivalence regarding its implications and illustrates the doctor's course in pursing the new science was far less regular than the course of the planets he observed.

Like other almanac makers, Ames played a conscious role as a mediator of culture between the learned and unlearned. On the most basic level, he was simply a conveyor of information. The format and requisite content of the almanac directed that Ames provide reliable information regarding meteorological data pertaining to the regular occurrence of the tides, setting and rising of the sun and moon, planetary aspects, and lunar and solar eclipses. But as the author-editor, Ames impregnated this information on the physical world with his own intellectual and metaphysical world view. By introducing himself in his first issue (*AD* . . . 1726) as "a Friend to all that are Mathematically inclined, and a Lover of the most sublime study of Astronomy," Ames disclosed his particular world view and also laid out an educational agenda that he would consistently pursue. His educated eighteenth-century readers would understand his reference to the "Mathematically inclined" to mean not just those who were adept at mathematical calculations, but also those who believed in the mathematical, that is, the orderly and rational, design of the universe. "Mathematicks," therefore implied both a system of calculations and a system of metaphysical truth. The operative word "sublime" in Ames' declaration of his love of astronomy revealed his belief in the moral efficacy of the study of the heavens. For Ames, as for other disciples of the new science, investigation of the universe would call forth the sublime—a concept that in the eighteenth century meant "something

[21]Robert Tolbert Sidwell, "The Colonial American Almanacs: A Study in Non-Institutional Education," Ph. D. Diss., (Rutgers–The State University, 1965), Chap. 3, quotes 137, 139.

which strikes the soul and makes a sentiment . . . to ravish and transport."[22] A year later (*AD* . . . 1727) Ames himself instructed his "Ingenious Reader" that "The Stars of Heaven give us such a Noble Idea of the Infinite Power, Wisdom & Glory of God, that they invite our Thoughts to Soar among the heavenly Glories." Contemplation of the heavenly glories, Ames added, would "afford Praise to the Infinite Creator and Contriver of them all."

Several years later Ames enlarged this theme and made the connection between astronomy and the religious sublime explicit. In 1732, Ames directs his readers' attention to this year's "Verses over each Monthly Page" that comprise an extended paean of praise for the "Contriver"of the universe, whose workings are illuminated by the new science. Ames himself points out his subject matter "does not properly appertain to the Months." Just how far this breaks with tradition Ames suggests by adding, "and some perhaps may say, to the *Almanack* neither." Nevertheless, in a statement that expresses the impetus for the genre of "philosophical" poetry that weds science and religion (i.e., physico-theological poetry), Ames argues,

> the consideration of the Distances, Places, Motions, Center, and Magnetism of the Heavenly Bodies, and how inviolably they obey the Laws of some Omniscient Contriver, in their exact Revolutions, according to their several Periods, is sufficient to lead my Thoughts this way to admire the Omniscient Mind [that contrived them].

Employing a catalogue of catch-phases that resonate with Newtonian overtones, he describes the action of this mind "whose All-disposing Providence not only guides the Rolling Worlds, as they Plough the Liquid Aether, but also the light Dust of the Ballance, and the Thousands of Atoms that wander up and down in a Sun-Beam, which are all under his Cognizance."

Ames then entertains his readers with six lines of verse for each month, each treating the workings and effects of "the Omniscient mind, the King Supreme/ [Who] Laid out his Work, . . . which all Creation shows." He then precedes from creation through the providential direction of

[22]Ephraim Chambers, *Cyclopedia; or, An Universal Dictionary of Arts and Sciences*, 2d ed., vol. 1 (London, 1741).

secondary causes: "A Special purpose always must be join'd / With Special knowledge in th' Omniscient Mind." Next he comes to the knotty question of man's preordained fate: "But O! Alas! Was Man made so accurst / His Fate so hard to Sin because he must?" Ames resolves this paradox, central to puritan Calvinism, in a rhyming couplet that restates the orthodox belief in man's free agency: "We be n[o]t constrain'd to Sin : for GOD's Decree, / Don't inconsist with Humane Liberty."[23] He concludes with the example of Judas, whose betrayal of Christ was "decreed before the Worlds were made," by contrasting his personal choice ("only for the sake of Gold, / . . . his Glorious Master sold") with the divine intent "to bring Redemption to Mankind." Deftly capturing the subtlety of Calvinist arguments, Ames explains, "Thus God for gracious ends ordain'd that Act,/And Judas justly Damned for the Fact." Far from turning the orthodox dogma of total depravity into a "light-hearted jest," as Jorgenson contends, Ames's verse is a celebratory, yet pious, statement that reconciles reason with religion.[24] It is only against this background of "mingled science and religious fervor," which infused philosophical poetry with Newtonian metaphysical "truths,"[25] that we can understand Ames's purpose in introducing a subject that on face value did not "properly appertain" to almanac writers.

Examination of the almanacs produced by the Ames and his son over the next forty-nine years shows how consistently these little books followed an educational agenda grounded in the new science. For the elder Ames, a self-taught student of astronomy, and his Harvard-educated son, the

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[23]Perry Miller has identified this as "the riddle of nature, the real problem for the Puritan theorist," Ibid., *The New England Mind: The Seventeenth Century Mind* (1939, Boston: Beacon Press, 1954), 224.

[24]Jorgenson, "New Science in Almanacks," 554. Briggs, to the contrary, views this poem as "a gentle endorsement of nearly every creed adduced from the fundamental basis of the Christian faith, Ibid., *Essays, Humor, and Poems*, 81-82.

[25]William Powell Jones, *The Rhetoric of Science: A Study of Scientific Ideas and Imagery in Eighteenth-Century English Poetry* (Berkeley: University of California Press, 1966), 22.

new science was embodied in the figure and theory of Isaac Newton. This was a view shared by the leading academic proponents of the new science who engaged directly in the practice of science, as teachers at the colonial colleges, writers of scientific papers, and correspondents and members of the Royal Society of London.[26] Although outside the inner network of scholars, the Ameses nevertheless occupied a unique position as popularizers of the new science mediating, as it were, between academic (high) and vernacular (low) science. In this respect they and their almanacs, like the colonial book printers and sellers and their books, occupied the middle ground, where, as David Hall has pointed out, high and low culture converged and exchange flourished.[27]

The most apparent didactic use of Newtonian theory in the elder Dr. Ames's almanac series is in the occasional essays where he introduces theories that he ties to Newtonian science. In 1734 Ames instructs his readers in the basic concept of the Copernican "Hypothesis," explaining that the sun is at the center of the solar system and that the revolution of the earth causes the seasons of the year, day and night, and the apparent motion of the heavens. Alluding to the accomplishments of Newton, Ames asserts the Copernican hypothesis has now been "render'd indisputable" by reasoning from "Geometrical Principles" and demonstration so that "every Objection against it has been fully answered, and no Man of Sense pretends to dispute it." Nevertheless, Ames acknowledges mathematical principles are beyond the capacity of the "Generality of Men" and attempts to meet the "Vulgar Objections" his untutored readers will raise: firstly, that "the Sun's standing still" is "repugnant" to Sacred Scriptures and, secondly, that it is contrary to the "Testimony of our Senses."

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[26]For individual proponents and their contributions, see Frederick E. Brasch, "The Newtonian Epoch in the American Colonies (1680-1783)," AAS *Proc.*, new ser., 64 (1939): 314-32, and Raymond Phineas Stearns, *Science in the British Colonies of America*, (Urbana, University of Illinois Press, 1970).

[27]Hall, "Introduction," *Cultures of Print*, 7.

Ames dismisses the objection based on Scripture by first arguing that it is not a matter of faith or practice, nor is it necessary for salvation. He then rebuts the "Anti Copernicans" reliance on Scripture by showing their literal interpretation of the passage where Joshua (Josh. 10:11), bids the Sun and Moon stand still will not withstand the test of "Humane Reason." He argues, "if the Sun had obey'd the very words of Joshua in a literal Sense, it would have scorched this Earth in a twinkling of an eye." In addition, he assures his readers this passage and other Biblical texts which refer to the Sun's "Running, Rising and Setting" are an example of the "frequent" use of figurative speech, "being Expressions adapted to our Capacities; . . . and proper in common discourse." Using homely examples, Ames next explains why the sense of sight cannot correctly perceive the size of celestial phenomena unless aided by reason and "Glasses" (telescopes). "To the naked Eye," he explains, "the Aether appears like a solid Arch, the Stars like the Heads of brass Nails, the Sun . . . as big as a Cheese, but our Reason informs us better." Furthermore, the eye cannot determine that the earth is moving, because it has nothing at rest to compare to, just as one cannot feel the earth move, because the "air" (i.e. the earth's atmosphere) moves as does the earth.

With his use of familiar examples, common expressions, and reassuring tone, Ames successfully mediates between the scientifically literate and illiterate. He demands, not that his readers master difficult theories or reject long-held tenets of faith, but simply that they exercise their own "Humane reason" in agreeing with men "of Sense." Lest his readers suspect Ames's argument disguises a broader assault upon the validity of the Scriptures, the monthly verses comprise a poetic rendering of the Biblical account of creation, man's fall into sin and confusion, and redemption through the Son of God. By thus displaying his own religious belief, Ames, in a sense, assures his readers that the new science does not constitute a challenge to orthodox Christianity.

In the following year (*AD . . . 1735*), Ames explains the "new System as 'tis called" of the "Fixed Stars." Again he gently introduces his readers to advanced scientific theory, forestalling a defensive reaction on the part of his unschooled readers by requesting them "[to] be not affronted if I offer you the opinion of the learned part of Mankind." He relies upon the authority and telescopic observations of Newton's disciples "Mr. Derham" and "Dr. Cheyne" to explain that the fixed stars "are supposed to be Suns to other systems; and also the neighboring Worlds of our own System," while stars that seems to appear and disappear may be planets visible as their orbits approach the earth.[28] Making effective use of analogy, he maintains the Suns "Govern in a Mundane Space, comforting, heating, and enlightening the Planets of their respective Systems, as the Sun does this Earth and the other Planets that belong to our System." The ultimate lesson the fixed stars teach, he reminds his readers in Derham's Newtonian fashion, is "the declarative Glory and Honour God . . . who alone Circumscribes the bounds of Matter, and is Essentially present through the Immensity of this Space."[29]

Ames then introduces another opinion of "those great Men who view the Heavens . . . with a learned niceness." Cautioning that it is not a certainty but, nevertheless, " a great Probability," he explains "that these Planets are Worlds stock'd with proper Inhabitants." Based on analogy and on the "Logick" of reasoning from what is certain (as shown by telescopic discoveries of the planets' periodic orbits, dense bodies, and diurnal motion and the moons of Jupiter), he deduces they must be "well Accommodated for Habitation," because of their similarities to the Earth. According to Ames, moral argument also confirmed the idea of inhabited worlds, for it follows that the "Divine Architect, would improve them to the "best Purposes," granting them life, as he granted it to the Earth.

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[28]William Derham and George Cheyne were English clerics and early popularizers of Newton who used the new science in the employ of religion. Derham's ***Astro-Theology; or, A Demonstration of the Being and Attributes of God from a Survey of the Heavens*** (1715) may well have been the most the most popular book of its type in New England, while Cheyne's ***Philosophical Principles of Natural Religion*** (1705) was less in demand; see Chap. I.

[29]This was one of the most common metaphysical tenets held by Newton's interpreters; see H. Drennon "Newtonianism: Its Method, Theology, and Metaphysics," ***Englishe Studien*** (1933), 405-07, 409.

This concept, termed "the plurality of worlds" and current in the seventeenth century, received new impetus from the discoveries made possible with the telescope and by the grafting of natural theology onto Newtonian natural philosophy, especially by one of Ames's favorite sources, William Derham.[30] A subject of poetry, popular science texts, and polite literature, it became a part of popular discourse throughout the eighteenth century. Ames had touched upon this subject in his almanac for 1728. There he explained that since the innumerable worlds of the universe were created by God according to the Biblical account in Hebrew 1and 2, it follows that "The Omnipotent Being is able to govern & provide for Ten Thousand Worlds, as well as One: for, the Unlimited extent of God's Presence fills the unfathomable Abyss of Infinite Extramundane Space." To consider these amazing worlds and their creator is enough "to weary the thoughts and the Faculties" of mere mortals; therefore he calls upon the authority of the poet Richard Blackmore, quoting from his poem of devotion and scientific discovery, *Creation: a Philosophical Poem in Seven Books:*

> Hail King Supream! Of Pow'r, Immense Abyss!
> Father of Lights! Exhaustless Source of Bliss!
> . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
> Since thou didst all the Spacious World display,
> Homage to thee let all Obedient pay,
> Let glitt'ring Stars, that Dance their Destin'd Ring
> Sublime in Sky with vocal Planets Sing.

Ames's frequent recourse to Blackmore, one of the first philosophical poets who versified the discoveries and metaphysical concepts of Newtonian science, illustrates the rapport between science and poetry common to the eighteenth century.[31] Blackmore wrote expressly "to bring

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[30]For the incorporation of this belief into Newtonian natural philosophy, see Michael J. Crowe, *The Extraterrestrial Life Debate, 1750-1900, The Idea of the Plurality of Worlds from Kant to Lowell* (Cambridge, Cambridge University Press, 1986), Chap. 6, and Steven J. Dick, *Plurality of Worlds, The Extraterrestrial Debate from Democritus to Kant* (Cambridge: Cambridge University Press, 1982), 22-27.

[31]For an account of Blackmore's "encyclopedic" use of the new science in *The Creation*, see William Powell Jones, *The Rhetoric of Science, A Study of Scientific Ideas and Imagery in* 86-90.*Eighteenth-Century English Poetry* (Berkeley and Los Angeles, University of California Press,

[natural] philosophy out of the schools and make it agreeable to general conversation."[32] Ames quotes Blackmore when his own words fail to sufficiently express the scientific concepts as well as the sublime wonder called forth by the revelations of their common subject—the glittering stars and planets.[33] But, because Blackmore's works were among the most commonly read poetry in colonial New England, Ames also quotes him as a means of authority and reassurance.

The theory of plurality of worlds, or "inhabited worlds," the term Ames more often used, emerges as a theme in the almanacs of the 1730s through the 1750s, as Ames's portrayal of these worlds becomes more detailed. At the same time, his essays serve as vehicles for concise summaries of current planetary science. When Ames gives his readers "the Astronomy of the Inhabitants" in 1737, he cleverly assumes the viewpoint of an inhabitant of the respective planets. Basing his information on the discoveries of "Mr.Huggins" relative to Mercury, Mars, Jupiter and Saturn, he systematically relates each planet's size, distance from the sun and Earth, diurnal rotation (length of day and of night), solar year, and satellites relative to the Earth.[34] In 1748, Ames summarizes this information and adds specific times of periodic revolution of each of the several moons about Jupiter and Saturn. He also informs his readers that Saturn is surrounded by a "wonderful Ring," and again quotes "the Poet" for a description:

How richly's this grave Wanderer drest,

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1966), For an overview, see Douglas Bush, *Science and English Poetry: A Historical Sketch, 1590-1950* ( New York: Oxford University Press, 1950), Chap. 3. For its popularity among American readers, see Chap. I above.

[32]Jones, *Rhetoric of Science*, 86.

[33]Ames also uses Blackmore's poetic diction in his prose essays. For instance, in 1733, he speaks of the "Earth and other Worlds that *dance their destin'd Ring* about the Sun" (italics mine).

[34]Christian Huygens authored the first "scientifically developed" presentation of the plurality of worlds with the publication of *Cosmotheoros* (1698) translated as *Celestial Worlds discover'd; or, Conjectures Concerning the Inhabitants, Plant and Productions of the Worlds in the Planets*. For key points, see Dick, *Plurality of Worlds*, 20-21.

> With an illustrious Ring, above the rest.
> Around it roles, makes all its Parts appear,
> Yet lies obscur'd in Light for half the Year."

Ames returns to the theme of inhabited worlds, perhaps taking a cue from the poem's concluding lines regarding Saturn's "Use and End," which "At once delight the wond'ring natives, & be-friend! / --And [en]rich Philosophy and charming views create!" As in 1735, Ames suggests all the planets, designed as the Earth is by the "Divine Architect," are inhabited so that they may be equal in all respects to "the Beauty and Dignity" of the Earth.[35] Employing the vernacular diction of his ordinary readers, Ames reasons, "As our Earth was not made only to twinkle on them; so they were made for nobler Ends than just to shine on us."

That astronomy has been brought to "the highest Pinnacle of Perfection" is the theme that underlies all of Ames' scientific essays. His observations in 1739 of the various theories of the age of the world included the argument "drawn from the Progress of Arts and Sciences" that the world was not eternal. Man could not have lived "an Infinity of Ages," Ames reasons, without the "Benefit and Comfort" of those Arts which have been developed only since the beginning of recorded history. Only the with the invention of the telescope, Ames explains, and with " every one improving on the Observation of his Predecessor" were all the phenomena of planets "compleatly gathered." Alluding to and encapsulating Newton's achievements, Ames concludes, "[by] applying the Science of Geometry and Number to investigate their motions, their natures, and their Causes . . . now in our Day, Astronomy is brought almost to the highest Pinnacle of Perfection."[36] In another nod to Newton, Ames sets the monthly verses—which the almanac maker instructs his readers are

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[35]In 1749, Ames elaborates further on the inhabitants of the planets, answering in the affirmative the questions, " Have they Bodies such as we?" and "Do their Faces, Eyes, &c. Look like ours?".

[36]In *AD . . . 1761*, Ames advises his "Kind Reader" of the "great Perfection" of astronomy in nearly identical terms.

his "poor Endeavors" upon the subject of the Sun—against the backdrop of his theory of gravity:

> The rolling Worlds to Him Obeysance Pay;
> Who all submit to His Magnetick Sway.
> His Gravity directs 'em where to role,
> None from their destin's Orbits dare to strole,
> . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
> Our Earth, obsequious to his great Command,
> Turns or is turn'd, whilst his all bounteous Hand,
> Distributes Life, and vital Warmth to Sea and Land.

A year later (*AD . . . 1740*), Ames begins his essay with a rhetorical question. "Who before the Great Sir Isaac Newton," he asks, "did behold the Wisdom of the Creator, in that he has bestowed on Matter such a property as that every Particle thereof throughout the Creation, has a Tendency towards every other Particle?" He lays out the mathematical foundation of Newton's theory of gravity, adding a simple example of the reckoning involved: "And this Gravity of all Bodies is observ'd manifestly to decrease in Proportion of the Square of their distance reciprocally; that is, at twice their Distance their Force is but one fourth of what it was at a single Distance, and but a ninth at thrice the Distance, etc." Choosing images that are within the ken of his readers, Ames also identifies "this simple gravitation Power" as "the cement (as t'were) of the whole Creation" and explains that the motions of the planets would carry them into infinite space beyond the light of the sun if they were not "bridled" by this "gravitating Power." The "projectile Motion" of each planet, he explains, is equaled by its gravitating power so that the planets describe "a Circle, so near as that their Orbits are not very Excentrical."

For the benefit of his readers ( and displaying a Newtonian use of science in the defense of orthodox religion), Ames points out, "And by this Contrivance in nature, the creator make good his Promise, *Gen. 8,2*: "While the Earth remaineth, Seed-time and Harvest, and Cold and Heat, and Summer and Winter, and Day and Night, shall not cease." But Ames cannot end without proper acknowledgment of "this incomparable Man" and thus turns again to "the Poet," quoting from Pope's "Essay on Man":

Superior Beings, when of late they saw
A mortal Man unfold all Nature's Law,
Admir'd such Wisdom in an Earthly Shape,
And shew'd a Newton as we show an Ape.
Could he whose Rules the whirling Comets bind,
Describe or fix one Movement of the Mind?
Who saw the Stars, here rise, and there descend,
Explain his own Beginning, or his End?
Alas, what Wonder! Man's superiour Part
Uncheck'd may rise, and climb from Art, to Art.

Ames implies Newton is the most superior of "Superior Beings," for he indeed unfolded Nature's laws. Newton, as "Man's superior Part," is "uncheck'd," (his readers may deduce) by the limitations of ordinary men. Hence Newton "climbs from Art, to Art" where, (as Ames had implied a year previously), he raised the art of astronomy to the pinnacle of perfection.[37] In verses of his own making on the title page of his 1736 almanac, Ames recalls a similar sentiment:

So Ho! Astronomy now mounts a height
And with its Lustre dazles our dull Sight,
The root from whence it first began to grow,
Lay couch'd in Principles obscure and low.

In addition to more or less general essays on astronomical theory, Ames used specific scientific information to explain eclipses, comets, and planetary conjunctions and transits as they periodically occurred throughout the years. In 1743, for instance, he responds to "numerous" inquiries occasioned by the appearence of a comet in February of the preceding year. Under the title "Of Comets or Blazing Stars," Ames systematically presents cometary information from "the best Philosophers,"organized for easy reading under the following topics: Nature, Constitution, Head, Atmosphere, Tail, Magnitude, "Apperance," Motion (elliptical but "very Excentrical"), and Number (25 in 400 years). He also presents a table that includes thirteen astronomical details, (periodicity, velocity, distances of orbits, next expected appearance, etc.) of the comets of 1682, 1718, 1661,

[37]Ames misses, or overlooks, Pope's satiric questions and tone in this passage that poetry critics have read as Pope's condemnation of science. For a more sympathetic reading, see Jones, *Rhetoric of Science*, 142.

1680 whose astronomy has been "perfected." He concludes by citing comets' "Extraordinary" effects such as tempests, hurricanes, and alterations of rivers and seas on the earth as well as deluges and conflagrations on other planetary bodies. Their "ordinary" or salutory effects include their capacity to "vivify" the atmosphere and replenish the heat and light of the sun. Ames identifies only one of the "best Philosophers" upon whose information he depended, namely "Whiston."[38] Yet his information regarding comets' effects are consistent with Newton's own theories, which assimilated traditional comet lore into his natural philosophy.[39]

In his almanac of 1753 Ames announced a "curious," or rare, celestial phenomenon: a Transit of the Planet Mercury over the Body of the Sun, predicted on May sixth of that year. He claimed he was the first almanac maker to report this celestial occurrence although it had been observed by "modern Astronomers." In this issue, Ames specifically addresses his "young Readers," in the role of an instructor. Since he is aware that many do not understand "the Characters on the Almanack," he will "set down" their "Names and Characters." He follows this with a table that depicts the astromical signs for the seven planets, the five aspects (which decribes the spatial relation of one planetary body to another), and the twelve signs of the Zodiac.

Ames's remarks are a reminder of his educational agenda and also indicate the range of his audience. The occasional extant almanac bearing a signature in a childish hand, such the *Astronomical Diary . . . for 1767* signed by an anonymous "Sarah" obviously showing off her penmanship (fig. 2.3), confirms his readership embraced both male and female, young and old. For the majority of his young and adult readers, Ames provided the only "glasses" through which they

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[38]William Whiston, Newton's colleague and successor at Cambridge, wrote two Latin texts explicating the new astronomy and experimental philosophy, published in English as *Astronomical Lectures* (1715) and *Mathematical Lectures* (1716), Chap. I above.

[39]Sara Schechner Genuth, "Newton and the Ongoing Teleological Role of Comets" in *Standing on the Sholders of Giants, A Longer View of Newton and Halley*, ed. Norman J. W. Thrower (Berkeley: University of California Press, 1990), 302.

would view the phenomena of the celestial world. Thus, his interpretation of the meaning of these events, presented to readers year after year, would assume authority and persuasiveness for them.

In 1759 Ames featured an illustration of the solar system on the front page and a line advertising the two-page explanation inside (fig. 2.4). For many of his readers without the benefit of formal schooling this simple, one-dimensional woodcut may have been the first time they had actually seen a pictorial representation of the Copernican universe. Thus at the outset Ames assures them of its validity and also instructs them in Newtonian fashion as to its metaphysical significance: "This Figure represents the true System of the Universe, which being understood, will exalt our Ideas and excite our highest Admiration of the magnificent Works of God." He follows with a brief synopsis directing his readers to the wood cut as he focuses upon the Earth (including how it turns on its axis, revolves about the Sun, and carries its Moon by the "Power of Attraction" as it revolves about the Earth—all "consonant to the known Laws of Matter and Motion") and also defines the meaning and calculation of a "Planetary Year." He remarks as well upon the composition and orbits of comets and upon the fixed stars and their inhabitants. On the latter, he refers his readers to "Mr. Huygen's Celestial Worlds discovered, and Mr. Derham's Astro.Theologia."

Ames explains to his untutuored, and perhaps skeptical, readers who must rely only "on the bear Sight of the Eye," why they cannot trust their impression that the Earth is a center of universe. Reason, as well as scientific equipment, must come to their aid. Disbelief in the true system of the universe denies the moral purpose of creation by placing mankind as the only intelligent being in the universe and by putting the Sun, Moon, and Stars in the position of merely "decorating" and "serving" the Earth. Ames is unequivocal in advocating the authority of science on this point:

> When we view this wonderful Fabric of the Universe . . . [and] throw aside our Reason, and form our Opinions. . . by the Dictates of our Senses, despising the Report of Men of Genius, Learning, and Leisure, who by the help of Glasses [telescopes], bring these distant Objects vastly nearer to the Eye. . . . Pride becomes such ignorance!

Lest his readers have missed the point, he draws a homely and picturesque parallel:

> But all those who have by a serious enquiry have gained sure (tho' not adequate, comprehensive) Notion of the Universe, look upon such an Opinion with the same Comtempt that we do on a poor Maniac who sits in his Hovel on a Wisp of Straw and fancies himself a Monarch, and that all the Persons about him are his Subjects.

Ames's assimilation of traditional lore and what he viewed as the the new system of modern astronomers led him to attempt the reconciliation of astrology and Newtonian theory. In his almanac of 1750, for instance, Ames wrote a brief but detailed essay on the conjunction of the Earth, Moon, and Mars which had occurred 18 June of the previous year and which, he asserted, accounted for the remarkable heat on that day. For the first time, the almanac maker illustrated his remarks with a diagram, included, Ames said, "that my Reader may see with his Eyes the remarkable Situation." In fairly technical terms, he explained the relative position of the three bodies to the Sun and how the elliptical path of Mars carried it near the Earth which itself was at that point in its orbit closest (i.e., in aphelion) to the Sun. By way of scientific authority he cited Kepler's evidence that the planets' orbits are not circular but elliptical, with the Sun located at a focus rather than center of true ellipse. And he added that according to "Sir Isaac Newton's" demonstrations "from the Laws of Nature," the planets which are carried in orbits "by the Rays drawn from them to the Sun, describe Areas exactly proportional to the Time they spend in their Revolution." The extreme heat of that particular day, Ames contended, was because the Moon "Step'd in between" the Earth and Mars—a non-Newtonian assertion that reveals Ames's lingering reliance on astrological explanations. "As the Astrologers phrase it," Ames continued, "it [the moon] handed down the Influence of that burning Planet to the Earth." Ames's conjoining of astrology and the new science is made all the more evident by the diagram's representation of a personified sun centered in a geometrical, that is, Newtonian, scheme of planetary motion (fig. 1); for Newton's science of geometry, Ames had maintained in the *Astronomical Diary . . . for1739*, had brought astronomy to the "Pinnacle of Perfection."

Twentieth-century readers see here the persistence of traditional lore—in the guise of astrology—and its seeming *compatibility* with the new science, despite Newton's own rejection of astrology. Most critics, however, have opposed the two (or simply disregarded their conjunction) by regarding a given almanac maker's use of astrology as a measure of his true"scientific" enlightenment—as if the rationality of a particular almanac maker decreased proportionately to his employment of astrology.[40] The condemnation of astrology has its roots in the late seventeenth century and the reaction of Enlightenment thinkers who saw astrology as evidence of the hold of superstition over the ignorant; yet Ames's careful distinction, occurring throughout the *Astronomical Diary*, between "judicial astrology" and "natural astrology," reflected astrologers' own efforts, concentrated in the late seventeenth century, to legitimize their practice in the face of attack from proponents of early modern science.[41]

Although the most obvious use of astrology in the almanacs is associated with the "Man of Signs," and its implication of the influence of the planets on human actions, Ames emphasized the difference he drew between "Judicial" Astrology or "conjurgation" with its roots in black magic and "natural" astrology. The latter, he insisted in his almanac of 1738, was "built on the Effects and Influences of the heavenly bodies on our earthly bodies."[42] He argues astrology thus has a "rational and phylosophic Foundation." Attempting to clarify the relationship between the Earth and the

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[40]On the elder Dr. Ames's use of astrology in conjuction with the new science, Jorgenson ("The New Science in the Almanacs of Ames and Franklin") is silent; Stowell (*Early American Almanacs*) treats them as two separate issues; and Briggs, (*Essays, Humor, and Poems*) looks on with amused tolerance.

[41]Patrick Curry, *Prophecy and Power, Astrology in Early Modern England* (Princeton: Princeton Univeristy Press, 1989), 11, 31.

[42]It is instructive to consider here Ames' reasoning as it appeared in the *AD* . . *for 1764* : "Astrology has a Philosophical Foundation: the caelestial Powers that can and do agitate and move the the [sic] whole Ocean, have also Force and Ability to change and alter the Fluids and Solids of the humane Body; and that which can and does affect the Mind, has a great Share and Influence in the Actions of Men."

planets, he points out that as members of the same solar system, they have "a mutual Dependence upon, and co-operation with one another"—a statement that hints the power of gravity provides the rational foundation Ames is seeeking.

As shown earlier, Ames was not adverse to using the old lore where it seemed appropriate. In fact, he made extensive reference to astrological predictions and emptied many an ink well in justifying his practice. His ambivalence reveals the accomodations that result when two world views come in opposition. In the *Astronomical Diary . . . 1759*, Ames addressed this subject in reference to a planetary conjunction due to occur in 1762. In remarks to his "Kind Reader," he discusses the implications of what he says may appear as "prophecy" in the verses that appeared on the title page which forecast,

> When three Times more the Sun has cher'd the Spring,
> A new important Aera will Begin:
> From which young Date and settled State of Things
> A Train of strange Events and Wonder springs.

Yet Ames, who is careful to tell his "Kind Reader" what astrological data he has based his prediction on, maintains, "What looks like prophecy in the outward Page, I grounded in the conjunction of Saturn and Jupiter, . . . in Aries, a Cardinal Equinoctial Sign." He adds that astrologers have traditionally seen such an occurrence as "big with new and remarkable events." And he continues, "if the Learned are not always free from Superstition, I hope an Almanack-Maker does not talk out of character to mention such Things." Ames intimates his work as an almanac maker who "[has] collected the best Rules that Experience has taught me . . . from the Aspects and Configuarations of the Planets" allows him a sort of license for rational prognostication. More significantly, his remark also suggests belief in such astrological lore is not confined just to his country readers, but extends to his more sophisticated readers. Here it is evident how Ames mediates between both audiences: on the one hand, frankly admitting the influence of supersition, and on the other, asserting a "factual" basis and scientific "method" for his claims.

Ames' struggle to define the appropriate role of astrology runs throughout the series issued under his pen. In 1727, his second year of publication, he is forthright in telling his readers, "As to what I have predicted of the Weather, it is from the Motions & Configurations of the heavenly Bodies, which belongs to Astrology." As his statement implies, the examples he then offers relate to purely natural causation, for example, the Sun's "regular Motion" causes the seasons, while the moon causes the tides. In 1728, however, Ames ventures further and characterizes the "natural Portends" of planets in eclipse as affecting the human condition. Thus he reports that according to (unnamed) "learned Authors," the eclipse of the Sun with Jupiter ruling signifies "Glory, Fertility, Tranquility, Peace and Plenty."

In 1730 Ames again refers to an anonymous author's observations on eclipses. But this year, the warnings are dire as the Superior Planets portend "Mischief to those Places and Countries, that are subject to the Sign Eclipsed." The almanac maker reinforces his calamitous message with a verse on the title page that predicts Mars busily stirring up war in Europe, while "Saturn & Jove contend and will not yield / So dead & Wounded pave the bloody Field." To his readers' greater enlightenment (or amusement), however, Ames presents them with a poem "written by an Accurate hand to Mr. H. Coley," who was the adopted son and pupil of the famous seventeenth-century court astrologer and almanac maker, William Lilly.[43] The poet laments mankind's loss of "Heaven's Language" due to Adam's fall. Although the (Biblical) "Patriarchs" had raised "scatter'd Glimmering Notions" to an such an art that "Urania" (astrology) became "a handmaid fit for bles'd Theology, the Chaldeans and their Gypsy descendents had debased this "chaste" knowledge to no more than a "Cheat." In 1731, Ames tucked a defense of his previous year's musings in the verses for October through December. Refering to those who "presume" to deny the dire portents of the

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[43]Curry, *Prophecy and Power*, 88-89; for Lilly's prominence as an astologer, writer of almanacs and empherides, and condemnation as a "judicial " astrologer, see, Ibid., 20-53, *passim*.

constellations and superior stars, he argues,

> But I unto such "fiery Zealots tell
> "Astrology's from Heaven not from Hell.
> "Tis not Black Art, no damned Necromancy
> "No Witchcraft neither, as some please to Fancy.

In subsequent issues Ames would return to this theme, but always stressing the difference he drew between judicial astrology and natural astrology.

In his alamack for 1747, nearly a decade after his appeal to the authority of Coley and Lilly, Ames again wrestles with his—and his readers'—perception of the proper subjects of those who study nature. Resorting, he says, to Bailey's dictionary definition, he explains that "conjurgation . . . signifies a personal dealing with the Devil, to know any Secret or compass any Design." Ames suggests the seemingly esoteric subjects of those who ligitimately pursue what appear to the uninformed as nature's secrets have rendered them suspect. "Many Persons," according to Ames, "have div'd so far above the Apprehension of the Vulgar, that they have been believed to be Necromancers, Magicians, &c." Yet, he maintains, it is ignorance on the part of unbelievers, rather than the subject that is to blame. But he adds a cautionary note, perhaps an indictment of the academic science of natural philosophers as well as a warning to the credulous:

> All Men are grasping after Novelties. Our Mathematical Demonstrations please us not so much because our Discoveries are certain, as because they are new. What we know we slight; and we are fond of believing Articles that are most beyond all Belief.

Despite Ames' willingness to effect a personal accomodation between traditional lore and the new science, by mid-century he was out of step with contemporary modern thinkers.[44] Ames himself discusses this in relation to his celestial observations and predictions for 1751. That year he informs his audience the "remarkable Advice" from the stars is that the opposition of the superior

[44]See Chap. III below for a discussion of the tensions between conservative (i.e., providential) and new (i.e., rational) views as they played out in the 1755 earthquake controversy.

planets Jupiter and Saturn will occur three times during the year. According to the "Spirit and Genius of ancient Astrology" this phenomenon, which occurs only every twenty years, presages "Discord and Difference." Ames (also a keen observer and reporter of contemporary political events) predicts a quarrel between the European nations as well as "an open Rupture" between New England and Canada.[45] He admits, however, that no "modern Authors" will confirm his opinion, because "those Men that write fashionably at this Day condemn the whole Art [of Astrology] and all who pretend to it." Ames intimates belief in astrology has waned even among more common folk. "The Multitude," he complains, "like empty Pitchers, are lugg'd by the Ears any Way that Custom leads." This situation he blames on the influence of "but a few Men who govern in the Kingdom of Learning as well as that of Policy." But for Ames, "Truth generally lies in a Medium between the Extremes." In an extended play on words, he urges his readers to seek the "Zodiac of Truth" between the extremes of "unprejudiced" wisdom and "prevailing Opinion," which"roll[s] around in an eternal Circle from one Extream to another."

Unwilling to accommodate popular opinion on this subject, Ames continued his practice of making "rational" predictions based, as he had said early on, not on conjurgation, but on sublime geometric demonstration. In the *Astronomical Diary . . . for 1764* (the last issue authored by the elder Dr. Ames before his sudden death in July, 1764), he again addressed his readers with a long essay that recapitulated his previous arguments to the effect that astrology has a philosophical foundation. He updates his argument by using Franklin's discovery of lightning rods for a defense against electricity as an example of "new" knowledge first suggested by the "Ancients." The ancients, he contended, had pointed the way toward the discovery of electricy, because they "[had] instituted certain bodies to be used against the Effects of Thunder and Lightning." The contempt of

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[45]Europe and the American colonies were on the brink of the Seven-Years War; for background, see Charles E. Clark, *The Eastern Frontier: The Settlement of Northern New England, 1610-1763* (Hanover, N. H.: University Press of New England, 1983), Chaps. 4-6.

modern men for the theories of the ancients, however, had precluded them from gleaning the "Shadows of Truth" contained in astrology, the use of which can lead men of "good Sense and Learning . . . on to Greatness."

The debate on astrology and the elder Dr. Ames's particular brand of mediation between his learned and unlearned readers came to a quiet end when his son, the younger Dr. Nathaniel Ames assumed authorship of the almanac upon his father's death in 1764. Like his father, the younger Dr. Ames was aware of the influence the almanac exerted in the lives of his readers with limited means.[46] Therefore in his first issue (*AD . . . 1765*), he pledged "to be as useful as possible to those whose Oracle is an Almanac, such as are destitute of any other periodical Perfomance, a Magazine, or the like, or even News Papers." He also was aware of the genteel readers at the other end of the spectrum who could afford the apparatus of polite science advertised in contemporary newspapers.[47] Thus in prediciting an eclipse for 21 March, he invited those "Gentlemen of Curiosity . . . such as are favored with a clear Horizon and Telescopes to make critical Observations." Does Dr. Ames' remark about "critical" observations presage a shift in world view? Certainly he brought a different perspective to almanac making, one informed by the formal study of Newtonian natural philosophy under the tutelage of Professor John Winthrop at Harvard, where the young Ames had graduated only three years before.

Although the young doctor is silent on this issue when directly addressing his readers, the monthly pages yield two clues. In the verse heading for January, he clearly indicates a Newtonian belief in the "wisdom of God in nature": "Hail, sacred Wisdom, in whose blest Abode / Unravell'd Nature clearly speaks the God." Interlined with weather and various events for June, the new

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[46]For biographical information, see Briggs, *Essay, Humor, and Poems*, 29-40, and *SHG*, 15:3-15.

[47]For booksellers' advertisement for science apparatus, see Chap. I below.

almanac maker informs his readers, "Your Glasses (telescopes), at present, prognosticate best concerning the Weather, seeing the Stars refuse." Acting upon this hint, he consistently refrains from investing natural phenomena with portentous capacities.[48] In the following year (*AD . . . 1766*), Dr.Ames explicitly informs his readers of his views. Like his father, he uses the pages on eclipses as a venue for his reflections upon their meaning. Like his father, he acknowledges the "ancients" viewed eclipses as portending "dire" events. But unlike his father, Dr. Ames labels "these notions" as "futile in this day-and-age"and refrains from any portentous prognostications. Therefore his remarks on the eclipse that would be visible on August fifth simply describe its previous and future appearances through the year 2090, and are accompanied by a detailed illustration. He follows this explanation with an account of how modern astronomers can date a given past event based on contemporaneous reports of an eclipse.

As did his father, Dr. Ames looked to the heavens as the provenance of the almanac maker. His verses became even more rapturous than those of his father, for he saw there the Newtonian "Order," "Majesty," and "Harmony" of the natural world and its Creator, as his verses enhancing the title page of the *Astronomical Diary . . . 1768* proclaimed. "Improving" this metaphysical concept, the verses exclaimed, "Ador'd Artificer" What Skill divine! / What Wonders in the wide Creation shine / Our Tho'ts are lost in thy Immensity." In 1774, he rhapsodized, "With Wonder we survey the upper Air, / And the gay gilded Meteors sporting there." Meteors, once part of God's arsenal of doom, have now lost their threat. For the younger Dr. Ames, even more so than for his father, Newtonian philosophy has succeeded in "unravelling," that is, rationalizing, nature. He thus acts as the intermediary between rational science and his readers. In this role he, too, represents Newton as the pinnacle of human achievement. But this is a height Ames's countrymen can aspire

[48]At times Dr. Ames indulged in a droll remark; for example, on the May 1765 calendar page he "predicted" that the Conjunction of Venus and Mercury "promises much Fruit of licentious Love next Winter."

to, as the doctor briefly hints in his monthly verses in 1769. There he predicts the fulfullment of the progress of arts and sciences as distinctly "New-England's Weal" where "Some second Newton [will] trace Creation's Laws, / Through each Dependance to the sov'reign Cause."

This chapter looked at an unpretentious vehicle of the new science aimed at both the learned and common reader—the almanac series produced by the Ameses for New England readers between 1726 and 1775. In order to present a coherent world view, the elder and younger Ames each forged an accommodation of his own beliefs and Newtonian natural philosophy which informed the scientific content and editorial bias of their almanacs. With a readership that encompassed the ranks of both "gentlemen" and "husbandmen," as well as their wives and children, the *Astronomical Diary* itself was situated between learned or genteel culture and vernacular culture, as the elder Dr. Ames himself had suggested in addressing his readers in the almanack for 1764 and "filling" a page for each. Ames's "Page for Gentlemen," began with a tongue-in-cheek poem addressed to ministers, merchants, physicians, lawyers, and politicians and continued with a two-page essay on the ills of tobacco, snuff, and punch—what were viewed by many as the vices of polite company. The page devoted to husbandmen, Ames explained would treat "Things useful rather than curious," in this instance, an "Introduction to Agriculture." In maintaining a steady readership for fifty decades, the Ameses' own syntheses developed over time to accommodate the beliefs of both types of readers, as both father and son responded to traditional lore, religious beliefs, and genteel aspirations. Thus the *Ames's Almanacks* are a vehicle not only for assessing the dissemination of Newtonian science aimed at a diverse audience, but also for examing in detail how two specific individuals, with the eye of the public upon them, adapted Newtonian thought to their own beliefs and agendas.

On one hand, the *Astronomical Diary* taught its readers the scientific underpinnings of the Newtonian universe, according to the Ameses' understanding of Newtonian astronomy, in articles that dealt with topics such as the laws of the planetary system, the force of gravity, and the paths of comets. But on the other hand, entwined with these "scientific" theories was a galaxy of metaphysical and theological ideas regarding the origin, inhabitance, governance, and ultimate purpose of the universe and humankind. Exemplifying this Newtonian-inspired melange, the Ameses' essays and verses reverently proclaimed nature's newly-revealed wonders and their awesome Creator. Yet pervading their almanacs is the tension between the old conservative world view and the new rational world view, that is, between an interventionist Creator who governed the natural world through "portentous" agents such as comets, and a beneficent Creator who himself acted within the laws governing the natural world and all its phenomena. Despite the elder Dr. Ames's protestations that Newton's "Science of Geometry and Number" had brought Astronomy "to Perfection," wherein nature acted only according to stated laws, he struggled to justify a belief in the planetary influence on human affairs. This ambivalence did not preoccupy the younger Dr. Ames who inherited the authorship of the *Astronomical Diary* fresh out of Harvard College and the enlightened natural philosophy classroom of Professor John Winthrop. Not until the young Dr. Nathaniel Ames quietly allowed traditional lore, which had so plagued his father, to simply disappear from the pages of the *Astromonical Diary* does a rational cosmology, which reflects the Newtonian culture of his own day and age, become a prevalent theme: comets, earth-quakes, and other "extraordinary" phenomena sport in a Newtonian universe obedient only to a benevolent "Artificer" and his laws.

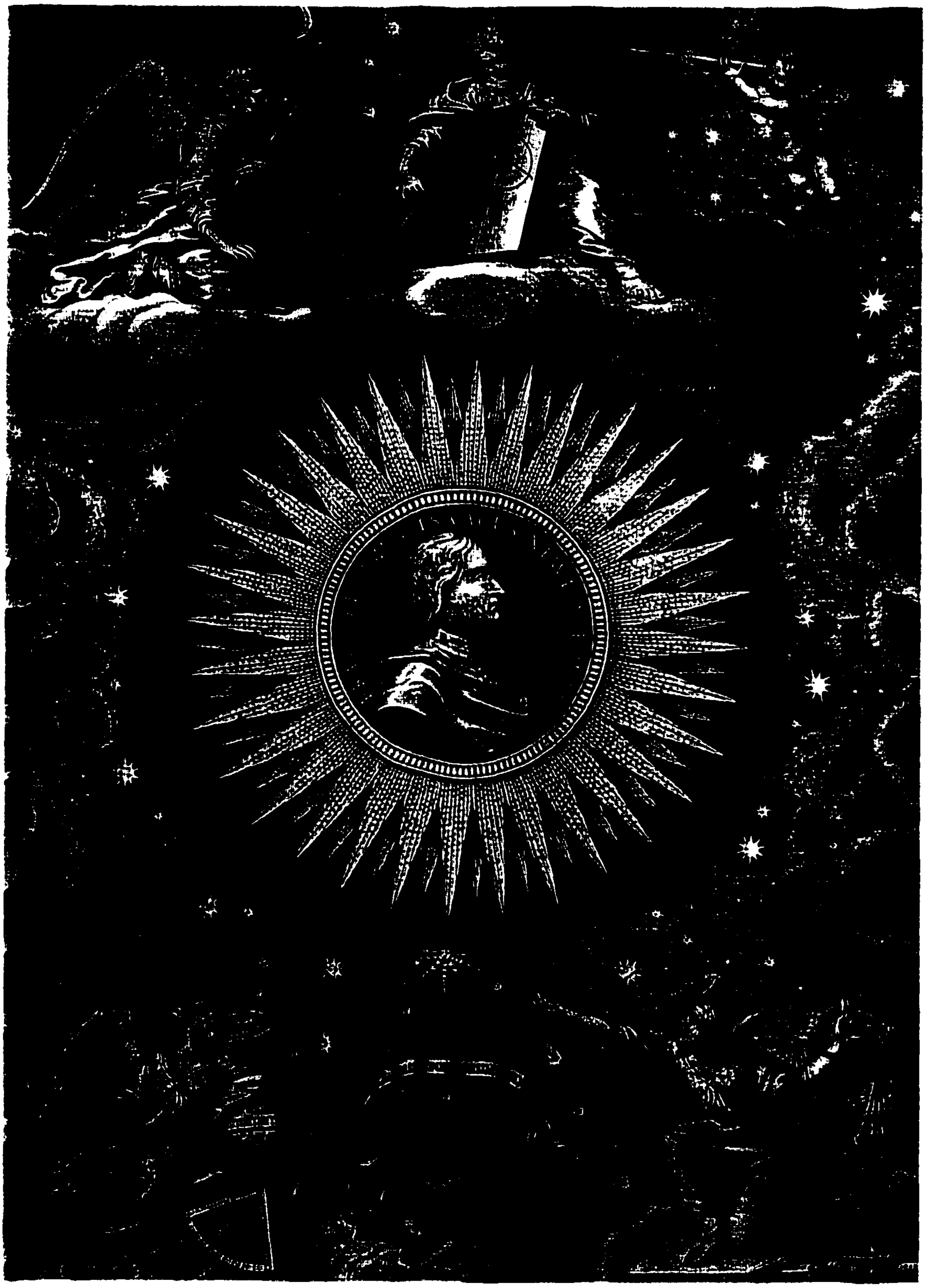

Fig I.1. This 1732 engraving of the "glorification" of Issac Newton portrays him in the center of the universe he made intelligible and harmonious, and hints at the galaxy of metaphysical as well as scientific truths spun out from his works by his ardent disciples.

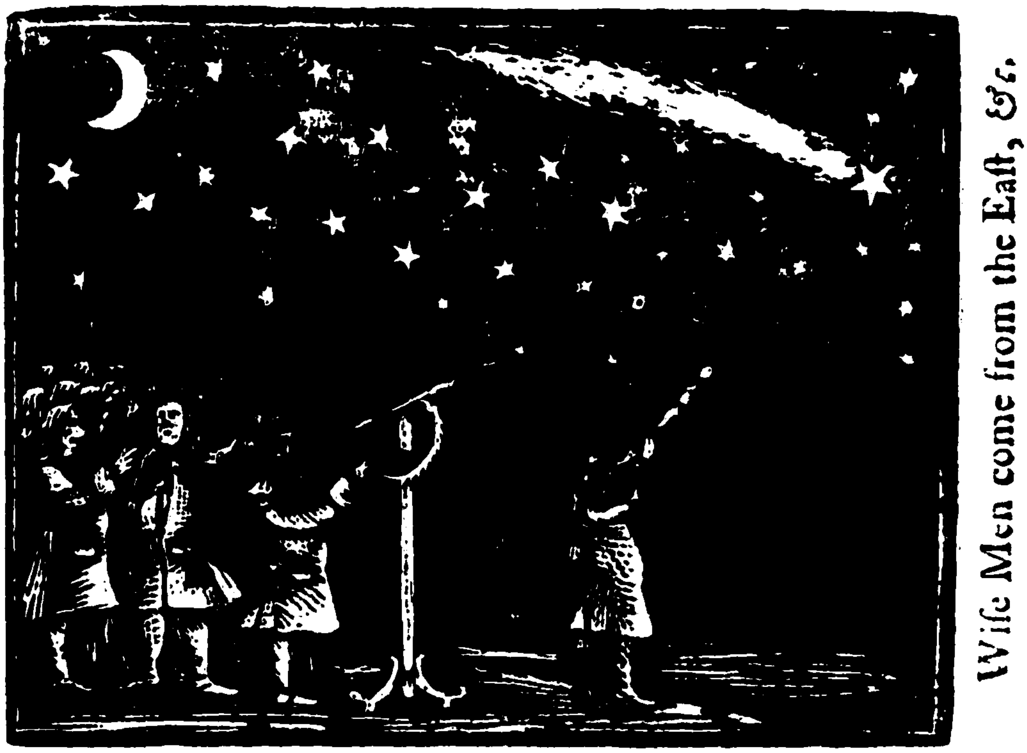


Fig. 1.2. The "Wise Men [who had] come from the East" used a telescope to trace the Star of Bethlehem in The History of the Holy Jesus, an illustrated book for young eighteenth-century readers.

Fig. 1.3. Men, women, and children cluster around the telescope mounted for public use in Boston near Old South Church to view the comet of 1744.

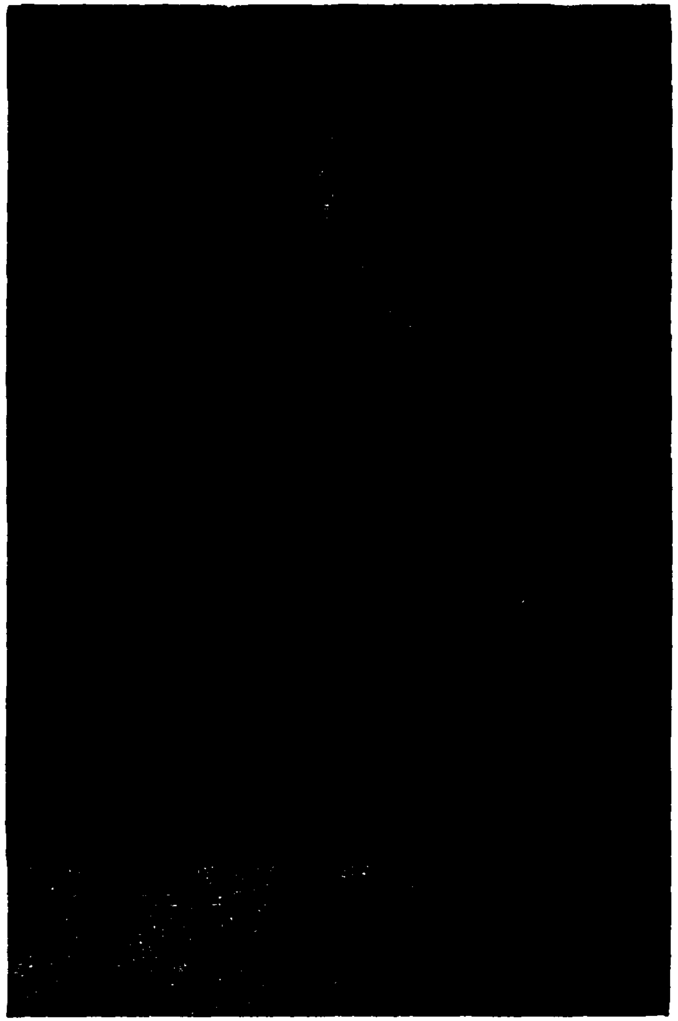

Fig. 1.1a. An English mezzotint portrait of Isaac Newton (by John Faber after the 1725 portrait by John Vanderbank) inspired this water-color copy, signed "William Taylor," perhaps an amateur Connecticut painter.

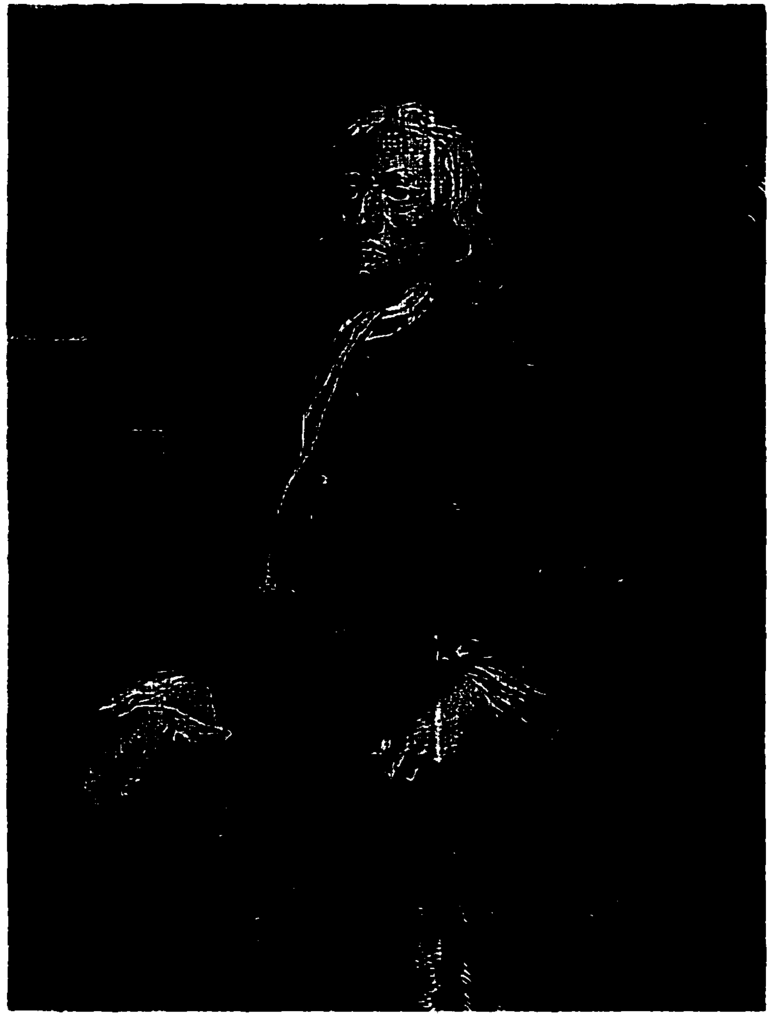

Fig 1.1b. New England readers became familiar with Newton's image as it appeared in Benjamin Martin's popular biographical dictionary, *Biographia Philosophica*. The anonymous engraver copied Faber's mezzotint reversing the mezzotint's orientation from right to left.

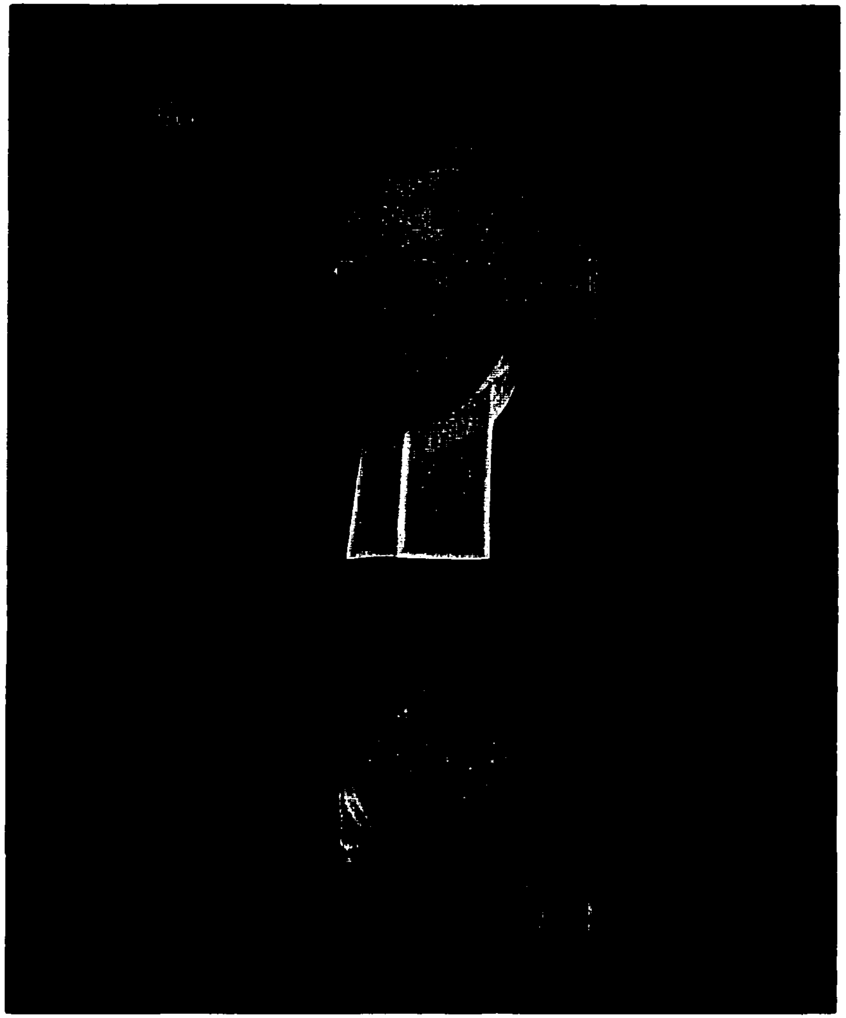

**Fig. 1.2. The Rev. Ezra Stiles chose a "Teaching Attitude" and a selection of history, theology, and natural philosophy books to convey his role in reconciling and promoting science and religion.**

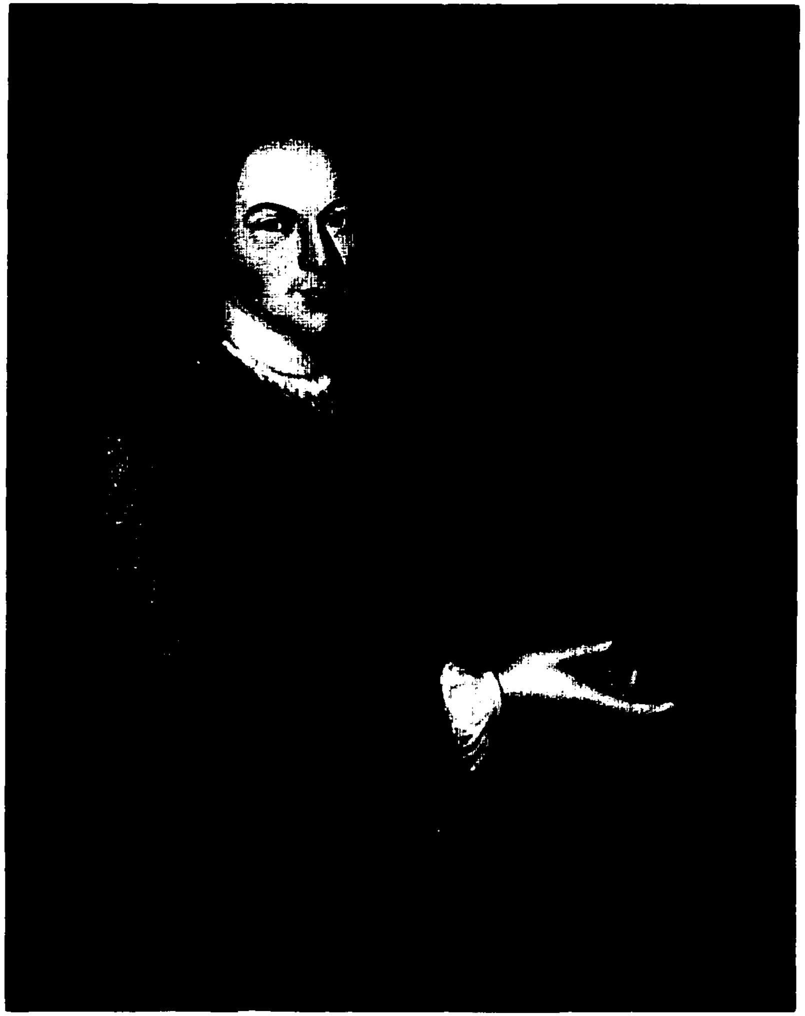

**Fig. 1.3. Science books, a compound microscope, and his fashionable dress convey the "gentleman-scientist" status of Edward Bromfield who entertained friends with optical demonstrations.**

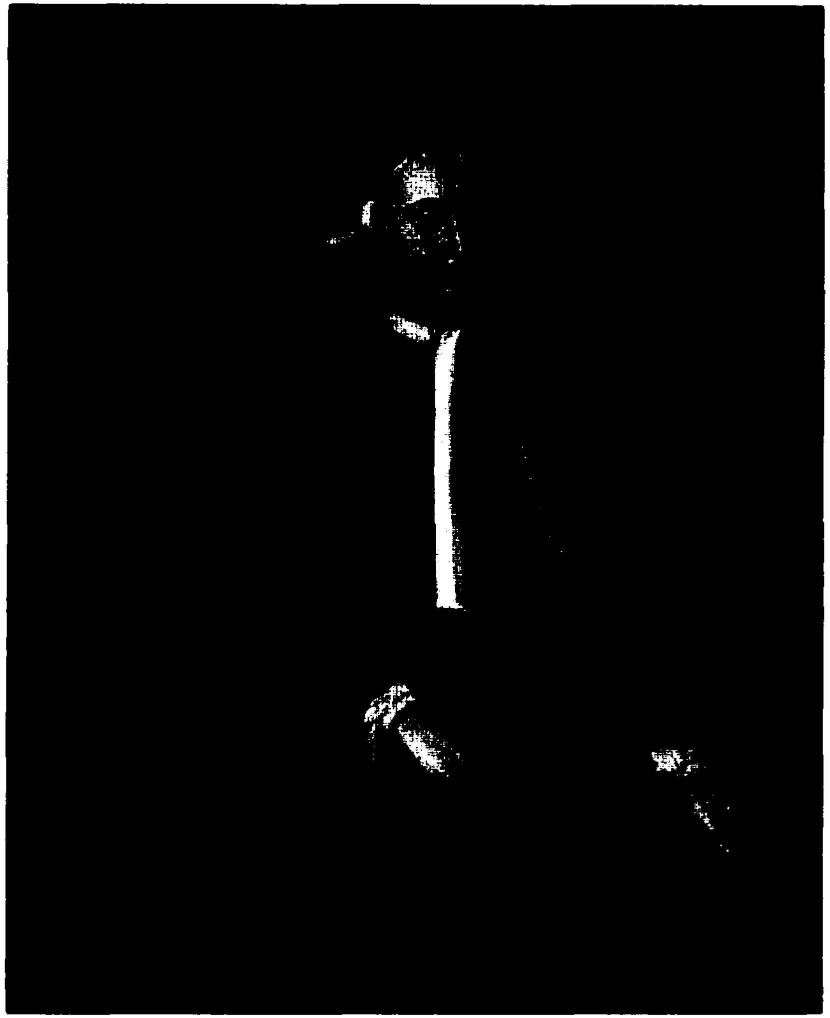

Fig. 1.4. Samuel Sewall was one of several Anglo-Americans who chose the "Newtonian pose," derived from Faber's mezzotint portrait of Newton, for his own portrait (compare fig. 1.1a).

Fig. 1.5. A Boston artist produced this 1751 mezzotint likeness of Thomas Hollis after an English portrait which depicted him as a scholarly gentleman of leisure. The inscription publicized his gifts to Harvard College.

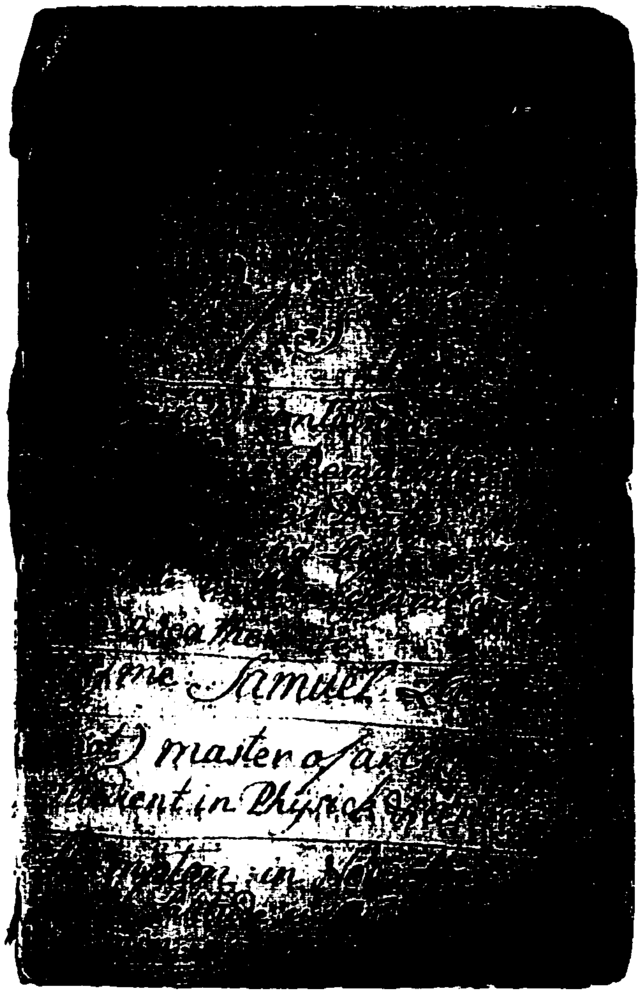

Fig. 2.1. Samuel Lane, a young New Hampshire cobbler, fashioned his 1738 journal cover and his ambitions on the model provided by the *Ames's Almanack* (see fig. 2.2).

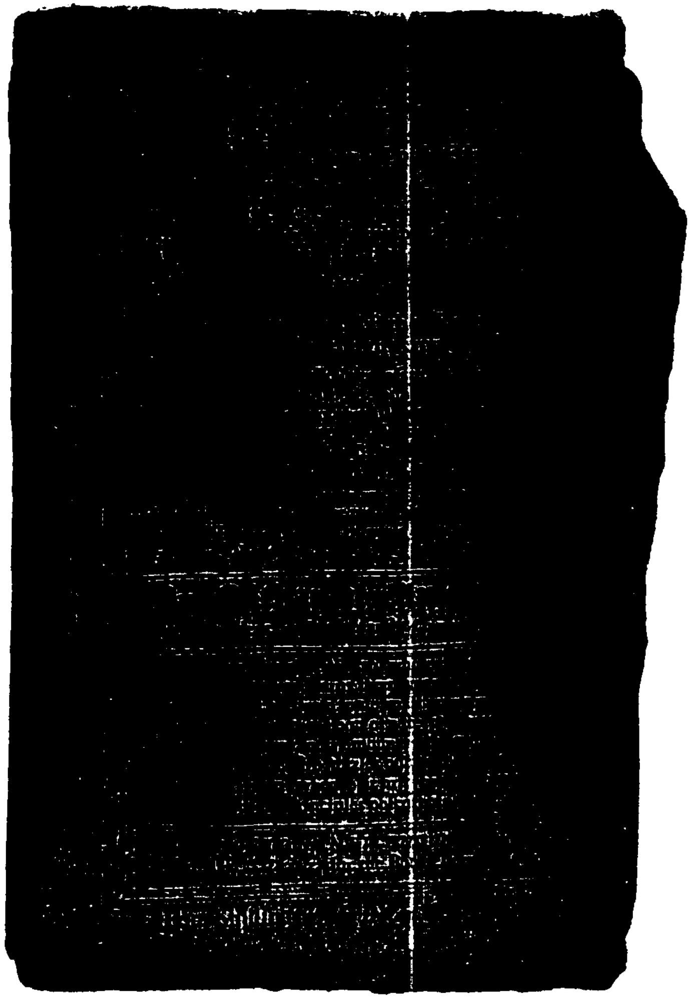

Fig. 2.2. Dr. Nathaniel Ames styled himself a "Student in Physick and Astronomy" in the 1736 and other early issues of the *Ames's Almanacks*, a series that informed New Englanders for nearly 50 years.

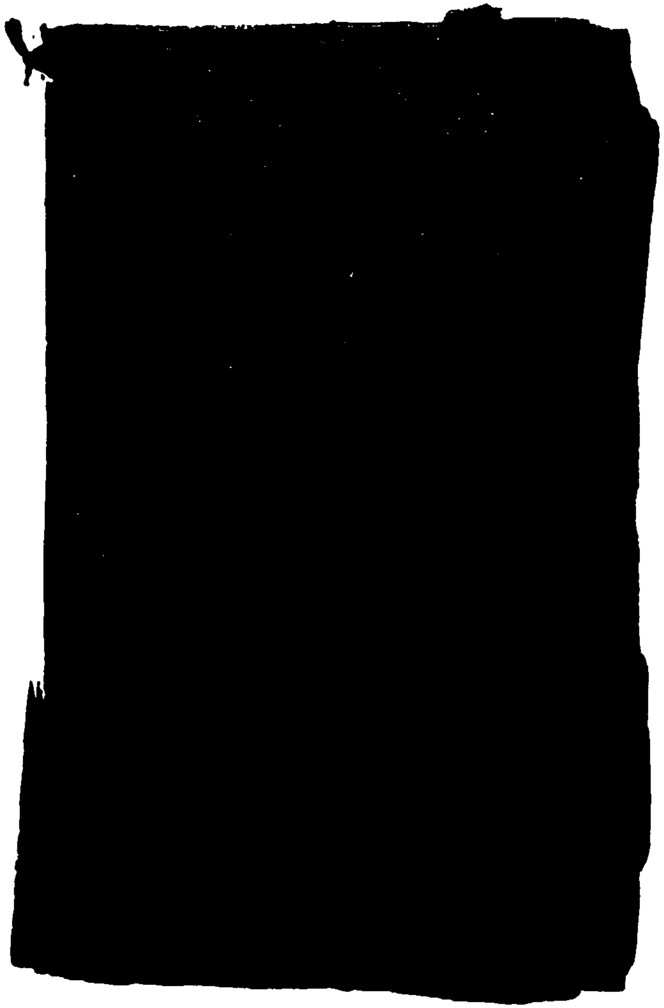

Fig. 2.3. A young reader of the 1767 *Ames's Almanack* used the cover page to practice her penmanship, inscribing the cover page in a childish hand, "Sarah Her Riten".

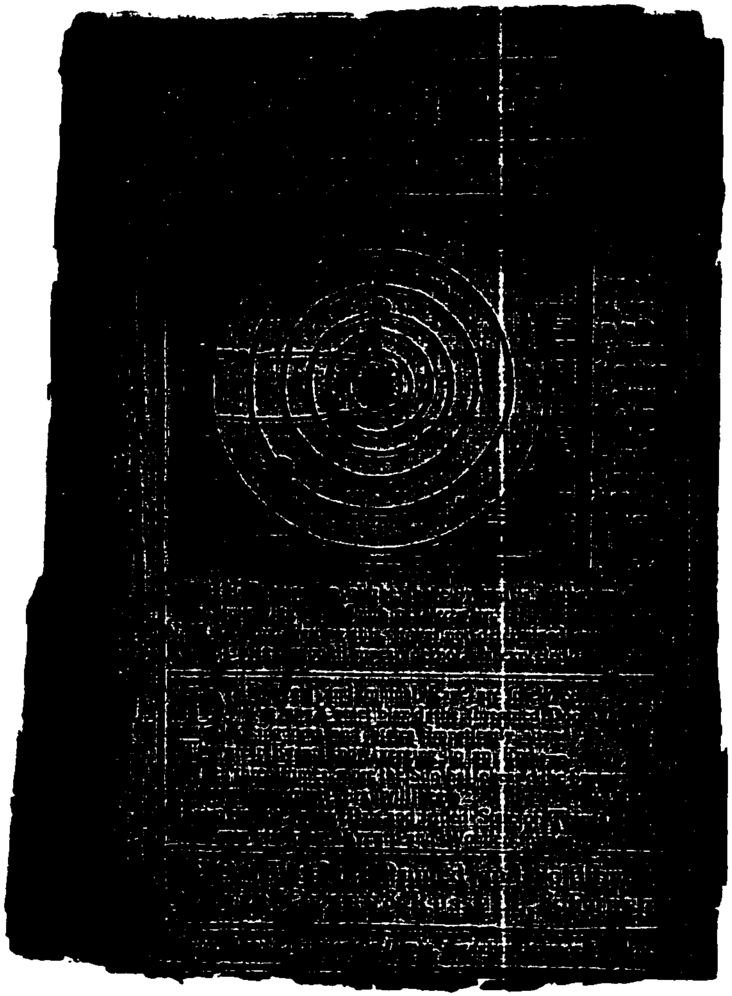

Fig. 2.4. Ads for *Ames's Almanack 1759* featured the "The Solar System," the first "picture" of the sun-centered universe for many readers. It appeared above a poem that took a providential view of the 1759 comet.

Fig. 3.1. The "rocking and cracking" of buildings during the 1755 earthquake shook Boston's churches and the faith of its inhabitants, as shown in this broadside illustration of the poem "Earthquakes Improved: or a solemn warning to the world ... Tues. Morning, the 18th of November..."

Fig. 3.2. The capricious nature of lightning inspired fear and awe, as in this broadside illustration of a fatal thunderstorm. By the 1770s, scientists such as John Winthrop had some success in promoting the use of Franklin's lightning rods over "misplaced" superstition and religious objections.

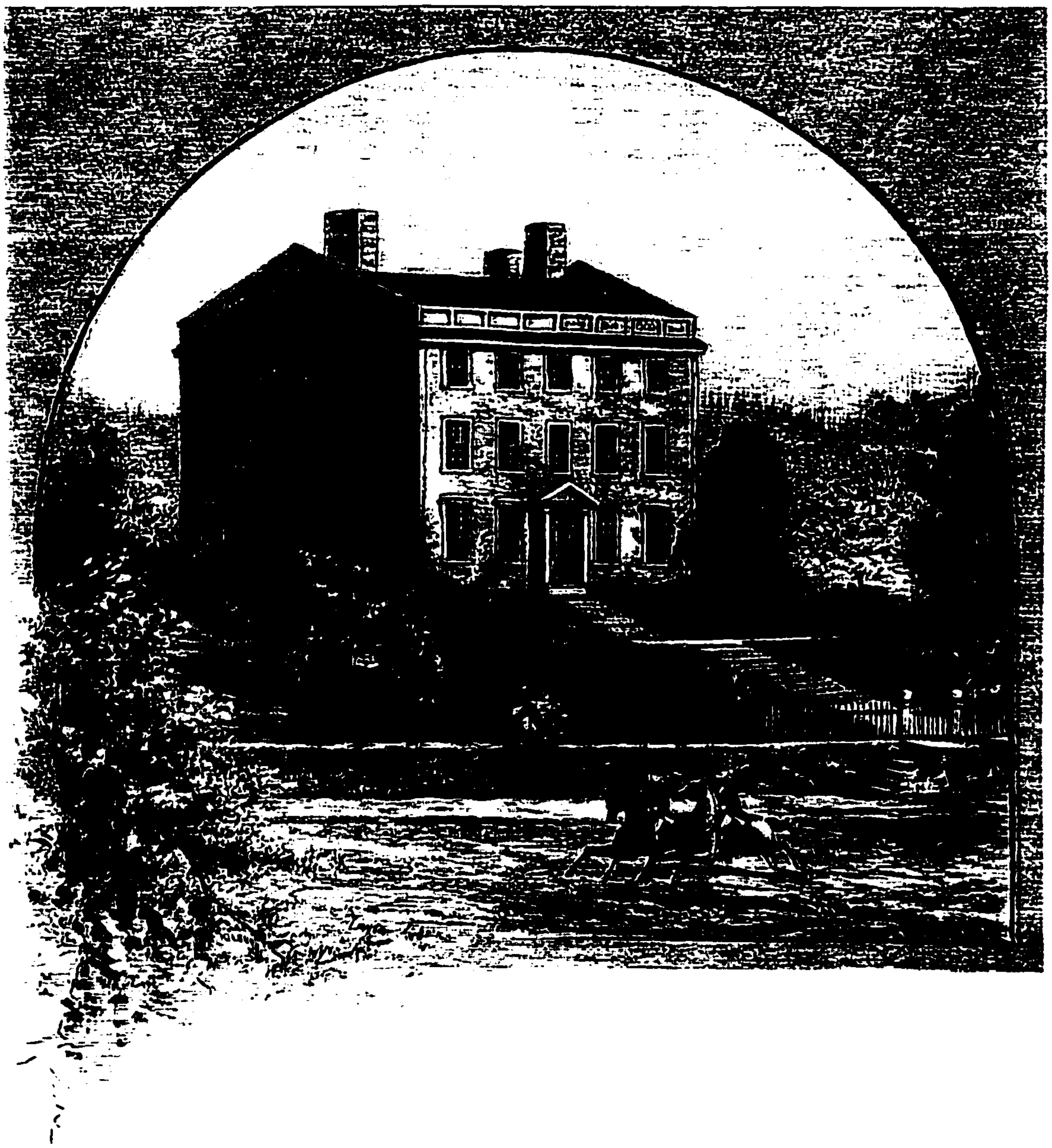

Fig. 4.1. According to family lore, curious "gazers" gathered outside to view the front gable window of the Bromfield mansion (demolished c. 1845) where Edward Bromfield had mounted his solar microscope in the 1740s.

**Fig. 4.2. Anglo-Americans could display their fascination with astronomical gadgetry with the purchase of this 1768 mezzotint copy of the English painting *A Philosopher Giving that Lecture upon the Orrery.***

Boston, *May* 13, 1756.

To be ſeen (for a ſhort Time) at the Houſe of Mr. *William Fletcher*, Merchant, *New-Boſton* ;

That Elaborate and Matchless Pile of A R T, called, The

# MICROCOSM,

## Or, The WORLD in MINIATURE.

BUILT *in the Form of a* Roman *Temple, after Twenty-two Years cloſe Study and Application, by the late ingenious Mr.* Henry Bridges, *of* London ; *who, having received the Approbation and Applauſe of the Royal Society,* &c. *afterwards made conſiderable Additions and Improvements ; ſo that the Whole, being now compleatly finiſhed, is humbly offered to the Curious of this City, as a Performance which has been the Admiration of every Spectator, and proved itſelf by its ſingular Perfections the moſt inſtructive as well as entertaining Piece of Work in* Europe.

A Piece *of ſuch complicated Workmanſhip, and that affords ſuch a Variety of Repreſentations (tho' all upon the moſt ſimple Principles) can but very imperfectly be deſcribed in Words the beſt choſen ; therefore 'tis deſired, what little is ſaid in this Advertiſement may not paſs for an Account of the* Microcosm, *but only what is thought nearly neceſſary in the Title of ſuch an Account,* &c.

Its *outward Structure is a moſt beautiful Compoſition of Architecture, Sculpture and Painting. The inward Contents are as judiciouſly adapted to gratify the Ear, the Eye, and the Underſtanding ; for it plays with great Exactneſs ſeveral fine Pieces of Muſick, and exhibits, by an amazing Variety of moving Figures, Scenes diverſified with natural Beauties, Operations of Art, of human Employments and Diverſions, all paſſing as in real Life,* &c.

1. Shews all the celeſtial Phænomena, with juſt Regard to the proportionable Magnitudes of their Bodies, the Figures of their Orbits, and the Periods of their Revolutions, with the Doctrine of Jupiter's Satellites, of Eclipſes, and of the Earth's annual and diurnal Motions, which are all rendered familiarly intelligible. In Particular will be ſeen the Trajectory and Type of a Comet, predicted by Sir Isaac Newton, to appear the Beginning of 1758 ; likewiſe a Tranſit of Venus over the Sun's Diſk, the Sixth of *June* 1761 ; alſo a large and viſible Eclipſe of the Sun, the Firſt of *April* 1764, *&c.*
2. Are the nine Muſes playing in Concert on divers muſical Inſtruments, as the Harp, Hautboy, Baſs Viol, *&c.*
3. Is Orpheus in the Foreſt, playing on his Lyre, and beating exact Time to each Tune ; who, by his exquiſite Harmony, charms even the wild Beaſts.
4. Is a Carpenter's Yard, wherein the various Branches of that Trade are moſt naturally repreſented, *&c.*
5. Is a delightful Grove, wherein are Birds flying, and in many other Motions warbling forth their melodious Notes, *&c.*
6. Is a fine Landſkip, with a Proſpect of the Sea, where Ships are ſailing with a proportionable Motion according to their Diſtance. On the Land are Coaches, Carts and Chaiſes paſſing along, with their Wheels turning round as if on the Road, and altering their Poſitions as they aſcend or deſcend a ſteep Hill ; and nearer, on a River, is a Gunpowder-Mill at Work. On the ſame River are Swans ſwimming, fiſhing, and bending their Necks backwards to feather themſelves ; as alſo the Sporting of the Dog and Duck, *&c.*
7. And laſtly, Is ſhewn the whole Machine in Motion, when upwards of twelve Hundred Wheels and Pinnions are in Motion at once : And during the whole Performance it plays ſeveral fine Pieces of Muſick on the Organ and other Inſtruments, both ſingle and in Concert, in a very elegant Manner, *&c.*

*It will be ſhewn every Day, exactly at Eleven o'Clock in the Morning, and again at Three and Five in the Afternoon, at* Four Shillings and Six Pence *each, and Children under Twelve Years of Age, at* Three Shillings *(Lawful Money) though Prices quite inferior to the Expences and Merits of this Machine.*

*N. B.* Any Perſon ſubſcribing *Thirteen Shillings and Six Pence*, will be entitled to ſee the MICROCOSM at the above Hours, during it's Stay in *Boſton*.

☞ *TICKETS to be had of* Edes & Gill *in* Queen-Street, *and at the above Mr.* Fletcher's.

Fig. 4.3. The "Microcosm, Or, The World in Miniature," a 10-by- 6-foot mechanical display of the Newtonian universe, toured the colonies in the 1750s. This broadside advertised its Boston debut in 1756.


Fig. 4.4. Newtonian science "rationalized" once-dire events. In "The Thunder Storm," an illustration of a popular romantic tale, lightning is a dramatic, but non-threatening, background for the two lovers.

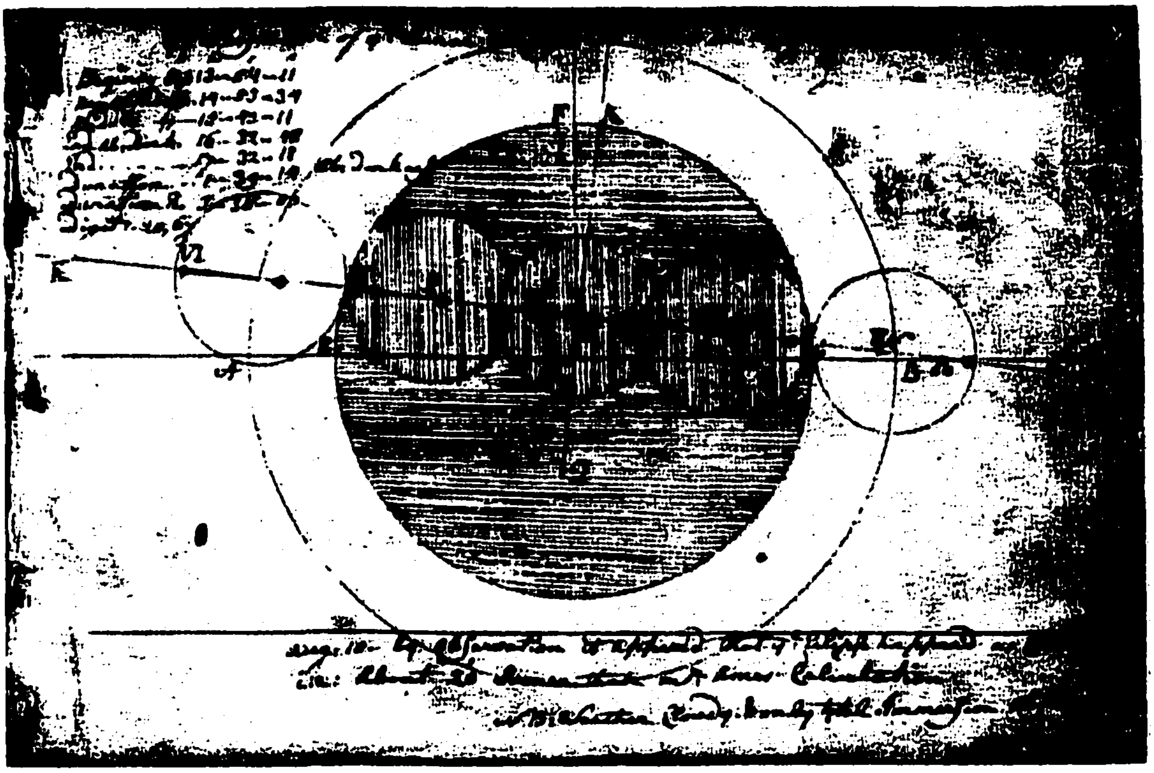

Fig. 5.1. Hannah Winthrop assisted her husband in taking observations of a lunar eclipse in 1777 similar to the observations John Winthrop made of the lunar eclipse of 1747, shown in his diagram above.

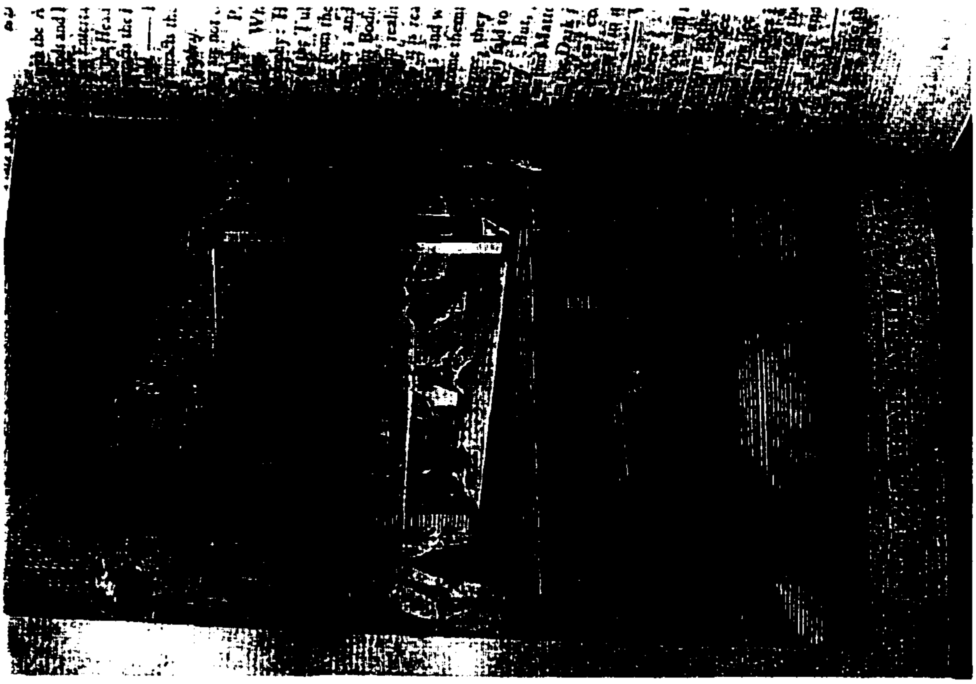

Fig. 5.2. Women's interest in science was encouraged in imported "polite" texts and domestic magazines, such as the *American Magazine*. This picture (from Benjamin Martin's *Young Gentleman and Lady's Philosophy*) depicts the "sociable" nature of at-home demonstrations.

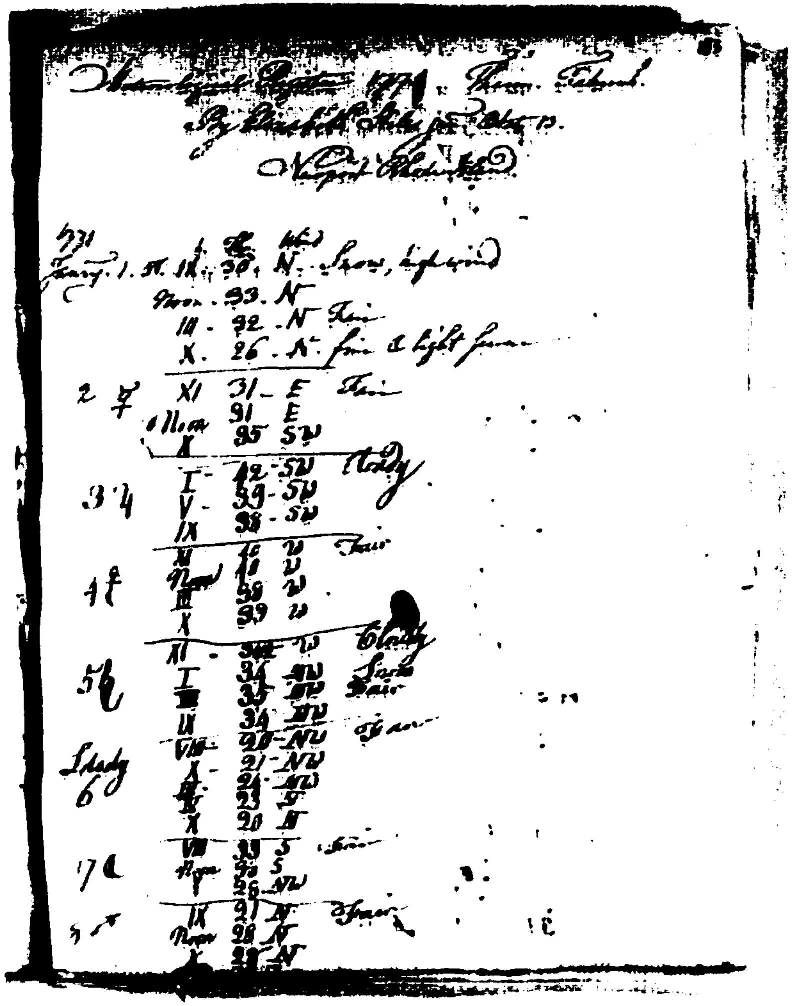

Fig. 5.3. Elizabeth Stiles took daily meteorological readings and entered them in annual registers, such as this one for 1771, as part of her father's promotion of the systematic recording of the climate of the American colonies.

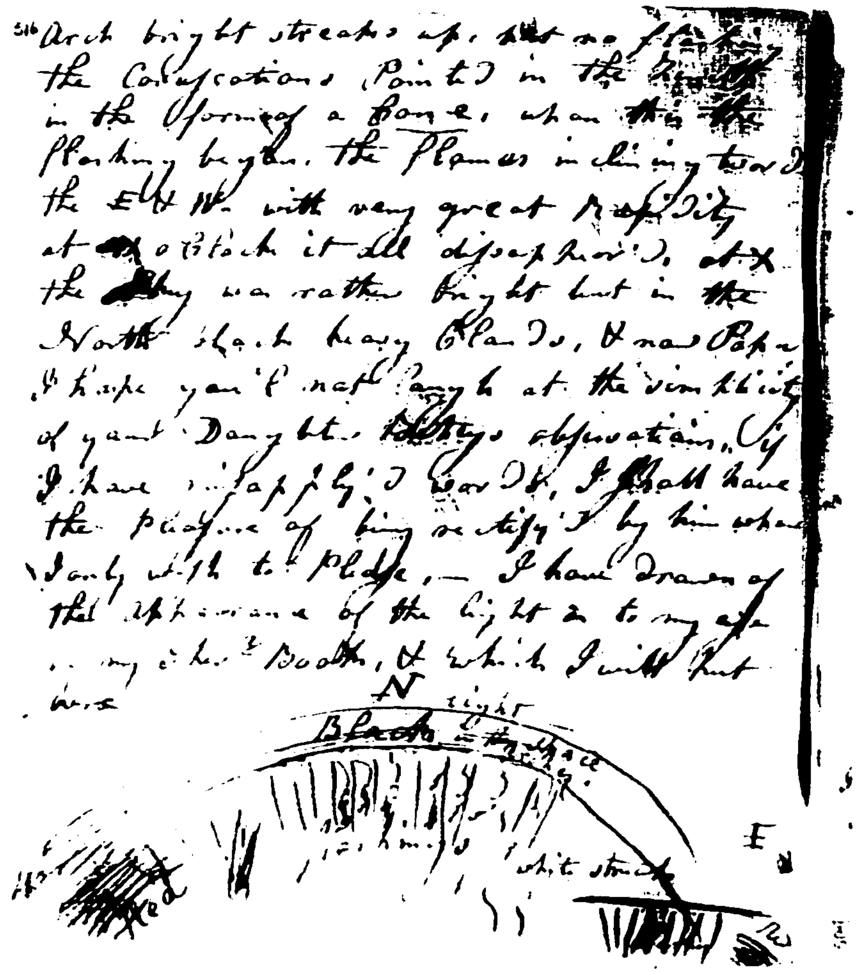

Fig. 5.4. In her father's absence, Elizabeth Stiles observed the Aurora Borealis of 1781 and sent him this sketch and observations of its progress which she had made.

## CHAPTER III

## THE PUBLIC PRINTS: APPROPRIATING NEWTONIAN NATURAL POWERS

On 13 May 1727, upon hearing John Corney had cleared his ship in from London, the printer of the *New England Weekly Journal* hurried to Long Wharf to collect the latest London newspapers.[1] After returning to the printing office, he and his editors perused the March London prints for news they would cull for their subscribers. According to the *London Daily Post*, the populace was speculating upon "the villainous persons yet unknown" who had defaced the King's statue in Grosvenor's Square; the royal ministers were arming for war with Spain; King George was in his counting house learning of a reduction in the public debt.[2] Here also was the obituary of Sir Isaac Newton, Master of the King's Mint and the President of the Royal Society, whose discoveries had laid open the workings of the universe and explained the mysterious force that keep all the heavenly globes in their proper paths. Re-setting the notice for the 22 May 1727 issue, the printer of the *Weekly Journal* advised readers:

> London, March 21, 1727. Yesterday morning between 1 and 2 of the Clock, Died Aged 85, Sir Isaac Newton. . . . He was universally known among Men of Letters throughout Europe, often quoted by Learned Foreigners, but scarce ever without an Epithet to his Praise, such as *Clorissimus Anglos, Celeberrimus Isaac Newton, Ver egregie Doctus*, or somewhat of the kind.

At the beginning of June, the *Boston Weekly News-Letter* carried the same report and an

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[1]*BG*, 29 May 1727. For the method of collecting news from abroad, see Charles E. Clark, *The Public Prints: The Newspaper in Anglo-American Culture, 1665-1740* (New York: Oxford University Press, 1994), 88-90.

[2]*BNL*, 18 May 1727; *NEWJ*, 22 May 1727; *BG*, 19 May 1727. All three carried similar articles on the impending war; the *News-Letter* and *Gazette* reported the defacement of the King's statue; and the *Weekly Journal* reported the reduction in the national debt. The *News-Letter* was the only paper to identify the *London Daily Post* as its source.

updated notice with news of the state funeral "attended by a great many Persons of Quality and Distinction"; "Six noble Peers" carried the funeral pall for burial of the corpse of "that unquestion-able great Man" in Westminster Abbey.[3] In the weeks and months following his death, England mourned the passing of the "most celebrated Isaac Newton" with all the embellishments due a national hero: a tomb inscribed "*Let Mortals rejoice That there has existed such and so great an Ornament to the Human Race*," commemorative coins and medallions, and ream upon ream of elegiac poetry and extravagant epithets.[4] In Boston, the editors of the *Weekly Journal* paid their own tribute to the "outstanding Doctor," in a lead article in the 24 July 1727 issue which celebrated the felicitous union of his natural philosophy with orthodox religion. According to the editors, Newton's investigation of the natural world confirmed the existence of the "Divine Artificer"—a term for the Creator overlaid with Newtonian nuance. "The wonderful Discoveries of Sir Isaac Newton," they enthusiastically declared,

> . . . are sufficient to feast the most refined Soul, and are an evident Demonstration how much Philosophy tends to heighten our idea of the Supreme Being . . . how does the modern System lead us up into infinite Heights of Aether, where it still discovers Globes above Globes . . . .[5]

* * *

This chapter turns to the Boston newspapers of the middle decades of the eighteenth century to examine their role as purveyors of Newton's "modern System" and some post-Newtonian advances in natural philosophy. Like almanacs, the newspapers were significant participants in

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[3] *BWNL*, 1 June 1727; the additional notice was dated "London, March 30."

[4] "Introduction" in *Let Newton be!*, John Fauvel, Raymond Flood, Michael Shortland, and Robin Wilson, eds. (Oxford: Oxford University Press, 1988), 20.

[5] Signed with only the initial "R," this essay was probably written by John Adams according to C. Lennart Carlson who has identified the authors of the *Journal's* weekly "Proteus Echo" literary essay series, Carlson, "John Adams, Matthew Adams, Mather Byles, and the *New England Weekly Journal*," *Early American Literature* 12 (1940-41): 347-48.

eighteenth-century print culture; both were also products of the popular press cutting across educational, class, and gender lines to address the general public.[6] The purview of the public prints, however, was necessarily much broader than that of the almanacs; man-made phenomena—politics, wars, and commerce, foreign and domestic in nature—provided the bulk of newspaper coverage. But natural phenomena, especially natural disasters, did make news; the severity of their effects and the rarity of their appearance determined their coverage. Thus the earthquakes of 1727 and 1755, thunder storms and lightning strikes of churches and public buildings, as well as the comets of 1759 and 1760 and the Transits of Venus in 1761 and 1769, were duly reported and speculated upon according to the bifurcated light of religion and Newtonian natural philosophy.

The purpose of this chapter is to analyze both the *role* of the public prints in providing a venue for natural philosophy discourse and the *use* reader-contributors made of the public prints in reporting and interpreting natural disasters and rarities. While ostensibly disseminating a Newtonian natural philosophy, contributors subtly appropriated Newtonian natural powers to bolster their own agenda regarding the "true" interpretations of nature, whether of providential or rational origin. Thus this chapter looks not only at *what* eighteenth-century readers learned regarding natural philosophy but also at the power struggle that culminated in the mid-century newspaper debate between the orthodox minister, Thomas Prince, and the natural philosopher, John Winthrop, to determine *who* readers would learn was the appropriate spokesman for that information. In tracing

[6]The standard works on the history of American newspapers are Isaiah Thomas, *History of Printing in America* (1810), ed. Marcus A. McCorison (New York: Weathervane Books, 1970); Clarence S. Brigham, *History and Bibliography of American Newspapers, 1690-1820*, 2 vols., (1947; repr. Westport, Ct.: Greenwood Press, 1975); Frank Luther Mott, *American Journalism: A History of Newspapers in the United States Through 250 Years, 1690 to 1940* (New York: Macmillian, 1949). The explosion of scholarship on print culture commencing in America in the late 1970s and taking its focus from French investigations of popular reading prompted by Robert Darnton and Roger Chartier has tended to concentrate on the history of the book and its various facets; for a review, see Clark, *Public Prints*, 5. Clark's own work has broken new ground in establishing the role of newspapers within colonial print culture; for the development of an audience bridging "elite" and "popular" readers, see Chap. 11, esp., 248-251

this process, we shall see how these power plays in the public prints interesected with the formation of a Newtonian culture in New England.

By the end of the second decade of the eighteenth century, Boston printer-publishers supplied the metropolitan center with two well-established newspapers, the *Boston News-Letter* and the *Boston Gazette*, and with the newly inaugurated newspaper-cum-literary journal, the *New England Weekly Journal*. By virtue of subscription networks serviced by post riders, their influence extended to households over nearly all of New England radiating northeastward to New Hampshire and Maine and southwestward to New York.[7] In tracing the role of the public prints in disseminating and shaping popular versions of Newtonian natural philosophy, this study looks primarily at the *Gazette* (which absorbed the *Weekly Journal* in 1741) and the *News-Letter*, whose longevity extended to 1775 and 1798 respectively, and occasionally at their competitors as the number of colonial newspapers increased during the century.[8] The newspaper coverage of the 1727 and 1755 earthquakes and of the comets of 1759 and 1769, provides a convincing measure of the politics involved in the public appropriation of the power implicit in extraordinary natural phenomena.

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[7]Clark, *Public Prints*, 87. Readership per household was multiplied by more than four or five in New England where the literacy rate, among both women and men, was high; Clark estimates that by 1740, Boston newspapers (based on a production figure of 600 copies per weekly issue of each of its 5 newspapers) were printing one copy each week for every five or six Boston residents or one copy for every 67 Massachusetts residents, Ibid., 259.

[8] Boston's 18th-century newspaper coverage increased with establishment of *The Weekly Rehearsal/Boston Evening Post* (1731-35/1725-75), and *The Boston Post-Boy* (1735-54); its monopoly in New England ceased with the advent of *The Rhode Island Gazette*, (Newport, 1732-1733); *The New Hampshire Gazette* (Portsmouth, 1756-1800 on); *The Newport Mercury* (1758-1775); the *Providence Gazette and Country Journal* (1762 into 1800); the *Essex Gazette* (Salem, MA, 1768-1775); *The Connecticut Gazette* (1755-67); *The New London Gazette/The Connecticut Gazette* (1763/1773 into 1800); *The Connecticut Journal and New-Haven Post Boy* (1767 into 1800); *The Connecticut Courant* (New Haven, 1764-81). For the founding of the *News-Letter* and *Boston Gazette*, the first two successful newspapers in the British colonies, see Clark, *Public Prints*, Chaps. 4 and 5. For other colonial newspapers established before 1740, see Ibid., 267-68. Also see Thomas, *History of Printing*, 215-74, 304-313, 324-30, 335-35.

During the course of the century, natural philosophy emerged from the relatively exclusive site of the church pulpit, where New England divines traditionally had employed science in defense of revealed religion, to the public forum provided by the popular press. In the late seventeenth and early eighteenth centuries, New England Puritanism had fostered an accommodation of Christian piety and natural philosophy. This harmony found expression in the view of Puritan ministers as uniting the "character of a Philosopher and a Divine." Cotton Mather, without peer among his ministerial colleagues in the early eighteenth century as both a divine and a philosopher, had urged the adoption of Newtonian philosophy in a passage often quoted by scholars to illustrate the acceptance of the new science. In *Manuductio ad Ministerium*, published in 1726, he advised young candidates for the ministry, in order to attain "as thorough an Insight as you can get into the *Principle* of our *Perpetual Dictator*, the Incomparable Sr. Isaac Newton, is what I mightily commend to you. . . . Be sure, the Experimental Philosophy is that, in which alone your Mind can be at all established."[9]

Yet the conjunction of religion and natural philosophy prescribed by Mather and fostered by the availability of various imported Newtonian texts was not without tension. The clergy's use of Newton's "modern System" to defend revealed religion unwittingly hastened the acceptance of a mechanistic, and eventually deistic, world view. By mid century, the perceived inroads of deism upon orthodox theology threatened the harmony of science and religion. On the one hand, this

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[9]*Manudutio ad Ministerium, Dr. Mather's Directions for a Candidate of the Ministry*, (Boston, 1726), 50-51. Mather included his own summary of current scientific knowledge, *The Christian Philosopher* (London, 1721) in the reading he proposed for candidates, *Manuductio*, 148. For Mather's course via his published works in "leading the way" to Newton, see Perry Miller, *The New England Mind From Colony to Province* (Cambridge: Harvard University Press, 1953), 437-43. For the sources of his knowledge of Newtonian science, see Pershing Vartanian, "Cotton Mather and the Puritan Transition into the Enlightenment," *Early American Literature* 7 (1973): 213-24, and Jeffrey Jeske, Cotton Mather: Physico-Theologian," *Early American Literature* 47 (1986): 583-95.

potential bifurcation was non-Newtonian in that it denied Newton's own belief in the harmony of religious and scientific truths. On the other, it was Newtonian in that Newton originated a new mathematical-experimental science that could operate independently of religious belief in fact, if not in intent. At stake in the impending rift of science and religion was the role of those who claimed to speak for the natural world—be they practitioners of science such as John Winthrop, Hollisian Professor of Natural Philosophy and Mathematics at Harvard and the most eminent member of Boston's scientific community, or ministers such as Thomas Prince, a relatively minor figure in the scientific circle, although one of New England's most prominent ministers.

Known to historians as the pastor of Old South Church, New Light proponent of the Great Awakening, bibliophile, and author of *A Chronological History of New England* (1736), Prince has been characterized as "probably the most scholarly and literate person in Boston next to Cotton Mather, and certainly the most Anglicized."[10] Nevertheless, Prince"s place within the trans-Atlantic scientific community of the early eighteenth century has proven elusive, although the natural philosophy content of his sermons has won him a modest reputation as "a convenient index" to the scientific "notions" of his era.[11] Raymond Stearns includes him in the group of "upwards of twenty" men with scientific interests in Boston during the second quarter of the 1700s drawn together by the towering presence of the elderly Cotton Mather. Elected a Fellow of the Royal Society of London in 1713, Mather was one of Prince's intimate friends and his theological mentor and ally. Although not formally organized, this group constituted "a community of scientifically-minded men armed with books and apparatus, able to confer with one another, to exchange data and

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[10]Clark, *The Public Prints*, 145.

[11]Theodore Hornberger, "The Science of Thomas Prince," *New England Quarterly* 9 (1936): 26. For a biographical sketch of Prince, see *SHG* 5:341-68.

opinions, and to give mutual encouragement, support, and inspiration."[12]

Even in examining his role in the 1755 earthquake controversy, scholars have tended to overlook Prince's connection to Boston's early scientific circle, because he was not a practitioner of science and neither a fellow nor a correspondent with the Royal Society. Instead they have looked through his sermons for direct borrowings from English and continental natural philosophers and have regarded him as representative of a ministerial, rather than a scientific, milieu.[13] But the fortuitous survival of Prince's copy of the prospectus for a course in experimental philosophy, offered in Boston by Isaac Greenwood in 1727 and extensively advertised in the public press, suggests a more immediate source for the minister's knowledge of "natural Philosophy" and "the Mathematicks." It draws Prince more closely within the folds of Boston's nascent scientific community, while it also illustrates the importance of such a community in providing a direct means of the dissemination in the American colonies of what Prince terms "Natural Knowledge." In a larger context, it opens discussion of the contest that played out in mid-century to interpret and speak for the powers of nature, and its consequences for Prince, Greenwood, and Winthrop as well as the formation of a Newtonian culture in New England.

Following his graduation from Harvard in 1707, where he had studied the recently reformed curriculum that sought a new and enlightened integration of religion and reason, Prince spent eight formative years in England.[14] There, in 1710 he attended the Gresham lectures in medicine delivered

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[12]Raymond Phineas Stearns, *Science in the British Colonies of America* (Urbana: University of Illionois Press, 1970), 485, n. 211; for the date of Mather's election as FRS, see Stearns, "Colonial Fellows of the Royal Society of London, 1661-1788," *William and Mary Quarterly*, 3rd ser., 3 (1946): 226-29.

[13]See, for instance, John E. Van de Wetering, "God, Science, and the Puritan Dilemma," *New England Quarterly* 38 (1965): 494-507.

[14]For the introduction of enlightenment thought at the expense of Scholasticism in the course of study at Harvard College, see Norman Fiering, "The First American Enlightenment: Tillotson, Leverett, and Philosophical Anglicanism," *New England Quarterly* 54 (1981): 307-44

by John Woodward and also lectures in astronomy delivered by John Harris.[15] This direct exposure to the English virtuosi and through them to the natural philosophy of Newton—as well as Prince's observation on March 8, 1716, of the century's first appearance of the aurora borealis in England—may have stirred his scientific ambitions.[16] Shortly thereafter, he communicated "an exact Historical Relation. . . . of the Manner, Appearance & Process of the wonderful Prodigy" to the Royal Society, in the unfulfilled hope that it would be published. Although "modern" in the exactness of its physical description, Prince's account generously combined theological doctrine and scientific theory. Prince contended this "amazing appearance" was "designed by PROVIDENCE for a general Observation and Terror" and possibly signified "the coming to pass" of "Mr. Whiston's Hypothesis . . . that the Train of a Burning Comet was then a seizing on this Terrestrial World."[17] When the aurora borealis appeared in New England on 11 December 1719, a year after Prince's return, he seized the opportunity, as he wrote, to "communicate" his 1716 "Piece of *Natural History* to the Publick," publishing it under the title *An Account of a Strange Appearance in the Heavens.*

Prince's interest in science and in publishing lay dormant after he assumed the duties of co-pastor of Old South Church, also in 1719; within the next seven years he published only one work, a sermon for young people on the practice of piety.[18] By the mid 1720s Prince's literary aspirations merged with his Anglophile pretensions (discernable in the accent and wig he affected upon his return from England) through his association with the *New England Weekly Journal,* Boston's

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[15]*SHG*, 5:344-45; Thomas Prince, "Journal," 28 Nov. 1710, MHS. For Harris's published works, see Chap. I.

[16]Thomas Prince, *An Account of a Strange Appearance in the Heavens. . . .* (Boston, 1719).

[17]Whiston had advanced this theory in *A New Theory of the Earth* (1708), 276-282, Katherine Bronnell Collier, *Cosmogonies of Our Fathers, Some Theories of the Seventeenth and the Eighteenth Centuries* (1934, repr., New York: Octagon Books, 1968), 109-24.

[18]"The Great and Solemn Obligations to Early Piety" in *A Course on Early Piety . . . By Eight Ministers* (Boston, 1721).

second newspaper-cum-literary journal established in early 1727.[19] With the announced purpose of "the Encouragement of Wit & Politeness," the *Weekly Journal* self-consciously styled itself upon its English predecessor, *The Spectator*, but combined its politeness with the orthodox Puritan morality of its editors who represented Cotton Mather's legacy of theological conservatism. As one of its three editors, Prince, indeed, may have been responsible for inserting Newton's obituary in the 14 March 1727. That Prince was formally engaged in an intensive course of Newtonian natural philosophy at the time of Newton's death bolsters to this claim.

Prince's interest in the pursuit of Newtonian science apparently re-surfaced when Isaac Greenwood returned to his native Boston in 1726 as the designee-in-waiting for the proposed Hollis Professsorship of Mathematics and Natural Philosophy at Harvard.[20] During his three-year stay in England, Greenwood had met several of the virtuosi including Newton, William Derham, and J. T. Desaguliers. It was Greenwood's association with Desaguliers, first as his student and then as his assistant, that would have the most impact upon not only the young scholar but the Boston scientific community and Prince as well. While awaiting final confirmation of the Hollisian chair, Greenwood advertised "An Experimental Course of Mechanical Philosophy . . . with discoveries of Newton" for

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[19]For Prince's appearance and his role in the *NEWJ*, see Clark, *Public Prints*, 143-146. For analysis of the *NEWJ*'s "Proteus Echo" literary essays that combined Christianity and the conventions of polite style and emulated English models, especially the *Spectator*, see Ibid., 148-153.

[20]The timing of the establishment of the Hollis professsorship and Greenwood's appointment in 1726, whether deliberate or not, coincided with Mather's recommendation in the *Manuductio ad Ministerium* of Newtonian science as a subject necessary for ministerial candidates. Mather was an early proponent of the establishment of a professsorship of natural philosophy at Harvard and backed Greenwood's candidacy; see Cotton Mather to Isaac Greenwood, 16 July 1724, *Selected Letters of Cotton Mather*, comp. with commentary by Kenneth Silverman (Baton Rouge, Louisiana State University Press, 1971), 388-89. Greenwood may have had that recommendation in mind while he was testing the market for a course aimed at laymen. For the delay in Greenwood's apppointment, see Chap. IV below. For biographical information, see *SHG* 6:471-482; for his significance as a transitional figure between Puritanism and deism and a bibliography of his published works, see David C. Leonard, "Harvard's First Science Professor: A Sketch of Isaac Greenwood's Life and Work," *Harvard Library Bulletin* 29 (April 1981): 135-68; for his association with Desaguliers, see Stearns, *Science in Colonies*, 447-48.

the benefit of Bostonian "Gentlemen" in the *Boston Gazette* during December 1726 and the following January.[21] Despite a late start due to an initial "insufficient number"of subscribers, the series finally commenced 16 January 1727.[22]

Greenwood also issued a prospectus, "free to Subscribers," which was advertised with the course and subsequently published.[23] The prospectus reveals how closely the new professor's course was modeled on the course his former mentor, Desaguliers, had developed "to explain and prove experimentally what Sir Isaac Newton has demonstrated mathematically."[24] Although the prospectus does not acknowledge Greenwood's debt to Desaguliers by name, the following claim made on the title page echoes his mentor's promotion of "mechanicks":

> . . . such a competent Skill in *Natural Knowledge* may be attained (by means of various *Instruments* and *Machines* . . . [and] above Three Hundred curious and useful Experiments performed) that such Persons . . . may . . . make Themselves better acquainted with the *Principles* of NATURE and the wonderful discoveries of the incomparable Sir *ISAAC NEWTON*.

Greenwood's invocation of Newton is consistent with two issues Simon Schaffer has explored in the acceptance of Newtonian science during the eighteenth century and its promulgation by means of public lectures and experiments. In setting themselves "the task of producing dramatic and wonderful active powers by the manipulation of passive and inert matter, [i.e., experimental

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[21]*BG*, 5, 19, 26 Dec. 1726; 2, 9, Jan. 1727.

[22]*BNL*, 12 Jan. 1727; *BG*, 9 Jan. 1727.

[23]Isaac Greenwood, *An Experimental Course of Mechanical Philosophy*. . . . (Boston, 1726); advertised with the course notice, *BG*, 19 Dec. 1726 and 9 Jan. 1727.

[24]J[ohn] T[heophilus] Desaguliers, "Preface," *A Course of Experimental Philosophy* (London, 1734). For Desguliers' "decisive" role in establishing and promoting the cultural, religious, and political implications of Newton's natural philosophy, see Simon Schaffer, "Newtonianism," in R. C. Olby et al, eds., *Companion to the History of Modern Science*, 615-16. For a sketch of Desaguliers' career and an analysis of his "defense of . . . controverted Newtonian doctrine" as well as original contributions to the development of English materialism, see Robert E. Schofield, *Mechanism and Materialism: British Natural Philosophy in An Age of Reason* (Princeton: Princeton University Press, 1970), 80-87.

apparatus]" natural philosophers, according to Schaffer, were doing no more than what Newton had suggested in the final query of the 1706 edition of the *Opticks*. Realizing that "Metaphysical arguments are intricate and understood by few," Newton acknowledged that most men understand only the argument for the Deity's existence which is drawn "from Phaenomena." Because experimental philosophy deals with creation where "we see the effects of a Deity . . . and thence gather the Cause," he asserted "the proof of a Deity and what are his Properties belong to experimental Philosophy." Newton further suggested that active powers of nature—including comets' tails, eruption, cohesion, and electricity—should be used to prove the effects and existence of the Deity. This Newtonian "model of *authority*," Schaffer asserts, was "perfectly suited" to public demonstration.[25]

Therein, however, was the kernel from which the authority of natural philosphers would grow. For Schaffer also points out, the role of natural philosophers in manipulating the "active powers" in their public experiments and lectures was critical. "Their task," he emphasizes, "was to exploit control over these powers, to draw out and make manifest the theological and moral implications for the audience."[26] Thus Newtonian natural philosophy, far from being "theologically and cosmologically neutral," connected the active powers of nature with divine action and then reproduced them.[27] By using the experimental equipment developed by such science demonstrators as Desaguliers, Greenwood would reproduce the active powers of nature and control their meaning, thus acting as a mediator between his audience and the principles of nature.

Greenwood's advertisement for his course implicitly reflects this attitude; he describes "Experimental Philosophy" as the manner of representing to the Eye, the *Laws*, and *Principles*,

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[25]Simon Schaffer, "Natural Philosophy and Public Spectacle in the Eighteenth Century," *History of Science* 21 (1983): 4-5.

[26]Ibid., 5.

[27]Ibid., 4.

upon which NATURE proceeds in the Construction of Things, in an orderly Collection of *Experiments* relating to the most remarkable *Phenomena*. . . .[28] Thus, Greenwood, like Desaguliers, increased his authority as the mediator of nature by using "proper Machines," and "above 300 experiments" devised not by God but by human ingenuity. Prince's notation of the course prospectus indicates he may have attended fourteen of the eighteen classes Greenwood conducted between January 16 and April 17, 1727.[29] The would-be scientist heard lectures and watched experiments on topics such as the methods of philosophers, essential properties of matter, general and special laws of nature, principles of mechanics and mechanical powers, Newton's laws of motion, astronomy and astronomical phenomena, and planetary motion.

Just six months after he had completed the course, the most violent heavings of any earthquake within their memory shook Prince and Greenwood along with the other twelve thousand residents of Boston and the environs from their beds on Sunday 29 October 1727.[30] The *Weekly Journal* was the first in print; hurriedly inserting a notice in the Monday issue, the publisher vividly reconstructed this "surprizing and awful" visitation of Providence:

> Last Night and this Morning we have in this Place felt several Shocks of an Earthquake . . . the Noise was like hard Thunder, which lasted from the space of about two Minutes, when the Earth trembled and shook to a very great degree, the Houses rock'd as if they would have fallen down, and many of the Inhabitants being amaz'd ran out into the Streets, and there seem'd to unite the Cry, *Lord our Flesh trembleth for fear of thee, and we are afraid of thy Judgments*. But to make just ans religious Improvement of this unexpected and unusual Event of Providence

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[28]Greenwood, "Advertisement" in *Experimental Course*, reverse of title page.

[29]Apparently several of the proposed lectures extended to two class meetings. See marginalia in Prince's shorthand on Greenwood, *Experimental Course*, MHS.

[30]William Douglas, *A Summary, Historical and Political, of the first Planting . . . and Present State of the British Settlements in North America* (Boston, 1747) I:536. Douglas reports this figure for 1742.

among us . . . we shall doubtless be instructed by the Philosopher and the Divine.[31]

The *Boston News-Letter* and the *Boston Gazette* followed with notices on 3 November and 6 November, respectively, describing in nearly identical articles the "rocking and trembling" of houses, the "affrighted" people rushing into the streets, and the merciful sparing of bodily injury. Both also reported the gathering of church congregations the next day for spontaneous prayer meetings and on Thursday for the public day of fasting, prayer and humiliation declared by the governor, which was "very strictly and reverently observed." The *News-Letter* reported the minds of the people were "gravely & justly affected," while the *Gazette* declared they were filled a with a "great and just terror and Dread," but neither adorned their accounts with the dramatic cry the *Weekly Journal* writer had ascribed to the amazed inhabitants. In the following weeks and months, the public prints continued to report aftershocks as they occurred in Boston and as far away as Arrowsick (Province of Maine) on the eastern frontier, Dover, New Hampshire to the north, Guilford, Connecticut to the west, and Providence, New York and Philadelphia to the south as well as an eyewitness account of the severe earthquake in Barbados in December.[32] Advertisements for the flood of sermons preached on the Sunday before, on both the Monday and the Sunday after the earthquake, and on the three public fast days (the aftershocks necessitated additional fast days, 21 December 1727 and 21 March 1728)[33] filled the columns of the *Weekly Journal* and the *News-Letter* and also the coffers of Boston's printers for next six months.[34]

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[31]Quoted in Clark, *Public Prints*, 151. A week later the earthquake was the topic of the *NEWJ*'s feature essay; written by the Rev. John Adams, it focused on the fear the quake engendered, dealing only briefly with natural causes "according to modern Philosophers," Ibid., 152.

[32]*NL*, 10, 16, 23 Nov., 14, 22 Dec. 1727, 22 Feb., 1728; *BG*, 13 Nov., 25 Dec. 1727, 5 Feb. 1728. Philadelphia, New York, and Long Island suffered minor shocks, *BNL*, 16 Nov. 1727.

[33]Proclamations printed in the *BNL*, 14 Dec. 1727 and 14 Mar. 1728.

[34]Advertisements for published sermons appeared in the *BNL* from 10 Nov. 1727 through 22 Mar. 1728, and 30 May 1728. The *NEWJ* ran substantially the same ads 6 Nov. 1727 through 8

Perhaps impelled by his recent instruction in natural philosophy, Thomas Prince took up the *Weekly Journal's* challenge to the philosopher and the divine, emerging in print as a self-designated arbiter of supernatural and natural causes. Prince's intention was known well in advance, and his role as "a *better Hand*" in explaining natural causes, as his fellow minister Benjamin Colman suggested, was apparently deferred to by his colleagues.[35] By the third week of November his eagerly-awaited work was in the press; publication notices in both the *Weekly News-Letter* (16 November) and the *Weekly Journal* (November 20) advertised:

> NOW *in the Press & will quickly be Published, Two Sermons, Intitled,* Earthquakes the Work of GOD and Tokens of His Divine Displeasure; *Wherein among other things are offer'd a brief Account of the Natural Causes of these Operations in the Hands of GOD. . . . By the Rev. Mr.* Prince.

The title of the published sermons employs the language, imagery, and dire moral message typical of the other earthquake sermons. But untypical is Prince's added statement addressing the "Natural causes" of the divine operations: although other ministers addressed these causes within their sermons to greater or lesser extent, Prince was the only author who incorporated the investigation of *natural* causes in his sermon title. Thus the newspaper advertisement emphasizes Prince's dual role as the mediator of supernatural and natural causes by which he interprets the earthquake as both a philosopher and a divine.

Within the sermons, Prince does indeed draw a moral lesson from the "affrightful Shakings

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Apr. 1728, with the last ads appearing 17 May through 10 June 1728. The *BG* ran only one sermon advertisement, 13 Nov, 1727. For a list of the earthquake sermons, see William Andrews, "The Literature of the 1727 New England Earthquake," *Early American Literature* 7 (1973): 294; Andrews apparently overlooked Samuel Mather, *Essay on the Good Impressions Produced by Earthquakes* (Boston, 1727) and (Anonymous) *Some Rude & Ingested Thoughts on the Terrible Majesty of God . . . Particularly in the Phenomenon of Earthquakes* (New London, 1730).

[35]Quote, from Benjamin Colman, *The Judgments of Providence in the Hands of Christ* (1727), Hornberger, "Science of Prince," 29; Hornberger reads this as an allusion to Prince. As Hornberger notes, interest in Prince's forth-coming work also was stimulated by Prince's promise to compile and include a history of earthquakes, Ibid., 29.

of the Earth," attributing the quake's "First and Principal Cause" to a "wrothful God." Turning to the explanation of secondary causes, Prince supplemented contemporary earthquake theory, based on explosions in underground caverns touched off by combustible minerals,[36] with his own theory. Here he used Boyle's calculations of atmospheric pressure to theorize how the "astonishing Weight" of the air forces the surface of the earth into the vacuum created by underground explosions.[37] Significantly, Prince's publication speaks to the confidence he displays in *his* ability to interpret the "Natural, Instrumental or Secondary Causes" inherent in the physical world. It also reveals his reliance on the power of print as well as science to advance his claim on the role of spokesman for both nature and God—a role bolstered by his admission that he had hurried the sermons into print to satisfy "those whose prevailing Desires were to see by the Press what they heard from the Pulpit."[38]

Prince's two sermons fall within the theological mainstream apparent in the other twenty-three published ministerial accounts of the earthquake.[39] Like his fellow divines, Prince united religion and science but subordinated physical to divine causes. In 1727, the religious "improvement" afforded by revealed truth still superseded scientific truth. As yet the inroad of rationalism, even in Boston's most enlightened church, the Brattle Street Church, was limited. Natural philosophy according to its minister, Benjamin Colman, was still searching in the dark. "The earthquake," he advised his congregation,

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[36]Andrews, "1727 Earthquake Literature," 284-85; for Andrews's assessment of Prince's "relatively sophisticated" theory, see 282.

[37]Prince, *Earthquakes the Works of God and Tokens of His just Displeasure. . . .* (Boston, 1727), 11; for Prince's historical and contemporary sources, see Hornberger, "Science of Prince," 30-31.

[38]Prince, *Earthquakes the Works of God*, preface.

[39]Andrews, 281-294; see also Hornberger, "Science of Prince," 31, and Perry Miller, *The New England Mind: From Colony to Province* (1939; repr., Harvard University Press: Cambridge, Ma., 1954), 445-46.

> was from *his* [Christ's ] hand, what ever might be the *natural Causes* of it; all of which are also in the hand of CHRIST . . . . This becomes us as *Sinners* that would be awakened, and as *Believers* that desire to be to be humbled . . . it behoves us to act the part of *such* rather than of *Philosophers*. They search darkly and uncertainly (however curiously and laudably) into the bowels of the earth and the secrets of nature; but we have the plain *Gospel* of *CHRIST* to look into, and *see as in a glass the glory of the LORD.*[40]

Ironically, despite Colman's stated reluctance to assume the mantle of a natural philosopher, his sermon, which suggested a wave-like motion of the earth traveling upward and outward from one central upheaval of the earth, was scientifically more accurate than that of Prince.[41]

Nevertheless, Prince's sermons with their stated emphasis on scientific speculation appear to have resonated with certain literate New Englanders; two months later, on 25 January 1728 the *News-Letter* announced, "This Day *Published*" a second edition of "Mr. Prince's Fast & Thanksgiving SERMONS *on the late* Earthquake."[42] This advertisement does not include the title of the sermons, but it does repeat in full Prince's claim to account for the natural causes of the earthquake—an indication, perhaps, that Prince and his publisher were emphasizing the minister's role as the interpreter of natural causes. It is instructive here to consider both the earthquake and Prince's claim in the light of Schaffer's thesis that for eighteenth-century natural philosophers, "the complex of atmospheric phenomena acted as a wider and grander theatre of power . . . in which a new economy of understanding and control might operate." Earthquakes, Schaffer contends, were one of the most popular phenomena Newton's disciples claimed in order to "connect" their "active

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[40]Benjamin Colman, *The Judgments of Providence in the hand of CHRIST . . . In four Sermons*, (Boston, 1727), 29.

[41]Andrews, 285-86. A letter by Colman which located the quake's center at Newbury 20 miles north of Boston and described the physical nature of the quake, but was devoid of scientific speculation and theological improvements, was published by the Royal Society in *Philosophical Transactions*, 36 (May-June-1729), 63-73; Ibid., 286-87.

[42]Prince was one of only four authors whose sermons went into second editions; the others were James Allin (1727), Joseph Sewall (1728), and Cotton Mather (1727, 2d and 3d eds); Andrews, 294. Prince also had a 3d edition in 1755; see below.

principle" with a primary divine principle.[43] Viewed in this context, Prince's awareness of the persuasive power of science and of the press—reinforced by Greenwood's course in mechanical philosophy and appealed to in the advertisement to his sermons—takes on added meaning. Is it not possible that by explicitly claiming for himself the role of mediator of the active powers of the physical world, Prince assumed a new degree of authority which exceeded his merely ministerial influence? His unequivocal claim to interpret the earthquake in terms of natural causes enabled him to establish his *bona fides* within the scientific community and also to enhance his reputation with the scientifically-uninitiated laity. At the same time, Prince's insistence on "God . . . as having the highest and principal Agency in this stupendous Work" allowed him to exploit the "higher" explanatory power of religion and thus not jeopardize his position as an "orthodox Divine."

From 1727 to 1745, Prince's activities turned from the direct pursuit of science to writing the history of New England, editing the *New England Weekly Journal*, and defending the moderate position in the controversy surrounding the Great Awakening.[44] Prince's direct contact with the Boston scientific community also must have waned early on in this period, for the two practitioners of science closest to him passed from the scene. His spiritual mentor Cotton Mather died in 1728, and his science mentor Isaac Greenwood ran into difficulty at Harvard. Despite a reprieve won for him by Prince, Greenwood was dismissed for intemperance from Harvard in 1737; failing to support himself as a public lecturer and schoolmaster, he left New England shortly thereafter.[45]

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[43]Schaffer, "Natural Philosophy and Public Spectacle," 16.

[44]Prince published his history in 1736 with a supplement in 1755; for his involvement in the Great Awakening, see *SHG*, 5:355-58.

[45]Although the Corporation had previously voted to relieve Greenwood, Prince was twice successful in obtaining the opportunity for Greenwood "to shew Reason" to the Board of Overseers that the Board should not concur; 2 and 8 Dec. 1737, "Diary of the Rev. Thomas Prince 1737," CSM *Pubs*. 19 (1916-17): 363-64. For Greenwood's career as a public lecturer, see Chap. IV below.

Greenwood's lasting influence on Prince is evident, nonetheless, in several sermons Prince published during this period. Direct references to God's governance of the Newtonian universe occur in the lecture Prince delivered to welcome Governor Burnet to Boston in 1728.[46] Brief as they are, these references may have generated Burnet's association with Prince as a contributor to the *Weekly Journal* in 1729. Burnet initiated a series on "the growing Improvement in humane Knowledge," by discussing the "*Philosophical view*" of Newton within a physico-theological framework.[47] It is two sermons from the 1740s, however, that showcase both Prince's direct debt to Greenwood and his role as the mediator of natural powers. The first is a sermon Prince preached upon the capture of Louisbourg in 1745, entitled *Extraordinary Events the Doings of God. . . .*[48] Here, for the first time, the minister offers a scientific explanation of the "known" Laws of Nature that accord with God's "usual" manner of operation of the material world. In an argument, neatly falling within the framework provided by Lecture II of Greenwood's course, Prince addresses the "Being, Nature or essential Properties" of "meerly corporeal . . . substances" and their action according God's "operation" of three "prime and general Laws of Nature": that is, the "Powers of Attraction or Gravity," of "Repulsion," and "Cohesion."

But Prince also argues that in order to accomplish the moral government of man as well as the natural government of the physical world, God works in "diverse other manners" (outside the realm of known natural laws) on certain other phenomena. These he identifies as "Planets, Comets,

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[46]Hornberger, "Science of Thomas Prince," 31-32. For Hornberger's analysis of Prince's mediation between science and religion in the sermons discussed below, see 33-38.

[47]*NEWJ*, May 26, 1729; contrary to most Newtonian adherents, Burnet saw Newton's achievement as a significant advance in the "inexhaustible" pursuit of knowledge rather than the pinnacle of natural philosophy; cf. Nathaniel Ames, Chap. II above. For Burnet as author of this series, see Clark, *Public Prints*, 155, note 46. For Burnet as a Fellow of the Royal Society, see Stearns, "Colonial FRS," 224.

[48]Thomas Prince, *Extraordinary Events the Doings of God . . . Occasion'd by Taking the City of Louisbourg* (Boston, 1745).

Rays of Light . . . also . . . Cases of Electricity, Magnetism, Cold, Heat, &c." Here is a list strikingly similar to Newton's list of "active powers"—but one that also demonstrates what Schaffer has pointed out as the "appropriation" of electricity by mid-eighteenth century natural philosophers as another element in their "repertoire of wonders."[49] Even though inquiry into the operations of nature reveals the agency of God, Prince warns, "Such is the natural Atheism, Blindness, and Prejudice in us, as we are averse to see it and prone to ascribe them to Nature only." Thus Prince's ministerial, that is to say, cautionary, role as an explicator of extraordinary events—whether in the physical or moral world—is critical or as he would say, "needful." *Extraordinary Events the Doings of God* became Prince's most popular work: six editions were published in London in 1746, one in Edinburgh in 1746, and another in Boston in 1747.

In 1749 Prince published the results of his own scientific inquiry, using as his vehicle a sermon preached on a day of public thanksgiving for the relief of a severe drought. Dedicated to the Royal Society, *The Natural and Moral Agency of God in Droughts and Rains* comprises an extended discussion of natural causes. In its preparation, Prince wrote, he "perused, examined and compared" the writings of Newton, Halley, Boyle, Nieuwentyt, Leeuwenhoek, Whiston, Gregory, John Harris, Benjamin Martin, Bradley, and Desaguliers.[50] But early on Prince advises his readers that his purpose is not to deliver "a Lecture of meer Philosophy." "No!" he warns,

> I am going to treat on a noble Subject of Divinity; viz. on the wise, mighty and constant Operations of GOD—to rescue some of you from that Branch of Atheism

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[49]Schaffer, "Natural Philosophy and Public Sectacle," 6; for Schaffer's discussion of the spread of "enthusiasm" generated by the connection of electricity to other natural powers, see 6-10. This reference predates by four years a similar one made by Prince in *The . . . Agency of God in Causing Droughts and Rains* (Boston, 1749) which Hornberger points to as "one of the earliest references in New England literature to the new knowledge or speculation about electricity," Hornberger, "Science of Prince," 35.

[50]Prince, *Droughts and Rains*, 7, 8. For the availablilty of texts by these authors, see Chap. I above.

> we are exceeding inclined to by [human] Nature, in limiting our Views to the meer Operation of created Instruments.

Within two years, Prince's treatise asserting ministerial authority (versus natural philosophy's deficiency) was republished once in Boston and three times in London. Not only did it offer the new science in "digest" form to lay readers, its popularity also bolstered Prince's "needful" role as the interpreter of "created Instruments" and won him acclaim as "the true Christian or religious philosopher."[51]

It may have been Prince's authority as a published mediator of science and religion that persuaded the Boston publishers Daniel and Zachariah Fowle to choose his 1727 earthquake sermons for reissuing after another, even more severe, earthquake struck New England on November 18, 1755. The initial shock occurred about four-twenty in the morning; the "rocking and cracking" of houses (fig. 3.1) shattered over 1200 brick chimneys and tore down the brick ends of buildings leaving Boston's streets covered with rubble, but none of the city's residents (numbering over fifteen thousand) suffered bodily harm, according to an extensive eye-witness account in the *Boston Gazette*, 24 November.[52] The publisher followed this entirely-descriptive report with an article pointing out the moral implications of "the extraordinary Convulsions" ordained by a wrothful yet merciful God. Although he acknowledged "various natural causes" might explain the earthquake, he pleaded for "those whose particular Province it is" to delineate the moral cause of this "Visitation" by enumerating "the particular Vices that abound among us."

As in the case of the 1727 earthquake, Boston's ministers, exercising their "particular"

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[51]Ibid., handwritten inscription on secondary title page.

[52] *BNL*, 12 Nov. 1755, carried a much abbreviated version of this account. Boston's population in 1760 was 15,631, Lester J. Capp, ed, *The Atlas of Early American History, The Revolutionary Era, 1760-1790* (Princeton: Princeton University Press, 1976);

province, hastened to comply by searching out both primary and secondary causes.[53] In an apparent effort to pre-empt the print media, the Fowles re-issued two separate volumes of Prince's previously-published sermons. The first, advertised and published on 24 November only five days after the quake, in fact, achieved their goal.[54] The advertisement in the *News-Letter* also announced this volume would be followed by Prince's soon-to-be published inquiry into "the natural, instrumental, or secondary Causes" of the earthquake. The first volume the Fowles issued was simply a reprint of the second sermon Prince published in 1727; now entitled *An Improvement of the Doctrine of Earthquakes*, it also contained a "Letter" from an anonymous "Gentleman" describing the 1755 quake and a notice regarding Prince's forthcoming inquiry into natural causes. While the Fowles prepared the press for the second volume (which would consist mainly of Prince's first 1727 sermon), the minister hastily prepared its promised appendix, dated 5 December 1755. This reprint, bearing a title similar to the original, again promises both a providential and a "natural" interpretation of "EARTHQUAKES the Works of GOD, and Token of his just Displeasure: . . . Wherein. . . . is offer'd a Brief Account of the *natural, instrumental, or secondary Causes* of these Operations in the Hands of GOD. . . ."

As in 1727 Prince specifically—and publicly through the medium of the newspaper advertisement—appropriated the power implicit in extraordinary natural phenomena in an effort to emerge as the moral as well as scientific authority on the earthquake. Perhaps the aging minister intended to reassert his pre-eminence as the spokesman for the natural world. Or perhaps he simply

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[53]For a bibliography and printing history of all the published works relating to the 1755 earthquake, including 13 sermons by 11 ministers (in addition to Prince), see Charles Clark, "The Literature of the New England Earthquake of 1755," *Papers of the Bibliographical Society of America* (June-Sept. 1965): 295-305.

[54]*BNL*, 24 Nov. 1727. Eleanor Tilton mistakenly records the *BG*'s date of publication, and thus Prince's publication, as Nov. 25, a day later than the actual date; Eleanor M. Tilton, "Lightning-Rods and the Earthquake of 1755," *New England Quarterly* 13 (Mar. 1940): 85.

intended to pre-empt the publication of John Winthrop's lecture on the earthquake delivered 16 January at the Wednesday afternoon public lectures in natural philosophy at Harvard, only two days after the publication of Prince's first reprint. Given his interest in science and his status as an overseer of the college, Prince probably attended the lecture of Greenwood's successor as the Hollis professor of natural philosophy. In his lecture Winthrop, establishing a divide between religion and science, had initially declined to speculate on the moral implications of the earthquake because "his province" limited him to consideration of the subject only in relation to natural philosophy "in the physical sense."[55] He had attributed the earthquake to an explosion of gradually built-up and "fermented" underground vapors or gases and described the "undulatory" motion it produced.[56] Prince's appendix to his second reprint may have been intended to showcase the modernity of his own scientific thinking, in contrast to what the venerable minister apparently regarded as the Hollis professor's reliance on the time-worn theory of subterranean explosions.

The title of Prince's appendix, "Concerning the Operation of GOD in *Earthquakes* by Means of the *Electrical Substance*," with its prominent mention of electricity indicates the thrust of his new inquiry. Prince based his original hypothesis, as he acknowledges, on an argument "from Analogy" concerning the century's newest scientific discovery. Given "the sagacious" Mr. Franklin's discovery "of the *Electrical Substance*, as one great and *main Instrument* of *Lightning* and

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[55]John Winthrop, A *Lecture on Earthquakes;* . . . (Boston, 1755), 26-27, 29; repr. in *The Scientific Work of John Winthrop*, Michael N. Shute, ed. (New York: Arno Press, 1980). Despite his initial claim, Winthrop concluded the earthquakes serve a moral as well as natural purpose both of which were "productive of an over-balance of *good*," Ibid., 27-31, quote, 31.

[56]Winthrop, *Lecture on Earthquakes*, 23-24. For Winthrop's original contribution to seismic wave theory, see Frederick E. Brasch, "Newton's First Critical Disciple in the American Colonies - John Winthrop," in *Sir Isaac Newton 1727-1927, A Bicentenary Evaluation of his Work*, (Baltimore: The Williams and Wilkins Company, 1928), 322. For competing claims regarding the first observation of wave-like motion, see Andrews (Barnard and Colman, 1727), "1727 Earthquake Literature," 285-86, and Shute (Prince, 1727), "John Winthrop: Professional Science, Imagination and Early American Culture" in *Work of Winthrop*, [7].

*Thunder*" which also excites "*sulphurious, nitrous, mineral, watery,* and *airy* Substances . . . into Action," Prince reasons its action must extend to "material Substances in this lower World." Just as an unequal distribution of this electrical substance in the clouds causes concussions in the air, an unequal distribution in the world below causes a shock in the bowels of the earth; both phenomena, the minister-cum-philosopher insists, reveal the action of God. After a labored explanation of the action of "Electrical Atoms" in producing lightning in two clouds of unequal size, Prince reiterates his contention that the operations of the electrical substance "must be moved, guided and proportioned by a BEING who knows them." Speculating on the force of the earthquake in Boston, Prince concludes the city's newly-installed "Points of Iron" (lightning rods) probably were instrumental in drawing the electrical substance out of the air and into the earth. He ends with an anguished lament, "O! there is no getting out of the mighty Hand of GOD! If we think to avoid it in the *Air*, we cannot in the *Earth*."[57]

Unhappily, the Fowle brothers' haste and Prince's obliging response had unforeseen consequences: John Winthrop, alerted by "several worthy persons that I should take some notice of it," took exception to Prince's entire argument.[58] Thus acting upon an implied *professional* obligation to respond, Winthrop issued a public rebuttal by publishing the lecture he had previously delivered at Harvard with a seven-page "Appendix" addressing earthquakes, electricity, and iron points. Winthrop's intended target was unmistakable; the ads for his pamphlet informed the readers of the *Weekly News-Letter* and the *Gazette* that the "*Hollisian* Professor's" Lecture was printed "with an APPENDIX concerning the Operation of the Electrical Substance in EARTHQUAKES; and the Effects of Iron Points." The advertisement ran under the head "THIS DAY Published" in both the 9 January *Weekly News-Letter* and the 12 January *Gazette*. Perhaps anticipating a profit in the

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57Prince, "Appendix" to *Earthquakes the Works of God* (1755), 20-23.

58John Winthrop, "Appendix" to *A Lecture on Earthquakes*, 32.

controversy, the printer of the *News-Letter* ran another ad for Winthrop's pamphlet in the "Post-script" to the 9 January issue over an ad for Prince's second publication which, of course, featured the minister's appendix concerning earthquakes and the "ELECTRICAL SUBSTANCE."

Winthrop launched a forceful, yet respectful attack, referring to his target merely as the "learned gentleman." After decrying the "reigning mode . . . to explain everything by ELECTRICITY," Winthrop punctured the core of Prince's argument, pointing out there is no parallel between lightning and earthquakes.[59] Briefly explaining the *known* laws of electricity, Winthrop next demonstrates the "electric substance" is essentially different when in the clouds of the air or the bowels of the earth. He dismisses Prince's insistence on "Divine Direction" of the operations of nature as an appeal to the "miraculous" which, if exercised "would put an intire end at once for all reasons about electricity or earthquakes, or any other natural phenomena." Winthrop's ire at Prince's misrepresentation of scientific knowledge erupted in his six-point refutation of Prince's "exceptional" postscript. Here he corrects the minister's faulty scientific knowledge: lightning rods by drawing electricity from clouds—not the air—do not "overcharge" the earth, but restore the balance between the two. He exposes Prince's inaccurate conclusions: the earthquake did more damage in Boston than elsewhere because of the city's preponderance of brick, rather than frame, houses. And he sarcastically derides the minister's final "pathetic exclamation": there is not one person, Winthrop insists, who is so ignorant to believe "a few yards of wire" will spare "the mighty hand of God."[60]

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[59]I. Bernard Cohen has pointed out the enthusiasm and "scientifically acceptability" among other natural philosophers of the 1750s to identify electricity as the agent of both lighting and earthquakes, but convincingly argues (along the lines outlined by Winthrop) that Franklin did not intend, nor did his theory support this contention. See, Cohen, "Prejudice against the Introduction of Lightning Rods," *Journal of the Franklin Institute* (May, 1952): 426-29. See also, Dennis R. Dean, "Benjamin Franklin and Earthquakes," *Annals of Science*, 46 (1989): 489.

[60]Winthrop, "Appendix" to *Lecture on Earthquakes*, 32-38, *passim.*

And so the debate, very publicly conducted in letters to the *Boston Gazette*, continued.[61] Prince responded in a missive published 26 January, strategically printed directly above an advertisement for Winthrop's *Lecture* and "Appendix." Prince charged the professor had "mistaken" him in several specific places and in the "main design" of his appendix: he had "only supposed" from Franklin's discovery of electricity that it was "likely" to cause earthquakes. But most significantly, Prince took cover behind the pulpit: the duties of his ministerial office necessitated that he (unlike Winthrop in his "academical Office") must consider the earthquake in more than a "meerly. . . Philosophical View. . . as the powers and operations of material substances." Electricity is, after all, but a secondary cause "acted upon. . .by [the] almighty Being we call by the Name of GOD." Prince would rather be "mistaken in a Point of Philosophy" than divert his readers "from their just Concern and Labour to Secure their eternal Interest."[62]

Two days later Winthrop took his pen in hand for another point-by-point refutation addressed to the editors of the *Gazette*. Published by the *Gazette's* printer as a separate, seven-page pamphlet entitled, *A Letter. . .Containing an Answer to the Rev. Mr. Prince's Letter. . .*, it was advertised by the *News-Letter* on 5 February and by the *Gazette* on 9 February. Winthrop continued to fault Prince's competency, accusing him of a "too slender acquaintance with the laws of electricity." While professing "a profound veneration for the united characters of a Philosopher and a Divine," he attacked Prince's exclusive bid to appropriate "first causes." Thus Winthrop, the natural philosopher, upbraided Prince, "this Rev. divine," for misrepresenting both the "nature" of his, that is, Winthrop's, academic office and his "conduct" of it. In language reminiscent of that used by

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[61]For the theological background and implications of the debate, see Charles Edwin Clark, "Science Reason, and an Angry God: The Literature of an Earthquake," *New England Quarterly* 38 (1965): 347-54. For a discussion the chronology and nuances of the debate which focuses on the personalities of the antagonists, see Tilton, "Lightning Rods," 85-97.

[62]Prince, "Letter to the *Boston Gazette*," Jan. 26, 1756.

Newton himself in staking out the claim of natural philosophers "to treat of God from phenomena is certainly a part of natural philosophy,"[63] Winthrop insisted,

> The consideration of a DEITY is not peculiar to Divinity, but belongs also to natural Philosophy...[whose] main business... is, to trace the chain of natural causes ...till we come to the FIRST CAUSE; who, in Philosophy, is considered as presiding over, and continually actuating, this whole chain and every link of it; and accordingly I have ever been careful to give my discourses this turn.[64]

Prince responded with a letter published in the *Gazette* on 23 February, to which Winthrop responded in the *Gazette* on 1 March. The additional rejoinders had become increasing personal while adding no new scientific clarification, but the polemics ended in seeming unanimity, with both men professing to seek truth not victory.[65]

In one regard, the debate between Prince and Winthrop represents little more than a tremor in what Clark has seen in the 1755 earthquake literature as "a science struggling to be born; a vigorous, aggressive Protestantism on its way to becoming humanized and rationalized."[66] On the other hand, this debate between minister and scientist reverberates with the force of an aftershock. For it exposed a rift in the authority hitherto shared between divinity and philosophy which had grown from that small kernel of active powers Newton had identified and claimed for natural philosophers. The argument between Prince and Winthrop was less about causes of the earthquake (whether moral or natural, principal or secondary) than about the qualifications required for the interpreters of active principles. Prince and Winthop both saw God as the ultimate cause and read a moral purpose in his action, but their reactions were shaped by different world views: Prince's by

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[63]See above, Chap. I, 41.

[64]Winthrop, "A Letter to the Publishers of the *Boston Gazette,*" [Boston, 1756].

[65]Prince, "Letter to the *Boston Gazette,*" 23 Feb. 1756; Winthrop, "Letter to the *Boston Gazette,*" 1 Mar. 1756.

[66]Clark, "Science, Reason and God," 362.

the providentialism of his Puritan heritage, and Winthrop's by the optimism of Newtonian metaphysics. Prince conflated the natural and the moral world; thus upheaval in the natural world was symptomatic of a corresponding upheaval within his people. Fear, then, was the proper response because it would lead to reformation of human character.

Winthrop admitted both a moral and a natural purpose, and "a most perfect coincidence," at all times, between God's government of the *natural* and of the *moral* world. Because the two worlds were not one, he could separate physical "evil" from moral intent. Therefore, Winthrop saw beyond the immediate disruptive effects of the earthquake, to suggest various beneficial ends (e.g. increased fertility of the earth due to the opening of the "pores" of the soil). Winthrop concludes his lecture, whatever is "under the direction of infinite wisdom, power and beneficence, is, in some or other of its consequences, productive of an over-balance of *good.*" The proper response, then, is awe, as the observer recognizes "how wonderful in counsel. . . . how excellent in working is that BEING, who can bring good out of the greatest evils." Thus Winthrop's theology was shaped by Newtonian optimism grounded in the "inevitable" and rational laws of nature.[67]

A letter published in the 23 February *Gazette* dealing with the controversy, and printed directly below Prince's letter, makes clear that their contemporaries saw the issue behind Prince's and Winthrop's argument. The anonymous writer cites a passage from a recently published earthquake sermon, advertised in the same issue, in which "the Rev. Mr. F[oxcroft]" suggests the investigation of the natural causes of earthquakes are the "Province" of [natural] Philosophy, whereas the "Controversies on this Head may well enough be left to the *Disputers of this World.*"[68]

[67]Winthrop, *Lecture on Earthquakes*, 29-31, *passim.*

[68]Thomas Foxcroft, *The Earthquake, a Divine Visitation, A Sermon Preached . . . January 8, 1756. Being a Day of Publick Humiliation and Prayer* . . . .(Boston, 1756). Clark mistakenly dates publication as 8 April 1756 based on a *Gazette* ad for that day, "The Literature of the New England Earthquake of 1755," 300.

As a New Light proponent of the Great Awakening, Foxcroft was one of Prince's staunchest allies in religious polity. Yet taking Foxcroft's remarks as a direct attack upon "the Rev. Mr. P[rince]," the anonymous writer castigates Foxcroft for his "low opinion" of his "Rev. brother Prince's" hypothesis about the "Electrical Substance in the Bowels of the Earth" and of Prince himself as "one of the Disputers of this World."[69]

Prince could speak authoritatively about the 1727 earthquake simply by claiming the mantle of natural philosophy. But by 1755, as evinced in the newspaper debate between Prince and Winthrop, that claim had to be substantiated by the practice of science (or, at the very least, by the demonstration of a correctly informed and competently expressed view of science); the publication of a few earnest treatises were mere pretension to natural philosophy. No one knew that better than Winthrop, veteran Hollis professor, lecturer on experimental philosophy (including electricity), observer of astronomical phenomena, correspondent of Benjamin Franklin and Fellows of the Royal Society, and contributor to the *Philosophical Transactions.*[70] As the foremost member of New England's mid-century scientific community, Winthrop enforced a truth only grudgingly acknowledged by Prince. By the mid-eighteenth century, it was no longer possible to unite the characters of a philosopher and a "meer" divine; henceforth, as heirs to the rational Newtonian universe, natural philosophers rather than divines would be the proper spokesmen of the natural world.

Winthrop did not hesitate to exercise his new role as the explicator of the natural world illumined by Newtonian natural philosophy. From his Cambridge study, the Harvard professor

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[69]For private reaction of contemporaries who perceived that Winthrop "has laid Mr. Prince flat on [his] back," due to his "Error in Philosophy," see Jared Eliot to Ezra Stiles, 24 Mar. 1756, in *Extracts from the Itineraries and other Miscellanies of Ezra Stiles, D.D., LL., 1755-1784, with a Selection from his Correspondence*, ed. Franklin B. Dexter (New Haven: Yale University Press, 1916), 480.

[70]For Winthrop's contribution to American science, see Stearns, *Science in Colonies*, 642-70; Winthrop was elected F.R.S. in 1765.

issued thoughtful, scientifically cogent, yet popular expositions of natural phenomena as they occurred throughout the next two decades. Thus after the report of a death caused by a lightning strike during a thunderstorm in July, 1757, Winthrop submitted a letter to the 29 July *Boston Gazette* explaining the similarity of lightning to electricity, how it is conducted, and the importance of not taking shelter under trees.[71] He extensively reviewed this topic in 1768, stimulated by a "prodigious explosion" of lightning that severely damaged Hollis Hall, which had not been outfitted with lightning rods, unlike Harvard Hall and the Cambridge meeting house which had escaped damage. The professor urged the installation of Franklin's "iron Points . . . a happy discovery that will overcome ignorance and superstition" as well as misplaced religious objection.[72] In 1770 Winthrop revisited the same topic recapitulating "the method of preserving our persons and properties" discovered by "our industrious countryman, Dr. FRANKLIN" and addressing in detail the religious scruples of those who objected to employing this "admirable invention." Winthop's communique reveals the persistence of a providential world view apparent, for instance, in the poetic eulogy, headed by a graphic illustration, occasioned by the death of six young men killed by lightning (fig. 3.2). It also reveals his efforts to mediate between it and the rational world view that should follow from the acceptance of "stated," that is, Newtonian, laws of nature. "Many persons," Professor Winthrop acknowledged,

> have considered Thunder and Lightning as tokens of the divine displeasure . . . and in consequence look upon it as a degree of impiety to endeavor to prevent them from doing their full execution.—But these scruples, I humbly conceive, are founded on misapprehensions of the method in which Divine Providence has thought fit to govern the material world; which is, not by immediate, extraordinary interpositions of power, but by stated, general laws . . . . If a stream of lightning fall on a building furnished with pointed iron rods. . . it is as much the Will of GOD

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[71]Reprinted in *NHG*, 8 July 1757.

[72]*BNL*, 9 Sept. 1770; according to Winthrop, Harvard Hall was also struck, but the lightning rods installed there earlier had prevented significant damage, whereas Hollis Hall had sustained extensive damage to both its interior and exterior.

> that it should follow the course of the iron without injuring the rest of building as, when it falls on a common wooden building, it should scar and split the boards, or set them on fire.

In April and May of 1759, Winthrop again wrote several times to the Boston newspapers, on these occasions to comment on "the general topic of conversation among us," the return of Halley's comet, which was first sighted 3 April 1759 and was long-awaited as confirmation of Newton's theory of the predictability of comets and their orbits.[73] Winthrop's letters, either quoted or reprinted by Boston newspapers as well as other provincial newspapers, informed readers of the comet's position, course, and motion—in language devoid of scientific jargon and religious moralizing.[74] Although Winthrop elsewhere assigned a teleological or moral purpose to comets,[75] similar to that of earthquakes and lightning, his careful avoidance here may indicate his desire to set the parameters of popular debate, that is, to clearly separate the moral and the natural worlds. With the appearance of exceptionally brilliant comets in 1769 and1770, Winthrop again used the public prints to instruct his general audience as to the natural laws governing their appearance.

In a letter dated 27 September 1769, Winthrop refers to calculations he had made to determine the earlier comet's revolution around the sun and to observations and measurements made with the aid of a "large" reflecting telescope and a micrometer. By employing and mentioning specific scientific apparatus (beyond the means of the general public and more specialized than that

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[73] *BG*, 9 Apr., 7 May 1759; *BNL*, 3 May 1759. For an analysis of Winthrop's cometary theory and his role in the "secularization" of astronomy through the newspaper coverage, see Sara Schechner Genuth, "From Heaven's Alarm to Public Appeal, Comets and the Rise of Astronomy at Harvard," in *Science at Harvard University: Historical Perspectives*, ed. Clark A. Elliott and Margaret W. Rossiter (Bethlehem, Pa., Lehigh University Press, 1992), 35-38.

[74] *BNL*, 12 Apr. 1759; *NHG*, 11 May 1759.

[75] That Winthrop believed comets have a salutary moral purpose, i.e., to remind and elicit awe from his creatures of God's beneficence, is clear from the lectures he delivered and published on the 1759 comet, *Two Lectures on Comets* (Boston: Green and Russell, 1759); also see Genuth, "From Heaven's Alarm," 37-38.

owned by "gentlemen" astronomers), Winthrop both asserts the exclusivity of his role as the arbiter of natural events and reassures his readers as to the credibility of his claims.[76] From September through November, and again the following June and July when the second comet appeared, the newspapers were instrumental in reporting sightings and disseminating information of varying degrees of scientific credibility. Natural philosophers from Kings College in New York and Yale College in Connecticut joined Winthrop in submitting learned observations, based on the cometary theory of Newton and Halley and clearly intended for the education of the general populace.[77]

Other writers used natural philosophy as an entrée to traditional beliefs concerning the inhabitability of comets or as a disguise for providential warnings.[78] As in 1759, poetry as well as news articles on the cometary theory of Newton, hailed him as "the sagacious sage," who heralded "the long-expected star."[79] The tendency of some writers to endow the comet with divine attributes

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[76] *BG*, 2 Oct. 1769; *BEP*, 2 Oct. 1769; and *Massachusetts Gazette and Post Boy*, 2 Oct. 1769; this letter is unsigned but dated from "Cambridge," as was Winthrop's usual practice (See Genuth, "Heaven's Alarm," 52, n. 78); *BNL*, 9 Aug. 1770.

[77] Letter to *New York Gazette* 9 Nov., 1769, signed "R. H[arper], King's College," reprinted in *NHG*, 29 Sept. 1769; articles "from the Hartford paper," signed "N. S.," reprinted in *BNL*, 16 Nov. 1769 and 17 July 1770 (probably Nehemiah Strong, professor of natural philosophy at Yale College).

[78] Reprints of lengthy articles from the *New York Gazette* by one "S. Sp. Skinner near King's College" appeared in the *BEP*, 9 Sept. 1769 and the *NHG*, 29 Sept. 1769; purporting to be "A Philosophical Description of Comets," they mixed quasi-scientific theory and traditional lore. The *Massachusetts Gazette and Post Boy* of 9 Oct. 1769 reprinted from the *Pennsylvania Journal* (reprinted in turn from the Minutes of the American Philosophical Society) an article "of a purely speculative nature" by Dr. Williamson (professor of natural history at Pennsylvania College) which sought to establish the habitability of comets by disproving they carried excessive heat in their tails.

[79] Poem "wrote by a Person . . . when he first observed the COMET," *BNL*, 3 May 1759 and *NHG*, 11 May 1759. For a view of the Newton's inclusion of traditional lore in his cometary theory, see Sara Schechner Genuth, "Newton and the Ongoing Teleological Role of Comets" in *Standing on the Shoulders of Giants, A Longer View of Newton and Halley*, ed. Norman J. W. Thrower (Berkeley: University of California Press, 1990), 299-311. Newton built on traditional lore's implicit moral message to establish that God intended to use comets only as a beneficial and "natural means to conserve, renovate, and, reform the cosmos," Ibid., 305.

as well as portentous meaning (and the willingness of newspaper editors to include their articles) reveals a lingering belief in traditional lore and an interventionist God among newspaper readers. Significantly, Winthrop did not respond to any articles claiming theological interpretation of the comet, but he did not hesitate to censure the faulty science of those writers who passed themselves off as natural philosophers while wrapping their warnings of "alarming Consequences" in a simplistic veneer of natural philosophy. He wrote to the public prints in September 1769 in reference to a certain "Gentleman from Elizabethtown, New Jersey" who had predicted in an letter to the papers that within thirty days the comet would pass so closely to the Earth that its tail would ignite the planet.[80] Winthrop reassured readers the "absurd and ridiculous article" should not alarm anyone because the writer "appears quite unacquainted with Astronomy" having made "contemptible and idle" calculations without any basis in fact. An anonymous letter writer to the *Evening Post* echoed Winthrop, using even stronger language: "Dabblers in Astronomy" and "Pretenders to Astrology" who sought to frighten people into preparing for death were neither acting out of love nor exercising their "rational sense of Duty."[81]

Both Winthrop and his anonymous ally reinforced the shift in scientific authority that had occurred at mid-century: that is, correctly informed natural philosophers were the appropriate mediators of Newtonian powers and spokesmen for the natural world.[82] The newspaper contributions of Winthrop and his fellow natural philosopher are evidence that by mid-century, the composi-

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[80]For the New Jersey gentleman's letter, see *BEP*, 18 Sept. 1769; *BNL*, 21 Sept. 1769; for Winthrop's response, see *BG*, 2 Oct. 1769; *BEP*, 2 Oct. 1769; *Massachusetts Gazette and Boston Post-Boy*, 2 Oct. 1769.

[81]*BEP*, 26 Oct. 1769.

[82]Genuth also arrives at this conclusion, "Heaven's Alarm," 38; Genuth refers to Winthrop's role in the "lively discussion" centered on the 1769 comet, because she relies, however, on Winthrop's published lectures rather than the newspaper coverage—the intellectual change she describes does not reflect the tension apparent in the actual process.

tion of the original scientific community had changed. Winthrop (and Franklin) were the leading members of a sprawling network bound by the practice of natural philosophy and by correspondence, via personal letter as well as newpapers communiqués, rather than the closely knit Boston community bound by ministerial and Harvard College ties. By the eighth decade of the eighteenth century, the arena of natural philosophy had widened as more people participated in scientific discourse. As the variety of newspaper articles implies, claimants continued to urge competing viewpoints, attempting to appropriate Newtonian authority in service to traditional lore and providentialism as well as rational science.

The coverage of the 1769 comet shows how far the debate regarding natural phenomena had come since the first half of the century, and how actively the members of the new sciencetific community sought to set the terms of the debate. Now those who mis-appropriated active powers were "Dabblers" and "Pretenders," in other words, scientific hacks without even the pulpit to stand behind. This was the message *bona fide* practitioners of science, with their professional claim to the higher explanatory powers of Newton's modern system, promulgated in the public prints. Yet the formation of a Newtonian culture in New England, like the formation of culture in general, was not straight-forward, smoothly flowing in a uniform direction. Like the aftershock of an earthquake, Newtonian culture in New England developed in waves as it traveled out from a center of active powers, rocking, tumbling, and reshaping those in its path.

## CHAPTER IV

## FORMAL AND INFORMAL SCIENCE DEMONSTRATIONS: PERFORMING NEWTONIAN PHILOSOPHY

Small knots of people gathered on Beacon Hill outside the Georgian mansion house of the Boston merchant Henry Bromfield and his family. Their attention focused not on the imposing entrance where provincial dignitaries and illustrious clergymen might emerge but on the blind affixed to the third floor window (fig. 4.1). Yes, they could just make out that strange hole everyone was talking about. The blind was shut; did that mean young Mr. Bromfield was planning one of his philosophic demonstrations?[1]

In 1745 the aspiring natural philosopher Edward Bromfield, the twenty-two year-old scion of the wealthy Bromfield family, a member of the Reverend Thomas Prince's Old South Church, and a former student of Harvard Professor John Winthrop, entertained both lay friends and clergymen by demonstrating the powers of his solar microscope as it drew light through the hole cut into the third floor blind.[2] Clad in a turban and banyan, the at-home dress favored by gentlemen of leisure, Bromfield (fig. 1.3) welcomed guests to the darkened room adorned with a print of the "glorification" of Isaac Newton (fig. I.1) and furnished with optical and mechanical apparatus and scientific texts

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[1]The opening for Bromfield's microscope was preserved by successive owners until the house was demolished in 1845, when its existence became part of the family lore of the last occupants, Justin Winsor, ed., *Memorial History of Boston*, (Boston: James Osgoode and Company, 1881), 2:521, n. 1.

[2]Mounted in a window shutter with its mirror facing outward and its barrel inward, a solar microscope utilized sunlight to project a magnified image onto a screen set up in a darkened room. The mirror captured the sunlight and reflected it through the microscope's barrel, which contained condensing lenses, a slide, and an objective lens, David P. Wheatland, *The Apparatus of Science at Harvard 1765-1800* (Cambridge: Harvard University, 1968), 184-85.

that included Newton's *Opticks*.[3] After one such philosophic performance featuring the gentleman-scientist's microscope, a young woman guest penned her reaction to the "gay Scene" of the previous afternoon in a poem published in the *Boston Weekly News-Letter* following Bromfield's untimely death eighteen months later. Her verses made clear the "well-spent Hour" was an "Act of Praise" on Bromfield's part for the Creator of those "Things unseen" revealed through his "Glass" to which she joined her own words of tribute:

> A Thousand untho't Glories you display
> In every Mote, by your enchanting Ray.
> . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
> Silent, in Extacy, my Soul ador'd
> The Wonders of my God, your Art explor'd.[4]

A conjoining of politeness and piety distinguishes this event, the former evident in the genteel surroundings, company, and activity of the "gay Scene" and the latter in the lesson drawn from the revelations of the philosopher's solar microscope. Noted but largely unexplored by either social historians or historians of science,[5] this incident provides a homely insight into the development of a Newtonian culture in New England. It also reflects the profound intellectual and social changes that occurred in both England and its American colonies in the eighteenth century, in

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[3]Winsor, *Memorial History*, 1:510. For Bromfield's scientific achievements and a list of apparatus of his own making, see the biographical sketch by Thomas Prince, "Late Mr. Edward Bromfield jun's Microscope–Divcoveries," *AMHC* (Dec. 1746): 548-49; repr. in *New England Historical and Genealogical Register*, (Jan. 1872), 10-11; and repr. in part in *SHG*, 6:134-35. Bromfield's extant scientific papers, mainly concerned with optics, are in the Harvard University Medical School Library. For18th-century leisure dress, see Patricia A. Cunningham, "Eighteenth-Century Nightgowns: The Gentleman's Robe in Art and Fashion," *Dress* 10 (1984): 2-11; for banyons as the apparel of choice in portraits of men of science (including Bromfield), see Brandon Brame Fortune with Deborah J. Warner, *Franklin & His Friends, Portraying the Man of Science in Eighteenth-Century America* (Washington, D. C.: Smithsonian National Portrait Gallery, 1999), Chap. 4.

[4]*BNL*, 21 Aug. 1746; reprinted in *SHG*, 6:134.

[5]Frederic T. Lewis cites this incident but mentions only Thomas Prince's attendance, in "The Advent of Microscopes in America with Notes on Their Earlier History, *The Scientific Monthly* 57 (July 1943): 258.

repsonse to forces of modernity, commercialization, and politeness. New discoveries in the various branches of natural philosophy impelled by the discoveries of the new science of Isaac Newton added to this mix, producing new products, new lecture courses, new lecturers, and new audiences for science. In an age of nascent industrialization and polite display, science took center stage. Edward Bromfield's afternoon entertainment, incorporating the search for scientific knowledge, the pious expression of nature's wonders, and the expensive trappings of refined living, marks a modest point in the process of incorporating these changes in Anglo-American society. The domestic scene also reveals an issue that is overlooked in scholarly studies of science in pre-Revolutionary America—namely, that the lay public, including women, played a role, however eclipsed, in this social and intellectual transformation.

In Chapter One this study looked at booksellers' shops and social libraries as sites where the colonial elite— largely merchant-, clergy- and professional men—encountered Newtonian natural philosophy. It turned to a more general audience in Chapters Two and Three, including genteel and vernacular readers, by looking at almanacs and newspapers as the two principal means that popularized the new science among the scientifically unschooled populace. By explaining natural events in terms of the discoveries of Sir Isaac Newton and the world view of his disciples, almanacs and newspapers played a key role in the formation of an indigenous Newtonian culture. This was a culture promulgated by scientifically literate authors directly through almanacs and newspaper articles, or indirectly through sermons occasioned by extraordinary natural events, many of which were published and advertised through the public prints. At the same time, the playing out in the newspapers of the debate to establish the natural philosopher's role as the proper spokesperson for the natural world showed how scientific production itself became performance, aimed at a specific audience and manipulated according to the practitioner's own aims.

The incident involving Edward Bromfield, his anonymous female guest, and the inquisitive sidewalk audience suggests yet another set of sites and participants in the expanding sites of natural philosophy discourse. These sites comprise arenas where Newtonian science entered the realm of *performance*. This could be in informal, domestic settings, such as Bromfield's study. It could be in quasi-public lectures, such as Greenwood's lecture series advertised in the public prints but held in private dwellings and attended by paying subscribers. Or it could be in public entertainments advertised in the public prints, held in public locations, and attended by the merely curious. In public and private demonstrations, natural philsophers consciously produced a "theatre," analogous to what they termed the "theatre of nature," wherein they effected the control of natural processes in a display of natural and moral power.[6] As the language of their advertisements and catalogues reveals, words borrowed from the perfomance stage stocked the lexicon of early science lecturers: courses were "performed"; apparatus was "exhibited"; and the "audience" was "entertained." Science demonstrators used the drama inherent in live productions not only "for the entertainment of the Curious," as a 1747 Boston advertisement for electrical demonstrations promised, but for the advancement of their own agenda.[7] This could be educational, religious, or merely entrepreneurial and varied according to the demonstrators' own world view as well as their assessment of the audience's expectations. Subject matter, content, and even audience composition changed over the course of the century as various scientific topics—mechanical philosophy (physics), astronomy, electricity, and pneumatics—took their turn upon the lecture stage. Yet as distinct as these branches of natural philosophy were, pervading them all was a sense of scientific discovery fostered by the example of Newtonian natural philosophy and the incorporation of that world view into the popular imagination. Thus, this chapter turns to gaze at the various stages where natural philosophers and

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[6]Simon Schaffer, "Natural Philosophy and Public Spectacle in the Eighteenth Century," *History of Science* 21 (1983): 14-15.

[7]*BEP*, 24, 31 August, and 7 September, 1747; quoted in William Northrop Morse, "Lectures on Electricity in Colonial Times," *The New England Quarterly* 7 (1934): 364-65.

entrepreneurs alike demonstrated the stuff of the new science. Here, with the aid of newspaper and broadside advertisements as well as course catalogues, we will examine how the forces of piety, politeness, and power intereacted in the performance of science.

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Act I—Experimental Philosophy—"the Principles of Sir Isaac Newton"

Just as New Englanders had their share of imported Newtonian texts and social libraries where the new knowledge could be perused at leisure, so too they were enlightened and entertained by a succession of science demonstrators and entrepreneurs. In the American colonies, as in England, the staged display of natural philosophy began with the demonstration of mechanical philocophy. This occurred in Boston in 1727 with a series designed by Isaac Greenwood while he awaited appointment as the first professor of mathematics and natural philosophy at Harvard after his return from a post-graduate visit to England. While in London Greenwood had cultivated the acquaintance of the Harvard benefactor, Thomas Hollis, whom he prevailed upon to establish the professorship in natural philosophy, an action Hollis had been contemplating for some time.[8] But Greenwood's precipitous departure from England leaving a wake of bad debts caused Hollis to rethink his appointment of Greenwood to the post; Harvard officials, not wishing to offend their benefactor but having no other acceptable candidate, took a series of dilatory actions that stretched

[8]I. Bernard Cohen, *Some Tools of Early American Science . . . in Harvard University* (1950, reissue, New York: Russell & Russell, 1967), 31. Hollis had established a Professorship of Divinity at Harvard in 1721, selecting Edward Wigglesworth as its first incumbent. Hollis had envisioned both "his" professors as "centering in one design and end . . . to promote the great design of the glory of God . . . instructing youth in useful knowledge, both as men and as Christians," Hollis to Wigglesworth, 27 July 1727, "Documents from the Harvard University Archives, 1638-1750," CSM *Pubs.*, 50 (1975): 608 (hereafter "Documents from Harvard Archives"). Although the occupants of both professorships were referred to by their contemporaries as "Hollisian" or "Hollis" professors," I use these titles only in reference to Greenwood.

into the fall of 1727.[9]

In the meantime, Greenwood went about establishing his *bona fides* as a science demonstrator independent of both Hollis and Harvard by advertising a course of experimental philosophy in December 1726, just two months after his return. He based his course, which began in January of 1727, upon his first-hand knowledge of the courses designed by J. T Desaguliers, the pre-eminent London science demonstrator-entrepreneur. Desaguliers had taken Greenwood on first as a student and then as his assistent, and had introduced him to Newton as well as the leading science demontrators in London during the fifteen-month period in which the young Bstonian had lived in his household.[10] A protegé of Newton and a curator of experiments for the Royal Society, Desaguliers had designed his course incorporating machines "contriv'd to show experimentally what Sir Isaac Newton had shown mathematically."[11] Greenwood was one of eight young men whom Desaguliers had trained and who in addition to three or four other persons subsequently

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[9]The Harvard Corporation and the Harvard Overseers, acting upon Hollis's approval, had taken formal votes to elect Greenwood in May 1727, but the impending summer vacation meant he would not begin teaching until the fall term. The affair is best traced through Hollis's correspondence with Benjamin Colman, acting on behalf of the Harvard Corporation, "Documents from Harvard Archives"; records of Corporation meetings in *Harvard College Records, Part 2*, CSM *Pubs.*, 16 (1925), *passim*; and entries in "The Book of Benjamin Wadsworth," (President of the Corporation), in *Harvard College Records, Part 3*, CSM *Pubs.* 31 (1935): 461-65 *passim*. See also Cohen, *Tools of Science*, 31-35; cf. David C. Leonard, "Harvard's First Science Professor: A Sketch of Isaac Greenwood's Life and Work," *Harvard Library Bulletin* 29 (Apr. 1981): 144-47 and *SHG* 6:473-76.

[10]Desaguliers to Mather, 16 Sept. 1726, Mather Papers, MHS; Leonard, "Harvard's First Science Professor," 144.

[11]J. T. Desaguliers, *A Course of Experimental Philosophy*, vol. 1, (London, 1734), Preface. For analysis of the changing role of natural philosophy experimenters for the Royal Society and Desaguliers' place within it, as well as the offical designation of "curator," see Stephen Pumfrey, "Who did the work? Experimental philosophers and public demonstrators in Augustan England," *The British Journal for the History of Science* 28 (1995): 131-56. For a succint analysis of Desaguliers' popularization of "practical" Newtonism, see Betty Jo Dobbs and Margaret C. Jacob, *Newton and the Culture of Newtonianism* (Atlantic Highlands, N.J.: Humanites Press, 1995), 71-95, *passim*.

"performed" experimental courses in England and "other Parts of the World."[12]

After Greenwood's departure, Desaguliers wrote as a "Bro^th[er] Virtuoso" to Cotton Mather, then a member of the Harvard Corporation, to endorse the college's employment of his former assistant.[13] After praising Greenwood's "Genius for Mathematicks" and "Mechanical bent to make Experiments," Desguliers noted the college's foresight in thus promoting natural philosophy. His remarks illuminate the stature of scientific knowledge as a mark of polite education. "Natural phylosophy," he boasted, "is at present so much cultivated in all the Civilized parts of y^e world, that Every young Gentleman That Travels now cannot make any Figure w^th out some Tincture, of that most Absolute branch of Knowledge."

In advertising his own course to the public, Greenwood relied on the authority of Newton's name to appeal to "such Persons as are desirous . . . [to] make themselve better acquainted with *Principles of Nature*, and the wonderful Discoveries of the Incomparable Sir ISAAC NEWTON." [14] In London Desaguliers could boast he had seen Newtonian philosophy "*generally received among Persons of all Ranks and Profession, and even the* Ladies, *by the Help of Experiments*."[15] As his assistant, Greenwood presumably had witnessed this phenomenon, but the advertisments for his own course show he targeted a more exclusive audience. A reference to "Subscribers & such Gentlemen" makes clear the elite, male composition of the intended audience.[16] The charge per subscriber was "*Three Pounds; Twenty Shillings* at the Time of Subscription, and the *Remainder* on the Third Day of the *Course*" which effectively limited attendance to men of means as well as

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[12]J. T. Desaguliers, *Course of Experimental Philosophy*, Preface.

[13]Desaguliers to Mather, 16 Sept. 1726, Mather Papers.

[14]*BG*, 5 Dec. 1726.

[15]J. T. Desaguliers, *Course of Experimental Philosophy*, Preface.

[16]*BG*, 1 Jan. 1727.

genteel aspirations.[17] Greenwood, himself successfully tinctured with natural philosophy, appealed to the desires that marked those able to consume the newest fashion in ideas as well as goods. In the advertisement printed with the prospectus he echoed his mentor's sentiment with the suggestion to readers of "Genius or Leisure" that as New England had successfully followed the "Politer Nations of *Europe*, in other Things," so they should embrace the introduction of experimental philosophy provided through his course.[18] That the one known course subscriber was the Reverend Mr. Thomas Prince, a self-described Anglophile with intellectual pretentions, confirms the merit of Greenwood's marketing strategy.[19]

At the same time, Greenwood took pains to assure potential subscribers they needed no previous knowledge of philosophy or mathematics. Indeed, he promised to deliver a great deal of knowledge for relatively little effort: attendance at sixteen "evening's entertainment" illustrated with "above *Three Hundred* Curious, and Useful *Experiments*" performed "by means of various *Instruments* and *Machines*" would ensure a better acquaintance with the discoveries of Newtonian philosophy than "a *Year's* Application to *Books* and *Schemes*."[20] The course prospectus reveals the "various" instruments comprised just over a dozen different types of scientific implements: the seven "simple machines" Desaguliers had included in his course and that have become basic to all physics courses, unnamed "compound Machines," (made up of various combinations of simple machines),

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[17]Greenwood, *An Experimental Course of Mechanical Philosophy*, (Boston: 1726), [10]. (Secondary sources have consistently quoted the cost as £4, apparently the result of adding the total charge and the down payment.) For the £3cost of Greenwood's course, one could buy 40 printed sermons at 18 pence (1shilling, six pence) per sermon or just over 13 bushels of imported Indian corn at 4 shillings, 6 pence per bushel; ads, *NEWJ*, 17 July 1727; *BNL*, 8 Feb. 1728, respectively.

[18]Greenwood, *Experimental Course*, reverse of title page.

[19]For Prince as an Anglophile and a member of Greenwood's course, see Chap. III above.

[20]Greenwood, *Experimental Course*, [10]; *BG*, 5 and 19 Dec. 1726

and several other instruments to illustrate "some particular Cases" of planetary motion.[21] However well-grounded in theory, Greenwood's boast that he would exhibit several hundred different experiments) thus implied a certain legerdemain in which the symbiosis of experiments and theatrics enhanced the display of the active principles of nature.

Despite the theatrical circumstances attendant to its display, Greenwood's approach in employing the new science was empiricist. This method he described as "representing to the Eye the *Laws*, and *Principles* upon which NATURE proceeeds."[22] Indeed, Greenwood touted this approach over "all fanciful Suppositions & Hypotheses (however plausible they may seem)," because it took nothing for granted except "what is shewn to be really in Nature, *de facto*."[23] Hence, as outlined in the prospectus, Greenwood's course in "rational mechanics"[24] revealed only the "true" or "physical" causes of the various phenomena of nature. Greenwood was following the methodology developed by Desaguliers in that he "added" to the theoretical foundation of experimental philosophy what his mentor described as the "mechanicks" or "the Explanation of mechanical Organs, and the Reason of their Effects."[25] Although this method restricted Newtonian philosophy to mechanical operations,

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[21]Desaguliers, *Course of Experimental Philosophy*, 88. Greenwood's prospectus mentions the following instruments by name: inclined plane (Lect. IV, "Of the *General* Principle of *Mechanicks* relating to . . . *Moving* Bodies"); balances, lever, pulley; (Lec. V, ". . . some General Things concerning the *Mechanical Powers*"); wedge, screw, inclined plane, wheel, "compound Machines, or Engines" (Lect. VI, ". . . on the "Axis in Peitrochio . . . or Wheelwork"); pendulum, (Lect. IX, on "Oscillatory Motion"); whirling table (Lect. XI, "Concerning *Circular Motion*"); bell, strings, monochord (Lect. XII, "Concerning *Elasticity*"); globe, and sphere (Lect. XIV, "Of the *System of the World*"); and the "*Copernicus*, or a *Machine* representing the Motions &c. Of the *Planets*" (Lect. XV, "Containing an Explanation of the most remarkable *Astronomical Phenomena* . . . according to the *Copernicum*, or True *System* of the World"); Greenwood, *Expirimental Course*.

[22]Greenwood, "Advertisement" for *Experimental Course*, reverse of title page.

[23]Ibid.

[24]For the derivation of this term and its particular application to Greenwood's mentor, Desaguliers, see Dobbs and Jacob, *Culture of Newtonianism*, 71-78.

[25]Desaguliers, *Course of Experimental Philosophy*, Preface.

even Desaguliers had felt obliged to acknowlege the ultimate end of experimental philosophy was not only "to discover the Causes from their Effects, and make Art and Nature subservient to the Necessity of Life," but also "To contemplate the Works of GOD."[26]

Despite his mentor's nod to religious convention, Greenwood himself suggested no providential cause or moral lesson for mechanical philosophy explained according to Newtonian principles. Moreover, his omission of a stated teleological end of the Newtonian universe was contrary to the expressed beliefs of his original patron, Cotton Mather, his course subscriber, Thomas Prince, and, perhaps more importantly, his reluctant patron, Thomas Hollis. In devising this course before his appointment to the Harvard faculty was finalized and by offering it outside the college walls, Greenwood could act independently of any restraints which would be imposed by his future employment as the Hollisian professor of mathematics and natural philosophy at Harvard.[27]

To encourage subscriptions for his course, Greenwood employed several marketing techniques. Through his newspaper advertisements, he offered subscribers a free prospectus of the course available for viewing at the four locations throughout Boston and Cambridge where subscriptions were taken. He also promised to arrange the time and site of the class (at Mr. Howard's in King Street) as well as the length of the lectures to suit the attendees. Later, when subscriptions were slow in coming, he offered potential participants the opportunity to attend a

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[26]Ibid., Dedication.

[27] At the ceremony for the inauguration of the Hollisian professorship of natural philosophy and mathematics held in February 1728, Greenwood would publically acquiesce to the "Rules and Statutes" drawn up by Hollis to govern the chair he had designed and funded, Overseers' Records, Harvard University Archives, I, 101, 104-06, quoted in *SHG* 6:476. Thus Greenwood's acceptance of Rule 13, "to promote true piety and Godliness by his own Example and encouragement," may well have necessitated the incorporation of a teleological message in his natural philosophy courses; the list of the Rules and Orders is printed in "Documents from the Harvard University Archives," 596-98.

"specimen" lecture as a preview of the course.[28] Additionally, Greenwood promised that those who took the course could attend any future courses (offered upon "suitable encouragement") at a reduced rate; the first such course would cost 40 shillings (£2) while all subsequent courses would be free.[29] Five weeks after the initial advertisement and two weeks after the specimen lecture, Greenwood either had found a sufficient number of participants or had exhausted the market for additional attendees, for the course commenced "without expectation of other Subscribers" on 19 January 1727.[30]

Greenwood also apparently found enough encouragement to warrant a "recapitulation" of the experimenal philosophy demonstrations, planned for July 1727, about three months after the conclusion of the initial course. But according to notices in the Boston public prints, the summer heat and the shortness of the evenings forced a postponement until the fall.[31] Greenwood also used these notices to announce private instructions and demonstrations for "Gentlemen" in all branches of "Speculative" and "Practical" mathematics "commonly taught in the *Colleges* or *Schools* in *Europe*." Newcomers could learn "Sir *Isaac Newton's* incomparable Method of *Fluxions*" (integral and differential calculus), while advanced students would attend the explanation and demonstration of Newtonian theory and other "Modern Discoveries" in astronomy and philosophy. Again emphasizing the accessibility of the new science, Greenwood assured readers the demonstrations would be performed "in a concise and easy manner."

It appears that Greenwood's plan to recapitulate the experimental course in the fall was

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[28]*BG*, 5, 19 Dec. 1726; 12 Dec. 1726 and 1 Jan. 1727. Notes in the handwriting of Thomas Prince on a copy of the prospectus (now in MHS Colls.) indicate the specimen lecture, delivered 2 Jan 1727, was devoted to light and vision.

[29]Greenwood, *Experimental Course*, [10].

[30]*BG*, 9 Jan. 1727.

[31]*NEWJ*, 10, 17, and 24 July 1727; *BNL*, 6, 13, and 20 July 1727.

postponed yet again, for no other course notices appear in the public prints until the following winter. Perhaps his time was fully occupied with preparing for his new position at Harvard. In late November (six months after his election by the Coporation and Overseers), he had received formal notice "forthwith to repair to ye College, and enter on ye duties of his office" which included one classroom lecture a week (limited to class attendees who paid a surcharge for enrolling) plus a weekly "public" lecture, held in the college hall and open to the entire college community.[32] In February, 1728, the month in which he was formally inaugurated as the Hollis professor, he advertised a recapitulation of the original course in a series of three-to-four lectures free to previous subscribers.[33] Again he sought new "Gentlemen" subscribers for a new series of the course. Greenwood's avoidance of any reference in the advertisements to his affiliation with the college or his position of Hollis professor, however, indicates he pursued this enterprise in a private capacity. Employing marketing techniques simliar to those of the previous year, Greenwood arranged for four locations (all outside of Cambridge) where subscriptions would be taken and catalogues examined. In the place of a specimen lecture, he offered new subscribers the opportunity to attend the recapitulation lectures.

Although the advertisement was specifically aimed at men and presumably precluded the attendance of women, the site of the lectures was procured through arrangements with a woman—one Mrs. Belnap. Mrs. Belnap apparently provided accommodations for the professional activities Greenwood privately pursued. This arrangement dated from at least the previous July when he had advertised private instructions and demonstrations available twice daily in three-hour sessions during the morning and the late afternoon "at Mrs. Belnap's house at the upper end of

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[32]"Benjamin Wadsworth's Book," 21 November 1727 in CSM *Pubs.*, 31 (1935), 469; Cohen, *Tools of Science*, 35. Greenwood assumed his teaching duties on 27 Nov. 1727, Cohen, Ibid., 35.

[33]*NEWJ*, 5, 12, and 19 Feb. 1728; *BNL*, 8, 15, and 22 Feb. 1728.

Queen Street."[34]

No further notices for the Greenwood's initial course in experimental philosophy appear in the public prints. Nevertheless, within the next few years advertisements associated with the practical application of mechanical philosophy, such as Greenwood had demonstrated, began to appear. Ads for fire engines, water pumps, and aquaducts—the machines of commercial science—touted their labour-saving and safety aspects.[35] Although practical devices, their novelty and engineering wizardry made them fit objects for display. In 1733, for instance, the owners of a Boston distillery deemed it a "Publick Service" to announce the installation of an especially powerful, horse-drawn water pump.[36] Erected "by the Advice and Direction" of a gentleman-expert, one "Mr. Roland Houghton," the "first of the kind" Water-Engine was capable of delivering "a large quantity of Water twelve Feet above the Ground." The owners' notice illustrates that the harnessing of natural processes even for practical ends could be viewed as theatrical display wherein specialized knowledge, spectacle, and entrepreneurship mingled in equal measure.

Act II— Astronomy—"composed upon the ORRERY"

The acquisition in 1732 of two new astronomical devices (as well as a microscope) for the Harvard apparatus collection prompted an immediate public announcement and eventually a new lecture series devised by its professor of natural philosophy. Sent from England by Thomas Hollis,

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[34]*NEWJ*, 10, 17, and 24 July 1727; *BNL*, 6, 13, and 20 July 1727.

[35]*BNL*, 14 and 21 Sept 1732, quoted in George Francis Dow, *The Arts & Crafts in New England* (1927; reprint, New York: Da Capo Press, 1967), 278; *BG*, 22 Jan. 1733, *BNL*, 26 Feb. 1736, *BG*, 24 Jan. 1737, quoted. in Ibid., *Every Day Life in the Massachusetts Bay Colony* (Boston: The Society for the Preservation of New England Antiquities, 1935), 141-42, 129, 122. For the development in England of an "industry of science" that fused the practical application of science, science lectures, and marketing, see Larry Stewart, "The Selling of Newton: Science and Technology in Early Eighteenth-Century England," *Journal of British Studies* 25 (1986), 178-92 and Ibid., *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain, 1660-1750* (Cambridge: Cambridge University Press, 1992), Part III.

[36]*BG*, Jan. 22, 1733, quoted in Dow, *Every Day Life*, 141-42.

the nephew and heir of Thomas Hollis the college's benefactor and Greenwood's patron, these were an armillary sphere and an orrery, the latter described by Hollis as "a new Invented Engine or Macheen . . . shewing the dayly and annual motion of ye Sun, Earth & Moon."[37] Greenwood may have requested these instruments himself, for a week after sending the apparatus, Hollis wrote to Edward Wigglesworth, "Mr. Professor Greenwood has favoured me with a Letter witch I answered with a Return (I hope) of a few usefull instruments." Hollis supposed the new apparatus would "furnish some instructive Lessons" for the professor's pupils as well as afford him some pleasure in his "Vacant Hours."[38] Perceiving the import and the public relations value of Hollis's "few useful instruments," Harvard officials trumpeted the "very rich Addition" to its apparatus collection in a notice initially carried in the *Boston Weekly Newsletter* of 14 September 1732. The notice was reprinted as follows in the *Pennsylvania Gazette* of 5 October 1732, evidence of the widespread interest in scientific curiosities:

> Cambridge, Septemb. 9. We have received from Mr. HOLLIS, Nephew of the late pious and most generous THOMAS HOLLIS Esq; of *London*; a fresh Confirmation of his Generosity and Regard to the *College* in a very rich *Addition* to the *Philosophical Apparatus*; consisiting of a curious *Microscope*, a large and exquisite *Armillary Sphere*, and a very costly *Orrery*, an Instrument, that this, or any other Part of *America*, as far as we can learn, has never before been favoured with.[39]

Named for Charles Boyle, fourth Earl of Orrery, who was one of the first gentlemen-scientists to commission this new type of three-dimensional planetarium, the orrery was invented by the London instrument maker, George Graham, about 1720 and displayed the rotations of the earth,

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[37] Thomas Hollis to Coll. Hutchinson (Treasurer of Harvard), 20 July 1732; quoted in David P. Wheatland, *The Apparatus of Science of Harvard 1765-1800* (Cambridge: Harvard University Press, 1968), 49.

[38] Hollis to Wigglesworth, 27 July 1732, "Documents from Harvard Archives."

[39] Reprinted in Harrold E. Gillingham, "The First Orreries in America," *Journal of the Franklin Institute* 229 (1940): 82.

moon, and sun by means of wheel-driven balls.[40] Subsequent improved models displayed the entire solar system and varied from modestly priced, hand-cranked, table-top models to expensive, free-standing, clock-driven models. Coinciding with the interest in astronomy engendered by Newton's concept of the "true System of the World,"[41] the orrery quickly became the newest addition to the equipage of those men and women in England who were devoted to the pursuit of polite as well as academic science.

The painter Joseph Wright of Derby captured the public's continuing fascination with the orrery, in a large canvas executed in 1766 for the Earl of Ferrers and exhibited in London, entitled, *A Philosopher Giving that Lecture on the Orrery in Which a Lamp Is Put in Place of the Sun*.[42] Exploiting both the orrery and the painting as curiosities, John Boydell published a mezzotint reproduction by William Pether for public consumption in 1768; thus it became an affordable and

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[40]Ibid. 81; Desaguliers, *Course of Experimental Philosophy*, 430-31. For the publicizing of the orrery by the English journalist, Sir Richard Steele and the "common" mis-perception of Steele as the orginator of the name "orrery," see Henry C. Knight in collaboration with John R.Milburn, *Geared to the Stars* (Toronto: University of Toronto Press, 1978), 154.

[41]This phrase was a common allusion to Newton's achievement in proving the Copernican system from the laws of gravity; see, for example, Desaguliers, *Course of Experimental Philosophy*, 430. The London instrument maker, science demonstrator, and prolific author of Newtonian science digests, Benjamin Martin used it in an advertisement for small orreries affordable at a "small price" in his publication *The Use of Both the Globes, the Armillary Sphere and Orrery* (London, 1766), quoted in Wheatland, *Apparatus of Science*, 51. For the develpment and manufacture of the orrery and its use by English science demonstrators as a means of teaching Newtonian astronomy, see Knight,*Geared to the Stars*, Chap. 5; for the orrery as a instrument of polite science, see Alice Nell Walters, "Conversation Pieces: Science and Politeness in Eighteenth-Century England," *History of Science*, 35 (1997), 141-45 and Ibid., "Tools of Enlightenment: The Material Culture of Science in Eighteenth-Century England," Ph.D. diss., (University of California at Berkeley, 1992), 220-41.

[42]Gillingham, "First Orreries ," 84. For provenance and exhibit history, see Judy Egerton, *Wright of Derby*, Exhibition Catalogue, (London: Tate Gallery Publications, 1990), 18, and Benedict Nicholson, ed., *Joseph Wright, Painter of Light* (New Haven: Yale University Press, 1968), 1:235. For discussion of its "cosmological theme" as an artistic expression of the Newtonian universe, see David Fraser, "Joseph Wright and the Lunar Society," in Ibid., 16-19.

popular image of science on display (fig. 4.2).[43] Wright's "conversation piece" depicts astronomy's appeal to an audience both male and female, young and old: a woman, the Earl's young son, and the boy's playmate have joined the note-taking natural philosopher and three other men plus the artist himself gathered about the orrery.[44] They gaze with rapt attention at the elegant clock-driven model of the solar system, which comprises a brass drum-like case whose top surface is fitted out with six concentric brass rings each with spherical models of the the corresponding planets and their moons which revolve about the central sun. Above the flat surface are five brass circles representing the five principal "Circles of the Sphere."[45] Preoccupied with his notes, the natural philosopher stands a little removed from the others—a hint at his special status as one whose expertise allows him to explicate the fascinating wonders revealed by the mechanical universe.

Greenwood's announcement of his course in the Boston newspapers of June and July 1734 engendered something of the same fascination among those interested in the new science, causing

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[43]For publishing history of the mezzotint, advertised at 15 shillings by Boydell, see Egerton, *Wright of Derby*, 152. The Earl of Ferrers paid £210 for the painting; [Homer Eaton Keyes], "The Editor's Attic: The Frontispiece" *Antiques* 33 (Jan. 1938): [110]. Imported mezzotint pictures, advertised in colonial newspapers as early as the 1720s, were widely available by mid-century to middle- as well as upper-class households; E. McSherry Fowble, *Two Centuries of Prints in America, 1680-1880, A Selective Catalogue of the Winterthur Museum Collection* (Charlottesville: University Press of Virginia, 1987), 10, 15-16.

[44]Displayed like books, decorative objects, and scientific instruments, paintings in this genre were intended to stimulate polite conversation, Richard Bushman, *The Refinement of America: Persons, Houses, Cities* (New York: Vintage Books, 1993), 87. Wright's identification of the figures was found on a mezzotint discovered among his possessions after his death; [Keyes], "Editor's Attic: Frontispiece," [110]. Cf. Egerton, who regards the center figure as the natural philosopher, and opines Wright deliberately invested him with much of the physical appearance of Isaac Newton, *Wright of Derby*, 54-55.

[45]I have relied on the description of the brass weight-driven orrery acquired by Harvard College in 1764 which closely resembles the orrery depicted by Wright; Wheatland, *Apparatus at Harvard*, 52. Manufactured in London by Benjamin Martin to replace the Hollis orrery that had been destroyed in the Harvard Hall fire of 1764, the new orrery cost over £90 at a time when Martin advertised orreries from £12.12.0 for hand-cranked models to £150 for clock-driven models, Ibid.

comment outside New England. In July the *New York Gazette* informed its readers in a front-page article of Boston's good fortune in procuring "that wonderful Machine or Instrument called the ORRERY" upon which Mr. Greenwood "proposes to illustrate and confirm the Elements of Astronomy . . . by certain explanatory Lectures." According to the newswriter, the intricacies of this "wonderful Contrivance" illustrated "the Motions of the Sun, Moon, and Earth. . . . perform'd by Wheels which are above fifty in Number, and all that World or Worlds put in Motion at once, by the hand of the Artificer, with the most beautiful Facility imaginable." Because it embodied wonders effected by both mechanical and divine contrivance, the orrery as an instrument in itself was worthy of permanent, public display. "It is hoped," the writer concluded "that in time not only each Province, but each principal Town in these parts will think it as necessary to have an Orrery as a publick Town Clock, the one gives the Time of the Day and Night, the other presents to our View the wonderful Works of the Diety.[46]

The *New York Gazette* writer assumed viewers would concur that the ultimate lesson learned from the public display of the orrery was teleological in nature. This was consistent with Greenwood's stated "Design" in composing his proposed course which, he advised *Boston Gazette* readers, was to exploit astronomy's "Use and Advantage" not only in practical applications, but also "in the Confirmation of the *Principles of Religion*."[47] The professor's design in presenting his philosophical lectures was also "very subservient to the Honoured founders intention," as the

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[46]*New York Gazette*, 8 July 1734, quoted in part in Leonard, "Sketch of Isaac Greenwood," 160, n. 83, and Gillingham, "First Orreries, 84. Despite the writer's hope, no town erected a publick orrery, although two American orreries won official sanction: the Pennsylvania Assembly voted to recompense David Rittenhouse for the orrery he made for the University of Pennsylvania in 1771(after having viewed a demonstration of the "Newtonian System" upon it), and the Massachusetts Legislature permitted Harvard to hold a public lottery to pay for the orrery the college acquired from the Boston watch-maker Joseph Pope in 1788; Gillingham, "First Orreries," 90, 92. For an extensive description of these and other American-made orreries, see Knight, "Early American Planetary Machines," *Geared to Stars*, Chap. 16.

[47]*BG*, 24 June and 1 July 1734.

orrery's donor, Thomas Hollis II, observed, because it also had a "Tendency to promote usefull Natural Knowledge to the Glory of God and Benefitt of Man."[48]

Greenwood's eight-week, sixteen-session series capitalized on both Hollis's gift and the contemporary appetite for astronomy and astronomical gadgetry.[49] He wooed prospective "attendants" with the promise to illustrate "the great Extent and Excellency of this font of Knowledge" with demonstrations "composed" not only "upon the ORRERY," but also "upon all such *Machines, Instruments and Schemes* as are used by Astronomers." Appealing to the metropolitan aspirations of his provincial audience, he assured them the "*great Variety and Value*" of the apparatus itself exceeded that which they could view in demonstrations given by prominent London lecturers. The Harvard professor (with all the the Harvard College apparatus at his disposal) remarked that his demonstrations lacked only the reflecting telescope invented by Sir Isaac Newton, since New England had not yet been "honoured" with an example.[50]

As a further aid and inducement for subscriptions, Greenwood proposed to print and distribute "*gratis*" to the subscribers a "Contents"or prospectus of the course. The four-page prospectus, published by mid-July, announced the topic and gave a succint summary of each of the sixteen lectures in an outline form organized rather like a sermon under five "heads," and developed

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[48]Hollis II to Edward Wigglesworth, 17 February 1734, "Documents from Harvard Archives," 701.

[49]New England ministers and their publishers also capitalized on this fascination; a few years earlier, for instance, the Rev. Mr. James Allin published a sermon entited *The Wheels of the World Govern'd by a Wise-Providence* (Boston, 1727), advertised, *NEWJ*, 8 May 1727.

[50]Greenwood produced two extant manuscript catalogues of the Hollis equipment, while he was under review for dismissal, the first dated 6 Sept. 1731 and the second, 19 Apr. 1738, Cohen, *Early Tools of Science*, 35-36. Cohen reproduces the latter with annotations describing each instrument's use according to Greenwood's references to a contemporary illustrated handbook of experimental philosophy, Ibid., App 1.

in the homeletical order of sermons—a form readily comprehended by his intended audience.[51] Thus topics one through three of Greenwood's "sermon heads" treat first, the sun and earth and their motion in general; second, the "doctrine" (i.e. the use) of the sphere and other mechanical representations of the globe; and third, an account of the entire solar system including planets, comets, and fixed stars. Greenwood's fourth head, the "Discovery and Proof" of the solar system comprises the "improvements" or expansion of the foregoing topics. Here Greenwood deals with the various branches of astronomy, such as optics and mechanics and their pertinent apparatus (lenses, telescopes, quadrants, etc.) and a report of the "progress" of astronomy from ancient to modern times. Greenwood's fifth and last head, corresponding to a sermon's application, treats the "Phaenomena and Consequences" of the planetary system including Astronomical topics (eclipses, transits, etc.); Chronology, Dialling, and "Fanciful" and "Real" Astrology.[52] In familiar sermonic fashion, this head concludes with a final moral lesson, showing in Greenwood's words, how "all [the previous heads] lead to an *invincible Faith* of the *Existence* and *Perfections* of GOD."

Greenwood's pointed reference to the moral message implicit in Newtonian astronomy marks a significant contrast to his previous silence regarding a moral message implicit in Newtonian experimental philosophy. This may be due to two reasons, the first pertaining to his obligations as the Hollis professor and the second to the nature of the topic and the entrepreneurial character of

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[51]Isaac Greenwood, *Explanatory Lectures on the Orrery, Armillary Sphere, Globes and other Machines, Instruments, and Schemes made use of by Astronomers: Accompanied With a great Variety of Physical Experiments and Curious Remarks* (Boston, 1734). The prospectus was published by 25 July 1734, see Greeenwood's notice, *BNL* 18 July 1734, advising subscribers the lecture series would begin a week later than previously scheduled "in consideration they [the prospectuses] could not be printed sooner." On sermon format, see Charles E. Hambrick-Stowe, *The Practice of Piety: Puritan Devotional Disciplines in Seventeenth-Century New England* (Chapel Hill: The University of North Carolina Press, 1982), 118.

[52]Greenwood's inclusion of astrology, with the careful distinction between "real" and "fanciful," in a lecture intended for a sophisticated audience reveals that the belief in traditional lore was not exclusive to the "country" people who read the *Ames's Almanacks*, see Chap. II.

Greenwood's endeavor. Greenwood was firmly ensconced as the Hollis professor of natural philosophy when he designed and advertised the course upon the orrery. Thus his professional identity was far different from when he had devised his first public lecture series. Even though this course like the first course was a private professional endeavor, Greenwood in 1734 obviously counted on his stature as the Hollisian professor to attract subscribers. On the title page of the course prospectus, he presents himself as "Isaac Greenwood, A.M. / Hollisian *Professor* of Philosophy & Mathematicks," thereby delineating his professional affiliation as well as his academic status. In 1726, with his appointment as Hollis professor not yet confirmed, he could rely only on the cachet of academic standing conferred by an advanced degree. But eight years later, he could invoke the authority of Hollis's name, although the price may have been conformance to Hollis's stated agenda in promoting the study of natural philosophy.

Hollis's name was influential even beyond the small academic circle in Cambridge, a fact Greenwood knew well. The London merchant's largess insured the college's financial well-being *and* placed the imprimatur of metropolitan culture and learning upon New England's intellectual striving. That Hollis chose natural philosophy and religion as the two subjects through which to accomplish his design elevated the new science to the standing of religion. His continued gifts of philosophic instruments legitimated the probing of science into the natural world. The announcement of the various instruments he donated and their use in demonstrations advertised in the newspapers insured an awareness of natural philosophy in the public's mind, as well as a sense of pride in scientific achievements.

Nearly twenty years after his death, Hollis was among the galaxy of personages New Englanders memorialized by the production and purchase of mezzotint portraits. The advertisement for his mezzotint engraved by the Boston artist, Peter Pelham (after the portrait commissioned by the college), included the wording in the inscription on the print (fig. 1.5).[53] Thus newspaper readers as well as viewers of the print would learn Hollis's fame in the American colonies derived from his beneficence to Harvard which consisted of two professorships, ten scholarships, a number of valuable books *and* "a fine Apparatus for Experimental Philosophy." Greenwood, of course, could not see twenty years into the future, but he could see the obligations imposed by his position as the Hollisian professor and the immediate benefit of the Hollis family's gifts of scientific instruments. Professional obligations may well have informed the young professor's decision to describe the ultimate lesson learned upon the orrery in terms which would earn the approbation rather than the condemnation of its donor.

Greenwood's emphasis on the moral lesson of astronomy, however, may have had just as much to do with an effort to claim a new audience. Having dawned as the brightest star in natural philosophy's constellation, astronomy captured an audience interested in the moral message, as well as the polite display, of Newtonian knowledge. Astronomical study, as the seminal study of "polite astronomy" has shown, "promoted rational thought and religious sentiments in a manner both emotionally pleasing and intellectually satisfying."[54] As such, it was particularly suited to women and children who were instructed through texts designed especially for them which employed, as a teaching device, dialogue between a teacher and students portrayed in a domestic setting.[55]

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[53]*BG*, 17 Sept. 1751, quoted in Dow, *Arts & Crafts*, 35. Pelham, a mezzotint engraver formerly of London, produced the mezzotint after a painting by Joseph Highmore, which Hollis had sent to the college in 1722 upon request of the president. The painting was destroyed in the Harvard Hall fire in 1764; see Hollis to Mr. John Leverett, 26 Sept. 1722, "Documents from Harvard Archives," 501. For Pelham's American career, see Andrew Oliver, "Peter Pelham (c.1697-1751), Sometime Printmaker of Boston" in *Boston Prints and Printmakers, 1670-1775* (Boston: CSM, 1773), 133-73; for the Hollis mezzotint, see 165 and 173.

[54]Walters, "Tools of Enlightenment," 207.

[55]For an introduction to the "canon" of polite science works, see Ibid., "Conversation Pieces," 123-24 and for analysis of "polite astronomy texts," see Ibid., "Tools of Enlightenment," 201-22; for the development of astronomical dialogue as a teaching tool, see Gerald Dennis Meyer,

Illustrations in these popular texts often showed young ladies and gentlemen grouped around astronomical instruments that included celestial globes and telescopes and also the "instrument of polite astonomy *par excellence*," the orrery.[56] By pointing out the metaphysical lesson revealed by his lessons upon the orrery, Greenwood—the natural philosopher cum entrepreneur—may have been aiming at this audience.

That Greenwood aimed for a popular audience is evident in his newspaper advertisement which asserts that the "Language and Argument" of the series are accommodated to the capacities of those yet "destitute" of astronomical "Skill." This statement implies Greenwood is seeking an audience less learned than the one he had sought for his previous course in mechanical philosophy. In seeking "Gentlemen" subscribers for that course, he had appealed to those who would "make themselves better acquainted" with Newtonian philosophy than a year's study of books would achieve, thus implying that his prospective audience had the opportunity for formal study. But in inviting those "destitute" of previous knowledge, Greenwood appears to be seeking a heterogeneous audience. That this unschooled audience would include women is made clear, for Greenwood concludes the advertisement with an explicit invitation to the "FAIR SEX": If the *Curiosity* and *Desire* of *Knowledge*, justly admired in the FAIR SEX should excite any of *Them*; there will be some *Expedient* found out that *They* may be gratified twice a Week in the Afternoon, with their usual Tea and a *Familiar* ASTRONOMICAL DIALOGUE.[57]

Greenwood couches his attempt to capture a female audience in the diction of polite discourse while suggesting that astronomy should become a "familiar," that is, domestic, pastime. The approbation of "the tea-table,"—the world of feminine civility and fashion, which since the

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*The Scientific Lady in England 1650-1760* (Berkeley: University of California Press, 1955), 16-48.

[56]Quote, Walters, "Conversation Pieces," 145.

[57]*BG*, 24 June and 1 July 1734.

1720s had been a force in disseminating manners and taste among Anglo-American women,[58]—would guarantee a new audience and secure astronomy's place as a rational pastime. Hence, he offers special accommodations for the ladies by suggesting a site and method adapted to female activity and capacities and by taking advantage of conversation as the "culminating genteel art."[59] Although the course content may be the same as that for his male subscribers, women will learn astronomy over a dish of tea in a setting that is private yet social, by way of a method adapted to their capacities—the "astronomical dialogue." Thus Greenwood's advertisement conjures a picture of astronomical study in Boston akin in function and content to Wright's "conversation piece," *A Philosopher Giving that Lecture on the Orrery.* Moreover, from the perspective of Greenwood's intended audience, the sermonic format of the prospectus for his astronomical course may have been a subtle strategem aimed at a "new" female contingent upon whose religious sentiment he played.

Although Greenwood employed a familiar format for the course prospectus, the prospectus emphasized the novel educational and entertainment value of the orrery and of the "*Physical Learning*" (i.e., experiments) he would perform (Part II). In its starring role as "the new *Ornament*" of astronomy, the orrery "very beautifully" represented the various solar phenomena (Part II). In concert with the professor's other "curious Machines," it made the most complicated astronomical theory "level to the Meanest Capacity" of his audience (Part III). Greenwood offered subscribers a participatory role in the "Actual Observations" made with the telescope and with various other

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[58]David S. Shields, *Civil Tongues & Polite Letters in British America* (Chapel Hill: University of North Carolina Press, 1997), 114; for a discussion of tea tables as a site of feminine civility, both complementing and challenging male tavern society, see Ibid., Chap. 4.

[59]Quote, Bushman, *Refinement of America*, 89. That polite science in England occurred in the "informal domestic space of the home" as well as in the formal "public sphere" is the theme of Walters, "Conversation Pieces," see esp. 122, 135-36. Segregation by sex was the norm in eighteenth-century schools for young misses and gentlemen, an arrangement that presumably carried over to incidental classes. In a notice preceding Greenwood's advertisement for astronomical lessons, one Mr. Langluiserie advertised French lessons for both sexes at a house in King Street where young ladies would be accommodated in a room "purposely provided for them," *BG*, 15 July 1734.

instruments, such as the macrometer and astrolabe, used in the "mechanicks" of astronomy (Part III). Capitalizing on the interest generated by Newton's and Halley's forecast of comets and transits of Venus and Mercury over the sun, he also offered to represent on the orrery any "solars visible in *Boston* for *Fifty Years* yet to come" that his "spectators" might choose (Part V). The number and identity of the spectators who subscribed to Greenwood's lecture series on the orrery remains unknown. They met, however, at Mr. Lutwyche's in King Street—adjacent to a site already familiar to those who wished to purchase "the very newest Fashion" in clothing and accessories as well as ideas.[60] There they gathered in Lutwyche's "Long Room" whose designation by size implies the crowd was larger than that accommodated in a room of ordinary size.[61]

A poem published in the *Boston Gazette* shortly after the completion of the course conveys the image of an audience enraptured with the latest fashion in natural philosophy. Printed across the entire front page and prominently headed, "To Mr. GREENWOOD, Hollisian *Professor* of *Mathematics and Astronomy at* Cambridge," the verses also present Greenwood as the rightful interpreter of the Newtonian world to those hundreds of newspaper readers, unable to actually attend the course.[62] Weary of the pomp and deadly ambition of "Statesmen" and "Kings," the anonymous poet hails Greenwood as that "generous Man! by whose Assistance led, / The Paths of Ignorance no more we tread." The professor has turned his students' "wond'ring Eyes" to "view the shining Glories of the Skies" where the anonymous poet finds his actual knowledge of the universe surpassed by its metaphysical implications. For the "friendly Aid" of Greenwood's "optic Glasses,"

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[60]For a list of imported English and European luxury wares for "Ladies" and "Gentlemen" (including brocaded "Banjans" [banyans]) sold at the house next door to Lutwyche's, see Thomas Trowell's advertisement in the *BG*, 18, 25 March 1734, quoted in Dow, *Arts & Crafts*, 155-56.

[61]*BG*, 22 July 1734.

[62]*BG*, 16 December 1734; reprinted in *SHG*, 6:157-59 and Leonard, "Harvard's First Science Professor," 157-59.

reveals that "Millions of Worlds in various Orbits roll , / And Harmony and Order grace the Whole." These views of "Orbs [hitherto] unseen," move the poet to acknowledge their still unseen creator:

> Great GOD! what Voice could into Being call
> These mighty Globes, and form this beauteous ALL!
> What Power can all their various Motions guide?
> And from what Hand but thine are they supply'd?

Yet as the revealer and, more importantly, as the interpreter of this wondrous world, Greenwood himself earns the poet's adulation. The poet's deft use of Newtonian references shows not only that he has grasped the essentials of Greenwood's instruction but also that he presupposes a familiarity with Newtonian imagery on the part of his literate audience. In the following lines, he uses poetic diction to allude to Newtonian theory concerning the orbits and motion of celestial bodies and the law of gravity:

> GREENWOOD, with what Delight we hear you prove
> The hidden Laws by which those Bodies move,
> Describe the Rings that shape their rapid Course,
> And bring to light Attraction's wondrous Force.

The poet then draws the rational implications of the Newtonian universe (perhaps from Greenwood's fifteenth lecture in which, according to the prospectus, he would address the "consequences" of "*Fanciful*" and "Real"astrology),[63] as he testifies, "No more we'll gaze with superstitious Fear, / While you the secret Laws of Nature clear." Nevertheless, this rational world view is tempered by the poet's apparent providentialism: the "Almighty" can intervene, as in the case of a blazing comet, to "strike it from its Path, / To bear along the Tokens of his Wrath." The

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[63]Greenwood's prospectus does not clarify what he meant by the terms "fanciful" and "real" astrology. He may have used the former to mean "judicial" astrology and the latter, "natural" astrology, i.e., astrology used in casting personal horscopes (discredited by natural philosophers as a sham science) and astrology used to predict consequences of natural phenomena. Greenwood concluded his 1727 course of experimental philosophy by showing that judicial astrology was a "pretended Science" that drew "vain" and "absurd" conclusions contrary to the laws of nature, *Experimental Course*, 9. No doubt he would make the same condemnation of judicial astrology in the atronomical lectures, while his inclusion and apparent differentiation of real astrology may have been a nod to the popular audience he was courting.

author's qualified acceptance of Newtonian philosophy shows the flexibility of the new science. Just as the almanac maker Nathananiel Ames II was able to accommodate Newtonian theory to "real" astrology,[64] this poet has unabashedly accommodated the new science revealed by Greenwood to his own religious views. Addressed directly to Greenwood as one who has "unveil'd" nature's secrets, the poem's concluding lines—"Long may you stay below to chear our Sight, / Inform our Mind, and set our Judgment right"—presage the emergence twenty years hence of the natural philosopher (rather than the cleric) as the accepted explicator of nature.[65] In according this role to Greenwood, the poet specifically cloaks him with the mantle of immortality awarded to Newton: upon his death, Greenwood's soul would "take it's way, / [to] join great NEWTON in the Realms of Day."

Couched in the language of polite learning overlaid with moral instruction, the poem conveys not only the *fact* of Greenwood's demonstrations but also an *image* of Newtonian philosophy's—and by extension the natural *philosopher's*—potent role in deciphering the hidden laws of nature. Beneath the extravagant praise determined in part by poetic conventions was a sound estimate of Greenwood's "happy Talent of adapting himself . . . to the capacity of his Hearers," which enabled him to present the most difficult theory in a "plain and easy Light."[66] This talent combined with his "enterprizing Genius"[67] stood him in good stead on the lecture stage where his audience may have been motivated as much by polite curiosity as intellectual inquiry. Only a roomful of course subscribers witnessed Greenwood's performances, but those many newspaper readers whose limited purse or distant location precluded their attendance found their curiosity satisfied by the anonymous poet. Thus the image of Newtonian science as pious, as well as

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[64]See Chap. II above.

[65]See Chap. III above.

[66]Eulogy for Greenwood, *BNL*, 9 November 1745; quoted in *SHG*, 6: 479.

[67]Ibid., 478-79.

spectacular, performance entered the mainstream of cultural discourse flowing along the distribution routes of the *Gazette*. Eventually this image and Greenwood's fame spread to Philadelphia and its environs when the *Pennsylvania Gazette* published the poem.[68]

'Tween Acts—Experimental Philosophy and Newtonian Astronomy Reprised

Four years after Greenwood's success upon Harvard's orrery, he found himself bereft of the status conferred by his association with the college as the Hollisian Professor of Mathematics and Natural Philosophy when he was "ejected" from Harvard in July of 1738 for intemperance.[69] Greenwood had lost his title, his patronage, and his access to the college's collection of philosophic apparatus.[70] Relying upon his "enterprizing genius," however, he attemped to establish a private school of mathematics and natural philosophy in Boston which he announced "as may be taught by Isaac Greenwood, *A.M.&c.*"—the ampersand the only remnant of his former position. Two series of advertisments in the public prints in the fall of 1738 and the spring of 1739 indicate his intent to provide instructions "in *any Part of* Practical *or* Theoretical Mathematicks" and "*in any Branch of* Natural Philosophy, *where there is a Number Sufficient to attend.*[71] During this time, he produced a three-page propectus seeking subscribers for a "A COURSE of Mathematical Lectures and Experiments" consisting of mechanics, optics, hydostatics, and pneumatics. Like the course he had

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[68]*Pennsylvania Gazette,* 4 Feb, 1735.

[69]Historians as well as Greenwood's contemporaries have accepted his well-documented alcoholism as the reason for his dismissal, but Leonard raises the issue of the professor's "deism" as the ultimate factor, see "Harvard's First Science Professor," 163-64 and 153-56.

[70]On 11 July 1738, upon official notice of his dismissal, Greenwood was required to surrender his key to the "strong Lock" to the "Hollis Chamber" where the apparatus donated by Hollis was kept; Cohen *Some Tools*, 34, 36.

[71]*BNW*, 9, 16 and 24 Nov. 1738. The second series of ads is essentially the same, except that the various branches of mathematics and natural philosophy are listed. In the second series Greenwood offers "private" lessons at the "premises" of individual or any "particular *company*" of "Gentlemen,"*BNL*, 30 Mar., 5 and 12 Apr. 1739; *BG*, 2 and 9 Apr. 1739.

introduced in the fall of 1726, this series comprised a course in rational mechanics with emphasis on practical experiments to illustrate Newtonian forces but with no speculation as to moral or teleological implications.[72] Although no advertisements appeared in the public prints for this couse, hand-written marginal dates, citing month and day, indicate the course may have been performed (or was intended to be performed) in a series of daily lectures, starting March 18 and concluding several days after April 4.[73] Greenwood may have designed the *Mathematical Lectures* in early 1739 and delivered them in the spring as a practical introduction to the theoretical course of Newtonian philosophy he did advertise in the summer of 1739.[74]

In June and July 1739 the *Boston Weekly News-Letter* carried Greenwood's advertisement for this course, entitled a "*Course* of *Philosophical Lectures*, with a *great Variety* of *Experiments*." Employing the marketing techniques he had developed a decade earlier, he solicited subscriptions at four different locations where he offered prospective subscribers "*Minutes* of the *Articles* and *Experiments* . . . *gratis*." The title of the prospectus emphasizes the conceptual nature of the course, in that it announces "Philosophical Lectures . . . *Illustrating* and *Confirming* Sir ISAAC NEWTON'S

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[72]Isaac Greenwood, *A Course of Mathematical Lectures and Experiments* (n.p., n.d.). The only known copy lacks a title page and the top portion of page 3.

[73]The dates entered are March 18 - 31, (excepting March 19) and April 1, 2, and 4. Following the pattern established therein, the missing portions of page three would logically have been dated April 3 and 6.

[74]Absent Greenwood's usual practice of advertising his natural philosophy courses by specific name and given the marginal dates of Mar. and Apr., a logical conclusion is the prospectus was prepared in early 1739. Greenwood may have been building upon the foundation of this course when he devised and advertised his last known course in Mar. and Apr. of 1739. (Evans dates the prospectus as 1735, while Leonard establishes the date as 1738 on the basis of Greenwood's advertisement in the *BNL*, 9 Nov. 1738; "Harvard's First Science Professor," 160, n. 83, 168. This ad, however, does not mention the course by name, but makes Greenwood's customary general solicitation for students of practical or theoretical mathematics who can attend at regular hours and for those interested in any branch of natural philosophy who will be accommodated when a "sufficient number" enroll; cf. advertisements for courses, Mar. and Apr.1739, n. 71 above.)

*Laws* OF MATTER and MOTION."[75] The course itself was organized under three "articles" that dealt principally with Newtonian theory regarding the law of matter, fundamental principles of motion, and the "true" causes of natural phenomena (including gravity, planetary and cometary motion, and waves and tides ). This marks a departure from his experimental and mathematical courses which were organized topically (i.e., mechanics, optics, hydrostatics, and pneumatics) with specific experiments and apparatus listed by topic and with many references to the "practical" nature of the demonstrations which were "made easy and consise." Consistent with the pedagogical approach apparent in the advertisements for his 1726-27 course, Greenwood was aiming at an audience "already instructed in the *Mathematical Sciences*" (perhaps most recently through his *Mathematical Lectures*) by introducing the "*Principles*" of Newton.[76]

The prospectus for the philosophical lectures, however, indicates the majority of the "great Variety of Curious Experiments" Greenwood touted in the course advertisement employed the same apparatus he had used in the earlier courses on experimental and mathematical philosophy. References to specific instruments illustrating mechanics occur only in the sixth and ninth lectures (on "mechanical powers" and the nature of sound, respectively). Greenwood updated this course, he claimed, with the latest discoveries regarding fixed stars and the Aurora Borealis and with "useful and *delightful Experiments* of *late Invention*" concerning magnetism and electricity.[77] Perhaps aware the course might appear too theoretical, he added a *note bene* to the last page that promised "some *Entertaining Things*" using apparatus such as the camera obscura, the magic lantern, and "good" microscopes and telescopes. These he acknowledged were outside the proper scope of mechanical philosophy, nevertheless, by their inclusion he may have intended to widen his audience.

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[75][Boston, 1739].

[76]*NEWJ*, 10 July 1727.

[77]*Philosophical Lectures*, Lectures 10, 12, and 4.

As in his first course, devised before his association with Harvard, Greenwood offers no speculation regarding natural philosophy's moral message. Nor does he make an effort to court an audience motivated by the pious investigation of the Newtonian system of the world, as he did in the astronomical course designed while he was the Hollisean professor. Released from any constraints imposed by the Hollisean professorship but also deprived of the use of the Hollis apparatus, Greenwood could not promise "entertaining things" upon the orrery. Nevertheless, he assured subscribers the apparatus for the experiments was "compleat." But he also hinted in the *note bene* that given the resources afforded by a "full" enrollment, he would "enlarge" the course with "new *Machines* and *Models* of some *curious Engines* lately invented." Greenwood's apparent hope to update and enlarge his own stock of scientific apparatus may have prompted the subscription price of £4, a thirty-three percent increase above the cost of previous courses.[78] Greenwood's advertisement had announced the site of the lecture series ("at Mr. Brown's, *Shoemaker* next Door to *Deacon Wait's*"), so there was no need for further notice in the public prints. Hence there is no confirmation that Greenwood actually found enough subscribers to warrant delivering the course.[79]

Greenwood's departure from Boston for Philadelphia in 1740 with no other advertisements for his private school is regarded as confirmation of his inability to support his family as a free-lance natural philosopher.[80] Perhaps his last proposed course sounded too theoretical, with none of the allure of polite science; perhaps its lack of overt religious content precluded approval from more powerful interests; or perhaps he simply had exhausted the market for science lectures in Boston and its environs. In Philadelphia, through the patronage of Benjamin Franklin, Greenwood advertised

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[78]Ibid., 4.

[79]Leonard offers no source for his statement that "a number of young men signed up [for this course]", "Harvard's First Science Professor," 161.

[80]*SHG*, 6: 479.

and performed a "*Course* of *Philosophical Lectures* and *Experiments*," whose title suggests it was based on his 1739 prospectus.[81] That he had to rely on Franklin's help to procur the air-pump he used in the Philadelphia course indicates Greenwood's plan to enlarge his own apparatus collection through subscriptions for the Boston course had met with limited success at best.

In practical terms, Greenwood's failure to maintain a position as an independent lecturer and demonstrator of Newtonian natural philosophy illustrates that the diffusion of the new science was dependent upon more than the availability of an advocate with approved academic training and "imported" credentials. Temporal powers of patronage and purse were forces just as real as the active powers of nature—and sometimes just as hidden. Control of the purse strings meant control of the agenda and the apparatus of Newtonian philosophy, which in turn set limitations upon its diffusion and display. Thus Greenwood's capacity to exploit the active powers of the Newtonian universe and to acquaint New England with the knowledge purveyed by the politer nations in Europe met with qualified success. In the first two decades of science demonstrations in New England, patronage and professional obligations in part set the agenda of natural philosophy. Nevertheless, Greenwood's semi-public lectures, however infrequent or minimally attended, created an audience for natural philosophy that extended far beyond the walls of the demonstration rooms provided by Mrs. Belnap and Messrs. Howard, Lutwyche, and Brown. Advertised in the public prints, aimed at a cross-section of society including both men and women, taught in semi-public sites, interpreted in verse and sermons, and reported in regional and local newspapers, his lecture-demonstrations were an essential element in the development of Newtonian culture in New England.

Preeminent among Greenwood's hearers at Harvard was John Winthrop. Winthrop would inherit his professor's veneration of Newton and Newtonian science as well as his position as Hollis

[81] *Pennsylvania Gazette* 5 June 1740, quoted in Leonard, " Harvard's First Science Professor," 161; Franklin arranged the use of one of the Philadelphia Library Company's rooms and the Library Company's air pump; Ibid., n. 89.

professor after Greenwood's dismissal in 1738. Unlike his former instructor, however, Winthrop used the medium of print in the form of newspaper articles and published lectures rather than public demonstrations to display the hidden secrets of the Newtonian universe. Thus in the late 1740s when electricity supplanted astronomy as the current fad in natural philosophy, the vacuum created by the absence of both Greenwood and Winthrop on the lecture stage was filled by a number of assorted science demontrators. None, however, could claim the academic training nor the mantle of a distinguished English virtuoso that had legitimated Greenwood's performance as a demonstrator of natural philosophy..

In the meantime, the display of natural philosophy occurred in private settings such as the at-home entertainments of Edward Bromfield and the astronomical dialogues over the tea tables of Bostonian women, alluded to by Greenwood. Although there is scant documentary evidence of informal science demonstrations, booksellers' catalogues and newspaper advertisements indicate the increasing availability of the accouterments, or "conversation pieces," of polite science beginning in the 1730s with the sale of imported science manuals and polite texts dealing with the display of Newtonian astronomy.[82] In the succeeeding decades, apparatus suitable for the domestic display of natural philosophy (especially globes, telescopes, and microscopes)[83] and texts, pertinent to whichever branch of natural philosophy was currently in vogue, appear with increasing frequency in booksellers' advertisements. Their appearance in the catalogues of social libraries as well is a reminder that informal demonstrations could occur in "literary" as well as "familiar" settings.

The fascination for the display of mechnical gadgetry persisited well after the vogue for

[82]For apparatus advertised by booksellers and in social library catalogues, see above Chap. I The personal display of astronomy could also merge with function, as in the example of a large, silver watch stolen from a goldsmith's shop in Portsmouth, N. H., that "instead of an Hour Hand, had the Sun and Planets, which alternately shew'd the Hour," *Supplement* to *NHG*, 1 Apr. 1757.

[83]For example, the advertisment for a "Pair of 12 Inch Globes, and a neat Compound Microscope," *BNL*, 20 Dec. 1770, quoted in Dow, *Arts & Crafts*, 138.

public demonstrations of experimental philosophy had passed. "That ELABORATE AND MATCHLESS PILE OF ART, Called, the MICROCOSM, Or, The WORLD in MINIATURE" entertained Bostonians in 1756 with a spectacular display of Newtonian astronomy, applied mechanics, and theatrical ingenuity (fig. 4.3). Constructed by the English clock-maker Henry Bridges prior to 1734 and exhibited throughout England for nearly twenty years before arriving in the American colonies, the microcosm was an especially innovative version of the astro-musical clock with automated figures, a type of clock that reached the height of development and popularity in the eighteenth century.[84] The middle section of the ten-feet-tall by six-feet-wide case featured two dials, or planetariums, nearly three feet in diameter, mounted vertically which illustrated the "Copernicum or true solar system"above the Ptolemaic system. Four smaller dials illustrated the second, minute, and hour,and the month and day of month, as well as the sunset and sunrise, zodiac, moonset and moonrise, and nodes. The upper and lower sections presented automated scenes drawn from classical as well as contemporary life and were accompanied by musical selections played upon a barrel-organ.

In an engraving of the clock published in 1734, Newton's portrait appears in the upper corner opposite one of Bridges—an implied statement of the inventor's exploitation of Newtonian astronomy and authority.[85] Newton had died only seven years before, and the adulation of his countrymen and popular interest in Newtonian astronomy had reached new heights. The "World in Miniature" constituted a three-dimensional realization of the clockwork metaphor that employed the mechanical clock as a model for the natural world. The clockwork metaphor had been adopted in the

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[84]King, *Geared to the Stars*, 142. The description that follows is drawn from King's detailed description of the clock's components and mechanisms which he based on the descriptive booklet sold to exhibition viewers, entitled *A Succinct Description of . . . the Microcosm; with a Short Account of the Solar System* (London, 1760), and on his examination of the extant dials. Ibid., 142-45, dials pictured, 144.

[85]Ibid., 142.

seventeenth century to legitimate mechanical philosophy. Monumental astronomical clocks, erected in public spaces as "examplars" of mechanical philosophy, attracted viewers from far and wide and thus legitimatized mechanical philosophy in both high and low culture.[86] Built and displayed in the era that experienced a revival of the clock analogy based on interest in Newton's synthesis of mathematics and planetary motion,[87] Bridge's impressive microcosm performed a similar function in that it publicized and legitimated Newtonian philosophy.

The microcosm made a brief tour of Philadelphia, New York, and Boston in 1756 before returning to England and Scotland where it continued to entertain popular audience until 1773.[88] According to advertisements in Boston, the "World in Miniature" utilised over 1200 wheels and pinions to portray seven scenes of "*natural Beauties, Operations of Art, of human Employments and Diversions*."[89] These were accompanied by "*several fine Pieces of Music*," and by an "*amazing Variety of moving Figures*." The first scene, which would have been shown upon the planetariums, comprised all the celestial phenomena and their "proportional" size, revolutions, and movements as well as the "Trajectory and Type of a Comet, predicted by Sir ISAAC NEWTON, to appear the Beginning of 1758," the Transit of Venus and an Eclipse of the Sun, predicted to occur 6 June 1761 and 1 April 1764, respectively. The other scenes portrayed "Orpheus in the Forest," "a Carpenter's Yard," "a delightful Grove," "a fine landskip" featuring moving ships, coaches, cars,

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[86]Francis C. Haber, "The Clock as Intellectual Artifact," in Klaus Maurice and Otto Mayr, eds., *The Clockwork Universe: German Clocks and Automata, 1550-1660*, Exhibition Catalogue, (New York: Neale Watson Academic Publications for the Smithsonian Institution, 1980), 18. For the history of the clock as a metaphor of the world, see Otto Mayr, "A Mechanical Symbol for an Authoritarian World," in *Clockwork Universe*, 1-4.

[87]King, *Geared to Stars*, 168.

[88]Ibid., 142.

[89]"To be seen . . . the MICROCOSM, Or, The WORLD in MINIATURE," Broadside (Boston, 13 May, 1756); *Boston Gazette*, 17 May 1756 reprinted in Dow, *Arts & Crafts*, 304. The description that follows is taken from this advertisement.

chaises" and "a Powder-Mill at Work," and lastly "the whole world in motion"set to music. Billed as "*the most instructive as well as entertaining Piece of Work in Europe*," the Microcosm bore the "*Approbation and Applause*" of the Royal Society. Children as well as adults were invited to view this mechanical wonder, the adults paying four-shilling-and-six-pence and children under twelve, three shillings. The display of the microcosm, consciously constructed to attract an audience, both elite and popular, young and old, illustrates the comprehensive appeal of the new science. The Microcosm was an artificial world, wherein Newtonian theory explicated the world of natural phenomena and Newtonian mechanics animated the world of human endeavor and commerce. Hence "The WORLD in MINIATURE" was not only an "an entertaining piece of work," but also a metaphor for the world contained and made manageable by Newtonian science.

Act III—Electricity—"That wonderful Element"

If the decades of the twenties and thirties were the decades of experimental philosophy and astronomy, the decades of the forties and fifties belonged to electricity. The advent of electrical demonstrations in New England occurred as early as 1739 with Greenwood's inclusion of a few "delightful Experiments," mentioned but not described, in the prospectus for his *Philosophical Lectures*. Four years later, the itinerant Scottish demonstrator, Dr. Adam Spencer, advertised that "*having a compleat Apparatus, [he] proposes to begin a Course of* Experimental Philosophy *in Boston as soon as* Twenty *shall have subscribed. . . .*"[90] This course, although apparently never publically delivered, included a few electrical experiments; these were demonstrated in at least one private meeting that was attended by Benjamin Franklin. In his autobiography, Franklin wrote that he had observed "a Dr. Spence" in Boston where he "imperfectly performed" some electrical experiments. Although Franklin remarked that Spencer "was not very expert," he found that the

[90] *BPB*, 30 May 1743, quoted in I. Bernard Cohen, "Benjamin Franklin and the Mysterious "Dr. Spence": The Date and Source of Franklin's Interest in Electricity," *Journal of the Franklin Institute* 235 (1943): 4.

doctor's experiments "on a subject quite new to me . . . equally surprised and pleased me." A year later when Spencer appeared in Philadelphia, Franklin purchased his experimental apparatus, including his electrical apparatus.[91]

Spencer's appearance in Boston predated by two years the Boston publication of a long article in a 1745 issue of *The American Magazine and Historical Chronicle*, reprinted from an article in the *Gentleman's Magazine* (London, 1745), which summarized the current state of research in Europe into "the electric fire."[92] American readers would learn that an "electrised" object produces fire, because "electricity produces flame as well as light, in both respects resembling lightning." They would also learn that since this discovery, electricity had become the "subject in vogue," having "awaken[ed] the indolent curiosity of the public, the ladies and people of quality, who never regard natural philosophy but when it works miracles." The "miracle" of electricity "which man produced from himself, which did not descend from heaven" was precisely what science demonstrators were now eager to exploit.

The subject of electricity had long excited natural philosophers, especially since Newton had included it as one of the active powers he introduced in the *Opticks*.[93] Science demonstrators at the Royal Society, such as Desaguliers, enhanced electricity's drama by introducing special instruments

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[91]Ibid. Cohen unravels not only the identity of Franklin's "Dr. Spence," but also Franklin's discrepancy in recollecting his meeting with Spencer as occurring in 1746, Ibid., 1-6, 14-20. For Spencer's electrical experiments confirmed by notes taken by subscribers to Spencer's course in Philadelphia in 1744, see Ibid., 6-13. Spencer's equipment consisted of a glass tube and some leaf brass, Ibid., *Franklin and Newton, An Inquiry into Speculative Newtonian Experi-mental Science and Franklin's Work in Electricity as an Example Thereof* (Philadelphia: The American Philosophical Society, 1956), 435.

[92]Cohen, *Franklin and Newton*, 431. The quotes that follow are from material Cohen quoted from "An historical account of the wonderful discoveries made in Germany, &c. concerning electricity," *AMHC* (Boston: Rogers & Fowle, 1745), Ibid., 431-32.

[93]Newton's theories of mutual attraction and repulsion especially lent themselves to speculation regarding electricity; for an example of this application as used by Desaguliers, see Cohen, *Franklin and Newton*, 246-257.

in their philosophic experiments and by connecting it to the "higher powers" of the universe.[94] Thus electricity, according to Newton's colleague, Edmund Halley, confirmed "Sir Isaac Newton's notion concerning the existence of an univeral medium which he sometimes calls the ether at other times an electrical spirit and which he apprehended was the cause of the phaenomena of Gravity of Light of Heat and of Electricty."[95] Keeping pace with London science demonstrators, including Desaguliers, Francis Hauksbee and Stephen Gray,[96] Greenwood had introduced electricity as the step-child of Newton to Boston and Philadelphia audiences with the addition to his 1739 lecture series of the "*Effects of* SIR ISAAC NEWTON'S other *Laws of Nature, viz.* . . . ELECTRICITY" along with "*particular Consideration*" of "Mr. *Gray's new* [?] as to *Electricity*."[97] Subsequent lecturers on the Boston scene would not always invoke Newton's name in their popular expositions of electricity, but implicit in their lectures was the use of Newtonian authority wherein electricity was exhibited as yet another of the elements in the "repertoire of wonders" that could "realize powers in matter."[98]

This concept, then, is what informed the use of the term "wonderful" which occurred

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[94]Schaffer, "Natural Philosophy and Public Spectacle," 7. Desaguliers describes the glass tube "commonly us'd in electrical Experiments" as three foot and a half long, an inch and a half in diameter, and one-eleventh thick and usually open at both ends, and describes the proper procedure for "exciting" electricity by rubbing it with the hand in *A Dissertation concerning Electricity* (London, 1742), 5-6.

[95]Quoted in Schaffer, "Natural Philosophy and Public Spectacle," 7.

[96]Ibid.

[97]Greenwood, *Philosophical Lectures*, 4. Some months earlier, Greenwood had introduced "Experiments relating to *Electrical* Bodies" as the penultimate entry in a list of experiments under the general head "Pneumaticks" in *Mathematical Lectures*, 3. Gray's communications to the Royal Society of his accounts of his experiments concerning electricity had been published in *Philosophical Transactions* 37 (1731-1732): 18-44, 227-30, 285-90, and 397-407.

[98]Schaffer, "Natural Philosophy and Public Spectacle," 6, 7-8.

consistently in the advertisements of demonstrators of electricity in Boston.[99] Hence in the first round of electrical experiments in Boston, which occurred in the fall of 1747, William Claggett showed "*the wonderful Phenomena of Electrical Attraction, Repulsion, and flamific Force*"; John Williams performed "*wonderful Operations*"; and Daniel King demonstrated "THE *wonderful and surprising Operations* in Electricity."[100] Claggett, a clock-maker from Newport, advertised that his course would be performed at the house of Captain John Williams. William's interest in electrical experiments had been stimulated by Clagget who had visited Newport between his Boston and Philadelphia visits.[101]

Claggett's series of advertisements encapsulate the fascination electricity held for demonstrators and their audiences, illustrating not only electricity's realization of active powers but also its drama, popularity, and connection with nervous energy that allowed it to be applied to the human body especially in spectacular cures for disease.[102] Announcing his performance as the "*Entertainment of the Curious*," Claggett promised to show the dramatic effects of the electricity, "*particularly the new Method of electerising several Persons at the same time, so that Fire shall*

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[99]Although uneducated in natural philosophy but well versed in religion, many New Englanders would have associated "wonders" with the drama and power of the supernatural world, especially evoked by sermons. For development in the 17th century of the "lore of wonders," its persistence into the 18th, and the tensions it evoked between elite (learned) and popular (vernacular) belief as a rational view of nature gradually developed, see David D. Hall, *World of Wonder, Days of Judgment: Popular Religious Beliefs in Early New England* (Cambridge, Harvard University Press, 1989), Chap. 2, esp. 107-16.

[100]*BEP*, 24, 31 Aug., 7 September 1747, (Clagett); 28 Sept., 5 and 19 Oct. 1747, (Williams); 12 and 19 Oct. 1747, (King).; quoted in Morse, "Lectures on Electricity," 364-65. For electrical demonstrators in Boston, I have relied chiefly on Morse's survey of Boston newpapers, which is the basis of his article.

[101]Cohen, "Franklin and Dr. Spence," 16.

[102]Schaffer, "Natural Philosophy and Public Spectacle," 8-9. Although no advertisements for demonstrations in Boston touted electricity as a medical remedy, the 1 Jan. 1750 issue of the *BEP* carried a notice fromWilliamsburg, Virginia publicizing an electrical demonstration in Suffolk, Virginia that did make these claims, quoted in Morse, "Lectures on Electricity," 366.

*dart from all Parts of their Bodies, as the same as lately been exhibited, to the Astonishment of the Curious in all Parts of Europe.*" Claggett may have based his experiments on those described in a second article on electricity which had appeared in the October, 1746 issue of the *American Magazine and Historical Chronicle.* Touting electrical demonstrations performed in Paris, the article described in detail the construction of the new electrical machine and the "surprizing Phenomena" it could produce. Among the twelve experiments, described in equal detail, was one in which a charge was sent from the electrical machine to the spectators who had all joined hands; the charge passing from one to the other caused them to "spring up at once." The drama of the event could be increased by the demonstrator who could vary the effect by his manipulation of the machine. Would-be demonstrators were warned, however, to avoid "violent shocks" that would produce paralysis in the participants' arms.[103]

Electricity, like astronomy, was a subject appropriate for women as well as men. The only requirement for "Gentlemen and Ladies" to attend electrical demonstrations was a curiosity "to behold those wonders" Claggett promised, plus a ten shilling admission charge—and, perhaps, the desire to emulate the cultural behavior of European trend-setters. Claggett's advertisement, with its emphasis on the spectacular bodily effects of "electerising," suggests his demonstrations went beyond merely "shading into showmanship" to outright entertainment for its own sake. That possession of the proper equipment (rather than academic credentials) was the *sine qua non* of early electrical entrepreneurship in New England is apparent in the maneuvering that followed Claggett's departure from Boston.

John Williams took over Claggett's electrical machine and his course when the clock-maker departed for Rhode Island in early October. By the mid-1740s the glass tube and gold leaf of Dr.

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[103]"Description of the electrical Apparatus used by M.Monnier at Paris, and the surprizing Phenomena produc'd by it," *AMHC* (Oct. 1746): 461-463.

Spencer had been replaced with the "electrical machine" touted in *American Magazine* article; this consisted of a huge globe or cylinder mounted on a wooden frame and rotated, by a cord passed through an axle pulley and a large wheel, with a hand crank.[104] Claggett's notice of his imminent departure in the 28 September *Boston Evening Post* (with an appeal for last-minute spectators) was immediately followed by Williams's announcement that the "*the said Operations would be performed as heretofore*," which had been "*vastly to the Satisfaction*" of those whose curiosity had prompted their attendance. In the meantime, one Daniel King also sought to exploit the curiosity of the public and the apparent success of Claggett, for he advertised that he would perform "near the Town-House in Salem, the *Operations* in Electricity, *lately shewn by Mr.* Claggett *in* Boston." This notice prompted Williams to set the record straight: only the person in possession of the equipment could claim "ownership" of the demonstrations. He exposed King's strategem with a rejoinder in the public prints, reassuring readers that, despite advertisements "that induced" people to think Clagett's "machine" had been removed from his house, he was in fact continuing the "surprizing Operations of Electricity" at his house in Boston.[105] By the middle of November, both Williams and King had passed from public view and with them, the first burst of electrical demonstrations and amateur scientific entrepreneurship in New England.

In the meantime Benjamin Franklin had embarked on a program of experiments to satisfy his curiosity in electricity. Perhaps initally aroused by Dr. Spencer, Franklin's interest probably had

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[104]Cohen, *Franklin and Newton*, 385. According to Cohen, the globes were capable of rotating at a speed of 1100 rpm. and "were excited by having an experimenter hold his hand against them while they were whirled. . . . to facilitate the making of experiments, a gun-barrel was suspended near the globe by insulating strings and received the charge from the globe through "metallic strings" inserted into the barrell and which hung down in contact with the globe, Ibid. For an 18th-century description, see "Electrical Apparatus," *AMHC* (Oct. 1746): 461-62.

[105]*BEP*, 26 Oct., 2 and 6 Nov. 1747, (Williams's rejoinder), quoted in Morse, "Lectures on Electricity," 365-66; for sources of Clagett's and King's advertisements and Williams's initial advertisement, see above, n. 100.

received additional impetus from information in the natural philosophy texts he had been reading; but it definitely was stimulated by the gift of electrical equipment and information from Peter Collinson in 1745.[106] Collinson, the London merchant and Fellow of the Royal Society who had helped procure the Library Company's initial order of books, corresponded with a number of colonial gentlemen-scientists. He had sent a glass tube, directions for its use, the latest German research, and an enthusiastic report of his first-hand experience of the electrical experiments that the "virtuosi in Europe are taken up in."[107] In 1747, Franklin was "totally engrossed. . . . with making experiments," as he wrote to Collinson, to whom he regularly communicated his scientific work.[108] He had gathered a small group of friends who participated in his research. Chief among them was Ebenezer Kinnersley who collaborated with Franklin on many of his discoveries.[109] In 1751, the year that Franklin's communications to Collinson were published in London as *Experiments and Observations on Electricity*, Kinnersley set out on a lecture series, prepared in large part by Franklin, that would display the wonders of electricity in Boston, Newport, Rhode Island, New York, and Antigua.[110]

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[106]Cohen, *Franklin and Newton*, 432-33. Cohen concludes Franklin may not have realized Spencer's experiments were electrical until alerted by his reading and Collinson's gift; Ibid., 435.

[107]Ibid., 432-34; quote, Collinson to Cadwallader Colden, in Ibid., 433.

[108]Ibid., 434-35.

[109]For a biography of Kinnersley, who became a professor of English and oratory at the College of Philadelphia (University of Pennsylvania), see Clark Elliott, ed., *Biographical Dictionary of American Science, The Seventeenth through the Nineteenth Centuries* (Westport, Ct.: Greenwood Press, 1979), 147. For insight into his working relationship with Franklin and description of many of his experiments, see Kinnersley to Franklin, 12 Mar. 1781 in *The Papers of Benjamin Franklin*, ed. Leonard W. Larabee, vol. 9 (New Haven: Yale University Press, 1966), 282-93.

[110]Cohen, "Franklin and Dr. Spence," 25-25. For an extended treatment of Kinnersley's lectures as well as his life and scientific achievements, see *Benjamin Franklin's Experiments, A New Edition of Franklin's "Experiments and Observations on Electricity,"* ed. and intro. I. Benard Cohen, (Cambridge: Harvard University Press, 1941). For an analysis of Franklin's work leading to publication, see Cohen, *Franklin and Newton*, Chap. 10, 429-28.

Kinnersley's advertisement of his course in the *Boston Evening Post* on 7 October, while touting the latest and "most curious" experiments made in Europe, also promoted "a considerable number of new Ones lately made in *Phladelphia.*" Like the science entrepreneurs who had preceded him, Kinnersley addressed his advertisement to both "Ladies and Gentlemen"and promised to exhibit "entertaining and astonishing Wonders of Nature." He performed the course in a two-part series before a "company" made up of at least twenty spectators (the number determined by the advance-ticket sales) in the public setting provided by Boston's Faneuil Hall. The lectures continued "each fair day" through the week of 20 January 1752; the five-month run was due in part to popular interest and in part to frequent interruptions caused by damp or cold weather (which interfered with the ability of the elecrical machine to produce an electrical charge). On 13 January, Kinnersley advised the public the apparatus had been removed from Faneuil Hall to the house of "James Gooch, Esq.," where the "Inconveniences may be remedied in a smaller room with a good Fire." At this time he also advised holders of outstanding tickets and others inclined to attend "to be expeditious" since the apparatus would shortly be leaving for Newport and New York. With an eye on the business end of his scientific endeavor, Kinnersley reiterated that the price remained "half a Dollar for each Lecture," cautioning "which Price will not, as some have expected, be lowered."[111]

The format and course content (outlined in the initial advertisment) reveal the serious intent and research that underlay the course. Kinnersley proposed to elucidate his experiments with "methodical LECTURES on the Nature and properties of "that wonderful Element" which would be delivered in a two-part lecture series. Enhancing Newtonian methodology with a metaphysical application, he piously reminded prospective "spectators" that "the Knowledge of nature tends to enlarge the human Mind, and give us more noble, more grand and exalted ideas of the AUTHOR of

[111]*BEP*, 7 Oct. 1751; 4 and 18 Nov. 1751; 13 Jan. 1752; 20 Jan. 1752; quoted in Morse, "Lectures on Electricity," 367-70.

Nature." In addition to its higher moral purpose, the knowledge of nature illuminated by electrical experimentation also had a utilitarian end, for, he maintained, "if well pursu'd [it] seldom fails producing something *useful* to Man."

Items one through nine of the first lecture establish the theoretical background of the "Electric Fire" showing that it is a "real Element . . . *collected* out of other Matter" and "a subtile Fluid," that is "intimately mixed" with all other substances whose "Parts do not mutally attract, but mutually repel each other," while it is "strongly attracted by all other Matter." Having established the nature and characteristics of electricity, Kinnersley proceeded to eleven experiments that included such vivid and reverberating effects as "Fire darting from a Lady's Lips," "Eight musical Bells rung by an electrified Phial of Water," and "A Battery of eleven Guns discharged by Fire issuing out of a Person's Finger." In the midst of these, Kinnersley made the appropriate bow to Newton by "A Representation of the seven Planets, shewing a probable Cause of their keeping their Distances from each other, and from the sun in the Center."

The second lecture comprised twenty demonstrations and commenced with perhaps the most spectacular and intriguing of the experiments in the repertoire of European natural philosophers: "Mr. *Muschenbrock's* wonde[r]ful Bottle" [i.e. condenser]. Also known as the "Leyden experiment," this experiment, accidently (and nearly mortally) discovered by the Dutch scientist in 1746, drew a dangerously large amount of electricity into a glass vial held in the hand of the experimenter while he also touched the gun barrel which conducted the charge from the whirling globe via the gun barrel and a wire into the vial.[112] In the seventh experiment, Kinnersley introduced the "Various Representations," and the cause and effect of Lightning, "explained by a more probable *Hypothesis* than has hitherto appeared [emphasis mine]." Kinnersley here hints at the direction Franklin's research had taken, but as yet is unable to identify lightning and electricity as the same

[112]Cohen, *Franklin and Newton*, 385-86.

element. Consequently, most of the remaining experiments attribute their shocking action to the "electric spark."[113] The lecture ends with a variation of the previous day's electrifying conclusion: the battery of eleven guns, discharged by a spark after passing through ten feet of water, sounds a thunderous finale.

Just as Greenwood had employed science and theatrics to spectacular effect, Kinnersley dramatically drew the electric spark from his whirling machine in a compelling display of electricity's active powers. The drama inherent in electricity enhanced the theatrical appeal of its demonstration, while it also enhanced the natural philosopher's role as the manipulator of natural powers. Following his appearance in Boston, Kinnersley took his traveling show to Rhode Island where he promoted his lectures by means of a broadside advertisement published in Newport. Prominently dispayed in public areas, the broadside itself (which reproduced the entire newspaper advertisement) became part of Kinnersley's display of electricity and part of the discourse of its viewers. It would disseminate the content and an image of his course to an audience who would learn the wonders of electricity second-hand. It would also stimulate an imaginative experience reinforced by each participant's own real experience of lightning—nature's astonishing wonder with which they were familiar.

Two years after Kinnersley's departure, the performance of electrical experiments resumed in Boston, although on an intermittent basis and at the hands of one Joseph Hiller, a "jeweller" by trade. His first advertisement in March 1754 simply announced "Electrical Experiments exhibited near the Old North Meeting House, Boston in two parts, price, one pistarene each part."[114] Two

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[113] In the published version , *A Course of Experiments, In that curious and entertaining Branch of Natural Philosophy, called Electricity; Accompanied with explanatory Lectures: In which Electricity and Lightning, will be proved to be the same Thing* (Philadelphia, 1764), he make the identification explicit. Cf. Lecture II, Items VII, VIII, IX, X, XIV, and XV of the advertisement with Lecture II, Items VIII, IX, XI, X, XIX, and XX, respectively.

[114] *BG*, 5 Mar. 1754; quoted in Dow, *Arts and Crafts*, 70.

years later he again appeared in the public prints, with a "NOTICE TO THE CURIOUS *That the* Electrical Experiments *with Methodical Lectures exhibited last Winter near the* Blue-Ball, *are now exhibited in* Orange Street. . . . *By* Joseph Hiller, *Jeweller*."[115] Another two years later, he advertised, "Electrical Experiments, with Methodical Lectures, are again exhibited by him . . . one Pistarene each Lecture."[116] Hiller's advertisements suggests he modeled his electrical demonstrations after those of Kinnersley in that he exhibited the experiments in two-parts accompanied by "methodical" lectures—perhaps taking advantage of an audience established by Kinnersley. Hiller's appearance as a part-time experimenter, with apparently no academic training to recommend him, also illustrates the susceptibility of electricity to entrepreneurship as does the case of the next experimenter to appear in Boston, one David Mason.

In 1765 Mason advertised "*A Course of Experiments* On the newly-discovered ELECTRICAL FIRE; to be accompanied with methodical LECTURES on the Nature and Properties of that wonderful Element."[117] The course would be in two lectures, would take place four nights a week, "Weather permitting," at his house near Sudbury Streeet, and would cost one pistareen each lecture. If Mason's opening announcement sounds suspiciciously like that of Kinnersly, the five experiments he describes in the advertisement are exact duplicates of those Kinnersly had previously performed in Boston. For example, Mason would demonstrate "Fire darting from a Lady's Lips," "A Representation of the seven Planets . . ." and "A Battery of Eleven Guns discharged by the Electric Spark. . . ." In addition Mason, unlike Kinnersley, would perform "several Experiments shewing

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[115]*BG*, 1 and 8 Mar. 1756; quoted in Morse, "Lectures on Electricity," 371.

[116]*BG*, 9 Jan. 1758; quoted in Dow, *Arts & Crafts*, 70.

[117]*Boston Gazette and Country Journal*, 7 and 14 Jan. 1765; quoted in Morse, "Lectures on Electricity," 371-72. Mason's advertisement does not reveal any personal information; he may have been a veteran of the Seven Years War, the "David Mason, Japanner" who, in 1758, advertised the opening of a Shop [under Edes and Gill's Printing Office] after returning from three-year's "Service to the Westward," *Boston Gazette*, 18 Dec. 1758; quoted in Dow, *Arts & Crafts*, 267.

that the Electric Fire and Lightning are the same; and that Points [lightning rods] will draw off the Fire so as to prevent the Stroke."[118] Although Kinnersley's Boston course had predated Franklin's discovery of the true nature of lightning and his invention of the lightning rod, by 1765 this information was available to would-be demonstrators, (such as Mason) in the published version of Kinnersley's course or even more readily in local newspaper accounts.[119] The activity of Hiller and Mason indicates that Kinnersley had provided a model for part-time electrical lecturer-demonstrators who, armed with his course outline and the proper machine, could proceed without benefit of academic training or credentials. Hiller's series of advertisements indicate that he was able to carve a niche by making electrical demonstrations into an annual winter entertainment that curious Bostonians patronized over a span of five years. Mason's case is more problematic; that no other advertisements for his exhibits appeared in the public prints suggest his venture into electrical entrepreneurship did not succeed.

Seven months after Mason's brief flare, William Johnson, took center stage with an advertisement for yet another "Course of Experiments in that instructive and entertaining Branch of Natural Philosophy, call'd ELECTRICITY," after having conducted an earlier round of electrical demonstrations in Newport, Rhode Island.[120] Johnson presented himself with no other qualifications than that of "Gentleman," and the ability to turn a phrase that enlivened his advertisement and, no

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[118]Mason's somewhat shortened descriptions are lifted directly from the corresponding items in Kinnersley's advertisement of his Boston demonstration, *BEP*, 7 Oct. 1751; reprinted in Morse, "Lectures on Electricity, 367-68, see Lect. I: I, II, VI, XV, XVII, XVIII, and Lect. II: XV (except that Mason says eight feet of water, while Kinnersley has ten feet).

[119]Kinnersley, *Course of Electricity*, Lect. II: VIII and XVII. For newspaper accounts of lightning rods, see Chap. III above. Mason may also have seen Franklin's announcement of the lightning rod with directions for construction in *Poor Richard's Almanack for . . . 1753*; Cohen, "Prejudice Against Lightning Rods," 401-02.

[120]*BG*, 12 Aug. 1765; quoted in Morse, "Lectures on Electricity," 372-73; *Newport Mercury*, 7, 14 Feb. 1764.

doubt, his demonstrations. Unlike the straight-forward tone of Mason's advertisement, Johnson's verges on the sensational as does his description of his "agreeable Entertainment." Thus Johnson would show in the second lecture that lightning is "one of the most awful Powers of Nature" whose effects "are imitated by the Electric Fire, such as, killing Animals, melting Metals, tearing and rending Bodies thro' which it passes." Having exploited his audience's fears, Johnson then calmed them by promising he would also show "A practical Method of preserving Ourselves and our Houses," the proof of which, Johnson claimed, "has not yet been exhibited to the World." Lest he appear presumptuous in appearing to tamper with nature (i.e., Divine action in nature), he added the caveat, that "endeavoring to guard against Lightning . . . [is not] inconsistent with any of the Principles of natural or revealed Religion." His course description concluded with now-familiar catchphrase inspired by Newtonian wonders, asserting that "Knowledge of Nature"enlarges the human heart and leads to "more exalted Ideas of the God of Nature." And thus, he hoped his course "will prove, to many, an agreeable Entertainment."

Despite Johnson's claims that his experiments were "intirely new"and "not yet exhibited to the World," his course, published in 1765, was closely based on the course Kinnersley had published only a year earlier.[121] Kinnersley had adapted the two-part course he had developed in 1751 to include demonstrations (as his title indicated) "In which ELECTRICITY and LIGHTNING, will be proved to be the same Thing."[122] Johnson performed the same experiments (with a few exceptions), but he enlarged the description of several to impart a more realistic or even lurid character. Whereas

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[121]William Johnson, *A Course of Experiments, In that Curious and Entertaining Branch of Natural Philosophy, Call'd Electricity; Accompanied with Lectures on the Nature and Properties of the Electric Fire* (New York, 1765). Although the actual experiments seem to be directly copied from Kinnersley, Johnson's thoretical explanation of electricity, unlike Kinnersley's, incorporated the terms "positive" and "negative" in describing electricity's properties, see Lect. I: XII, XIII, and XX and Lect. 2: XVII; cf. Kinnersley, *Experiments in Electricity and Lightning*, Lect. I: XV and XVIII.

[122]See above, p. 33.

Kinnersley would demonstrate "A bright flash of real Lightning, darting from a Cloud in a painted Thunder-Storm," Johnson would demonstrate the flash of lightning, "darting from a painted Cloud, so as to give the most beautiful and natural Representation of a real Thunder-Storm." And where Kinnersley would show, "Electricity . . . to be the same with Lightning," Johnson would show, "The electric Element . . . to be real Lightning, from the Simularity of the Effects in tearing and rending Bodies thro' which it passes." Kinnersley would perform an experiment showing how houses and ships "may be secured from being damaged by Lightning," while Johnson would show "how to avert the Course of a Flash of Lightning from Buildings, Ships, &c. so as to prevent it from doing them the least Damage." Additionally, Johnson, unlike Kinnersley, would show how to "intirely" prevent an "impending Stroke of Lightning."

Like Kinnersley, Johnson had prefaced his course with the familiar Newtonian catchphrase, each using it as the basis for the presumption that his course "*will meet with Encouragement, as a rational and agreeable Entertainment.*" Both demonstrators' introduction of painted scenery (to simulate clouds and lightning) and props (model houses, buildings, and ships) highlighted the entertainment value of their performance and reinforced the theatrical nature of their enterprise. What may appear as minor differences in their course descriptions and experiments illustrate, however, that the characterization and display of electricity could be manipulated according to each experimenter's agenda and his perception of his audience. Even though Johnson's course included the theoretical (i.e., "rational") foundation of electricity, he slanted his advertisement and his experiments to emphasize the spectacular nature of the "electric fire"—a much more dramatic appellation than "electricity." He thus appealed to the "agreeable" rather than "rational" emotions of his spectators. And in terms of eighteenth-century parlance, his "entertainment" may have incorporated elements of "lower comedy" as well as "dramatick performance."[123]

From Boston, Johnson continued his successful tour, entertaining audiences at Burn's City Arms Tavern in New York and at the Library Room in Charleston, South Carolina.[124] When Bostonians learned of his death four years later, he was hailed "as a Gentleman well known by his ingenious Lectures and Experiments in Electricity."[125] The ingenious Johnson, in the manner of a true entrepreneur, had studied his audience as well as his subject. He had cast a canny eye on the the market for electricity and found the electric fire kindled a popular response, which stood him in good stead when he advertised to "the Polite and sensible Part of the Town" that his lectures "would prove as agreeable an Entertainment as a Puppet Shew."[126]

Although there would be no more formal electrical displays in New England in the 1760s and 1770s, electricity remained a vital force in the lives of its residents. As seen in Chapter III, electricity and lightning rods reoccurred as subjects of discourse whenever thundergusts and lightning shook New Englanders' homes and rattled their beliefs in the principles of natural or revealed religion. And it indubitably occurred as the subject of informal demonstrations. Loammi Baldwin of Woburn, Massachusetts could not have been the only amateur experimenter inspired to imitate the activites of "professional" experimenters. In 1771 he built an "electrical kite" that he launched "in the most piercing shafts of lightning and tremendous thunder."[127] In a detailed account

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[123]Samuel Johnson, *A Dictionary of the English Language in which Words are Deduced from Originals* (London, 1755).

[124]Carl Bridenbaugh, *Cities in Revolt: Urban Life In America, 1743-1776* (New York: Alfred A. Knof, 1955), 416.

[125]*BPB*, 13 Feb. 1769; quoted in Morse, "Lectures on Electricty," 373.

[126]Bridenbaugh, *Cities*, 416.

[127]*American Herald*, 2 July, 1786; quoted in Morse, "Lectures on Electricty," 373-74. Baldwin communicated his experiment to the American Academy of Arts and Sciences by letter, 26 May 1783.

recorded some years later, Baldwin recalled that his electrifying performance was witnessed by his "astonished" parents and neighbors. Like the unknown spectators outside Bromfield's window, these ordinary men and women were part of a vernacular audience whose second-hand exposure to the display of Newtonian science aided in the formation of Newtonian culture in New England.

Ordinary men and women were part of the general public whose exposure to the wonders of Newtonian philosophy could occur in events that had no pretense to "scientific" endeavors. Felix Fissour solicited subscriptions from "Ladies and Gentlemen" to underwrite "The FIRE-WORKS" he displayed for the "Satisfaction" of the "Public" at Boston Common in November of 1769.[128] Among the "very beautiful Works, far exceeding any Performance of the Kind" ever before in Boston, Fissour listed two "curious Pieces" that may have been especially exciting. Following the "horizontal Wheel adorned with yellow and purple Italian Candles," Fissour would explode "a Tornant [torrent?] representing a Chinese Fire forming the Sun and the Moon" and "[a piece that] will communicate Fire to a large fixed Sun." Fissour had improved the display of astronomy in truly spectacular fashion by the application of electricity. His apparent use of the electric fire illustrates how active powers could be co-opted by entrepreneurs and directed toward a public audience. Although an informal demonstration, the firework's success depended on the careful orchestration of active powers, at the direction of the showman whose goal was to astonish and amaze.

Finale—Pneumatics—"made sensible" on the Air Pump

By the 1770s, pneumatics had assumed center stage in the display of natural philosophy in New England. Daniel Eccleston literally took his turn on the stage when he appeared at Boston's Concert Hall with the presentation of "Two LECTURES on PNEUMATICS; or that part of Natural

[128]*BEP*, 23 Oct. 1769.

Philosophy which treats of the nature and properties of the Air" in June, 1770.[129] As electricity had the electrical machine, so pneumatics had the air pump, which Eccleston promoted as "that curious machine by which the several wonderful properties and effects of the Air are demonstrated, and in a very entertaining manner made sensible to." His mention of the "sensible" effect of the air pump is an accurate representation of the allure of air-pumps, for their power "resided in their capacity to enhance perception and to constitute new perceptual objects."[130] This was the fascination the air pump held for both natural philosophy demonstrators and spectators. Like other tools of early science, particularly telescopes and microscopes, air pumps made essentially invisible things visible or gave them "visual manifestations."[131] Thus the air pump gave "visual manifestation" to the pressure of the air, just as Kinnersley's electric machine manifested the "charge" of electricity, Greenwood's "optic glasses" revealed the planets, and Bromfield's solar microscope displayed the "motes" in the air.

The air pump was developed by Robert Boyle in the 1650s for his experiments in pneumatics, many of which were performed for the Royal Society. Popularized by the publication in 1660 of his *New Experiments Physico-Mechanical*, it became a powerful emblem of the new experimental philosophy.[132] The air pump soon became part of the stock-in-trade of demonstrator-entrepreneurs, whose object was to entertain the curious by displaying the wonders of the natural

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[129]*BNL*, 21 and 28 June 1770. Eccleston also lectured on the "nature, use, and best construction" of barometers, thermometers and hygrometers. His charge was one-half dollar, each lecture.

[130]Stephen Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton: Princeton University Press, 1985), 36-37. Shapin and Schaffer examinine Boyle's development of the air pump as a "political" instrument in reference to the use of intellectual knowledge.

[131]Ibid., 37.

[132]Ibid., 26, 30. For its use in 16th- and 17th-century iconography, see Ibid., 32-35.

world.[133] Just as the English virtuosi had grafted pneumatics onto their repertoire of Newtonian experimental philosophy, Greenwood had introduced this subject to his Harvard classes, no doubt with the use of the apparatus he described in the 1738 catalogue of the Hollis apparatus as "A large double Air Pump with its apparatus."[134] Pneumatics was one of the four topics Greenwood planned to treat in his *Course of Mathematical Lectures and Experiments*, although by 1739 he no longer had the use of the Hollis air pump. When he delivered his *Course of Philosophical Lectures* (expressly designed to confirm Newton's laws of matter and motion) in Philadelphia in 1740, he incorporated pneumatical experiments performed upon the Library Company's air pump.[135]

Eccleston's advertisement claimed the air pump was unrivalled when it came to both the number and the "entertainment" value of the experiments it afforded. The drama of the entertainment afforded by the air pump is strikingly conveyed by Joseph Wright's exploitation of the air pump as an artifact of polite science in a painting executed *ca.* 1767-68 and exhibited in London in 1768.[136] Engraved as a mezzotint in 1769 by Valentine Green and widely distributed by the publisher, John Boydell, *An Experiment on a Bird in the Air Pump* provided a model for philosophic conversation as well as demonstration. Although Eccleston's notice does not list any experiments he would perform, the most dramatic experiment on the air pump involved placing a bird within the

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[133]Plumb, "The Acceptance of Modernity," in Neil McKendrick, John Brewster, and J. H. Plumb, *The Birth of a Consumer Society: The Commercialization of Eighteenth-Century England* (Bloomington: The University Press, 1982), 328.

[134]For a description of the Hollis air pump, see Cohen, *Some Tools of Early Science*, 141.

[135]Greenwoood introduced pneumatics in Lectures 11 and 12 under the topic "*Of the Effects of* GRAVITATION, as to the EARTH in *particular. Of the* Fundamental Pinciples *with many Experiments relating to* FLUIDS, HYDOSTATICAL AND PNEUMATICAL," *Philosophical Lectures*, 3.

[136]For provenance and exhibition history, see Nicolson, *Joseph Wright*, I:235; for description and iconography, see Judy Egerton, *Wright of Derby*, 58-61; for the air pump's significance concerning its moral use as an instrument of polite science, see Walters, "Conversation Pieces,' 139-40.

glass vacuum jar, mounted atop the frame, as in Wright's depiction. When the demonstrator turned the handle, the crankshaft activated the pistons which withdrew air from the jar. The drama, of course, lay in the frenetic exertions of the bird as the air supply dwindled. By manipulating the handle, the demonstrator controlled not only the life of the animal but the emotions of his audience. Unscrupulous demonstrators exploited this power, much like electrical "showmen" exploited the power inherent in electrical machines, to create sensational rather than rational entertainment.

Eccleston avoided appealing to the sensational, proclaiming instead, the "rational" and "agreeable" nature of the entertainment he would provide. Such satisfaction would be found especially by "those happy enough to have any taste for literary knowledge." With this subtle appeal, (appearing for the first time in science demonstration advertisements), Eccleston suggests persons of fashion, or those aspiring to the cultural stature afforded by acquaintance with the literary world, would find cultural validation in attending his demonstrations. Eccleston pointedly courted the attendance of women as well as men by headlining his notice, "To the Ladies and Gentlemen in *BOSTON*." Like Greenwood in advertising his lessons on the orrery, Eccleston adapted his course to meet the requirements of those "who may perhaps not have made Philosophy a previous study," by taking care "to make every proposition and experiment as plain and evident as the nature of the subject will admit to." Unlike Greenwood, however, Eccleston delivered his lectures to a mixed audience. Although women's access to higher education had remained unchanged in the nearly forty years since Greenwood lectured on the orrery, their participation with men in cultural events, sanctioned by the "improvements" of science, was now taken for granted.

Yet Eccleston made no appeal to the the religious sentiments Greenwood had evoked with his allusion to the moral lessons the orrery provided. Nor did he emphasize the "wonderful" aspects of the air-pump's revelations. Rather, in mentioning the "wonderful properties and effects of the Air," he balanced them against the "rational and agreeable manner" in which the air pump operates.

The public performance of natural philosophy, it would appear from the advertisement, has now become less concerned with revealing the divine arm in nature and more concerned with displaying the mechanics of nature. Moreover, this display took place in a fashionable milieu before a select audience of thirty men and women seemingly motivated by social aspirations rather than the expression of piety.[137] The ladies, coiffed by an expert hairdresser, and gentlemen, small-swords at their side, met for performances on the air-pump at Boston's Concert Hall, a site "well calculated for publick Entertainments. . . . being the genteelest of any in America," where previously they may have heard performed "A Grand CONCERT of Vocal and Instrumental MUSICK."[138] Their public acquaintance with natural philosophy, like their fashionable attire, was a social emblem attesting to their assimilation of metropolitan values and culture. Here in this setting, science became the handmaid, not of religion, but of fashion, as piety receded in its interplay with politeness and Newtonian philosophy.

Eccleston's performance at the Concert Hall brings to an end the newspaper accounts of the formal demonstration of natural philosophy in New England before the onset of civil war between England and the colonies.[139] The nearly fifty years that had elapsed between Greenwood's first

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[137]Eccleston states 30 is the maximum that can "conveniently" attend; he also offered private lectures for companies of 20 to 30 ladies and gentlemen. His advertisements indicate he delivered two-lecture series that met on the Thursday and Friday of the weeks of 21 and 28 June 1771. See advertisements of those dates, *BNL*.

[138]Advertisements by "Fay, Ladies hair-dresser," *BNL*, 31 May, 1770; William Pope, "Dancing, Small-sword," Ibid., 6 July 1770; "Gilbert Deblois Notifies . . ." (sale of the Concert-Hall), *BEP*, 25 Sept. 1769, and "This Evening . . . Mr. Flagg," (concert admission, "Half a Dollar each"), *BNL*, 7 June, 1770.

[139]Not until Osgood Carlton lectured in Boston on "that sublime Science," astronomy in 1787 and Isaac Greenwood's son and namesake appeared in Newport 1787with his electrical machine did the public performance of astronomical and electrical demonstrations resume, "By Permission, Mr. Carleton, Professor of Astronomy, Proposes. . . . ," Broadside (Boston, June 20, 1787); "Sublime Entertainment. . . . A brilliant ELECTRICAL EXHIBITION; By I. GREEN-WOOD," Broadside (Providence, R. I., Feb. 1793). Greenwood's broadside indicates demonstrators were turning to a more inclusive audience, for he solicited the "Ladies and Youth of both Sexes" and

lecture on mechanical philosophy and Eccleston's demonstration of the air pump provided an exposure to the new science embodied in the principles of Isaac Newton. Instead of the written accounts of Newtonian philosophy, which the public encountered in almanacs and newspapers, Greenwood and his fellow demonstrators brought science to a new site where it entered the realm of performance. On the lecture stage, the various branches of natural philosophy were performed upon apparatus designed to manifest the hitherto hidden powers of nature before audiences who were entertained as well as instructed. Academically trained natural philosophers such as Greenwood and Kinnersley balanced the drama of active forces with careful explanations of their theoretical origins and, in the case of astronomy and electricity, acknowledged the moral lesson they afforded. Other demonstrators, seemingly more motivated by entrepreneurial impulses, such as Johnson, exploited the sensational appeal of their apparatus and the emotions of the audience. Still others, such as Eccleston, promoted the fashionable appeal of natural philosophy to reinforce the rational and secular values of a polite audience. Such was the flexibility of the new science that it could be manipulated by each of its demonstrators to respond equally to the pious or the rational needs each perceived in his audience. And, as the case of the anonymous poet who immortalized Greenwood illustrates, spectators could overlay their own beliefs on the framework of Newtonian philosophy.

The circumstances of Greenwood's semi-public lectures in experimental philosophy and astronomy show how carefully he cultivated his spectators. Taking advantage of a developing market for imported English culture, goods, and intellectual fare, he "pitched" the new science initially toward those men and then toward both those men and women who had the resources to invest both money and time in the pursuit of the new science. He used his connections to the English virtuosi, especially to his mentor, Desaguliers, as the basis for his lectures, while he

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proposed on the fifth and list night's demonstration "to give Black People [admittance] so that they may be somewhat enlightened."

explicitly exploited the principles of Newton via machines created by human art in order to interpret the wonders of the natural world. While occupying the Hollisian chair, his professional indebtedness to his Harvard patron necessitated that he adapt his lectures to the religious sentiments of his principal benefactor—an adaptation, however, that was as suitable to the metaphysical interpretation of Newtonian astronomy as it was compatible with "polite" astronomy. Although Greenwood was unable to create a market large enough to support an independent career, through his courses and the attendant publicity, he created a climate receptive both to the performance of natural philosophy and to the philosopher's role as the spokesman for the hidden laws of nature.

With new discoveries in electricity and pneumatics, aided by the development of apparatus that dramatically manifested the active forces of lightning and air, demonstrators had an even more potent arsenal at their command. The availability of apparatus and the dissemination of information via newspapers, magazines, and catalogues printed in broadside or pamphlet form ensured that electricity found a popular outlet in the hands of semi-skilled tradesmen, rather than formally trained science entrpreneurs. Their advertisements, like those of Greenwood and Kinnersley, reveal the marketing techniques they crafted to sell Newtonian philosophy. Their newspaper notices also provide an insight into the religious and intellectual values of their prospective audiences and show how lecturers manipulated their demonstrations to accommodate them. By the time Eccleston performed upon the air pump, natural philosophy, responding to the demands of a social class motivated by consumerism and rational belief, acted as a validation of polite society. For genteel audiences, Newtonian science had rationalized the natural world. In this world meteors sported in the skies, and once-dire lightning provided no more than a dramatic background for genteel lovers' entertainment, as pictured in the engraving which illustrated a "popular romance" published in Boston in the 1760s (fig. 4.4).[140]

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[140]"The Thunder Storm," *The Royal American Magazine* (Jan. 1774).

Through the advertisements of science demonstrators and the publicity they generated, as well as their attendance at both formal and informal displays, the general public also apprehended the wonders of Newtonian active forces. Thus, ordinary women and men would learn of the demonstrators' potent role in the theatrical recreation of Newtonian natural powers and share in the drama that unveiled nature. In 1772 the Seneca chief, Kayashta, attended an electrical performance in Philadelphia by Edward Kinnersley, whom he had seen perform on a previous visit. Certainly Kayashta's perception of Kinnersley's power as the re-creator of Newtonian forces was not unique; he had wanted to see again, he explained, "Thunder and Lightning produced by human Art."[141] Hence it was as the artful producers of Newtonian forces, that natural philosophy performers played the most dramatic role in the formation of Newtonian culture in New England.

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[141]The incident and quote are mentioned by Bridenbaugh, *Cities in Revolt*, 416.

## CHAPTER V

## SCIENCE OBSERVATIONS AT HOME: "DOMESTICATING" NATURAL PHILOSOPHY

Clearing a space for her pen, paper, and inkwell at the desk "adorned with a variety of authors"[1] on history, theology and natural philosophy, Hannah Winthrop reflected on recent events, both public and domestic, from her vantage at home in Cambridge, Massachusetts. With the new year of 1777 came news that the " Scale [of war] is turnd greatly in our Favor"; the "Sage Venerable Mentor" [Benjamin Franklin] had again "gone beyond [the] Sea" to engage in negotations; and her sister had been obliged to undertake yet another move—the fifth—since the burning of Charlestown; and she herself was lately "an humble Attendant" to her husband's observations of an lunar eclipse of the sun.[2] Madam Winthrop industriously applied pen to paper—any news of the war would be welcome to her childhood friend and dearest correspondent, Mercy Otis Warren. Although preoccupied in her rural Plymouth, Massachusetts home with her five sons and the Whig politics of her husband, Mrs. Warren was a keen observer of the war and through her poetry and plays, an acute commentator on politics. Both women had supported their husbands' active advocacy of the colonies' overthrow of the burdensome yoke of English oppression. Following the outbreak of hostilites, James Warren, then Speaker of the Masachusetts House, served as a member of the Navy Board for the eastern department, although John Winthrop's age and frail health, if not his position

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[1]Hannah Winthrop to Mercy Otis Warren, Jan. 9, 1778, W-W Papers; Winthrop mentions books on these topics in various letters to Warren. The W-W Papers include 50 letters (46 from Winthrop, 4 from Warren) that survive from their correspondence that extended from late 1768 to at least 23 March 1786 and dealt with intimate family news as well as contemporary political and military events; some are reproduced in whole or part in "Warren-Adams Letters, Being Chiefly a Correspondence among John Adams, Samuel Adams, and James Warren" Vol. 1, 1743-1777, MHS *Collections* 73 (1925), 283 (hereafter "W-A Letters," ).

[2]Winthrop to Warren, Jan. 14, 1777, W-W Papers; "W-A Letters," 1:283-84.

as Hollis professor of mathematics and natural philosophy at Harvard, precluded his active involvement in military affairs. Mercy Warren's admiration of Professor Winthrop's scientific endeavors, however, was no less fervent than Hannah Winthrop's admiration of Colonel Warren's military activities.[3]

After a sally deprecating General's Howe's latest boast to conquer America, Mrs. Winthrop paused in her writing: Would her "dear Friend," she wondered, charge her "with an Affectation of dabbling in Astronomy" if she revealed her participation in her husband's latest scientific observation. Despite her doubts, she proceeded with an elegantly refined description "of Cynthia in Eclipsing that glorious Luminary that rules the Day." Drawing a practical and moral conclusion, she remarked that the eclipse and other celestial phenomena are "great Points to an astronomer, tho the greater part of Mankind are . . . inattentive to these Glorious works of an almighty Creator." With a nod to the conventions of polite discourse, she concluded, "Now [if] I have incurrd your Censure," "pray pass Sentence."

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[3]Warren to Winthrop, Feb. 1773; Winthrop to Warren, 12 April 1773, W-W Papers.

Hannah Fayerweather Tolman Winthrop (1726-1790), daughter of Thomas and Hannah Waldo Fayerweather of Boston, sister to Samuel Fayerweather (Harvard, 1743, and thus, a student of John Winthrop), and widow of Farr Tolman married John Winthrop in 1756. Winthrop had married first Rebecca Townsend in 1746; she died in 1753, leaving four sons whose care Hannah assumed, *SHG* 10:246-48. For John Winthrop's political activities, see Ibid. 257-62.

Mercy Otis Warren (1728-1814), daughter of James and Mary Allyne Otis of Barnstable and sister of James Otis, married James Warren in 1754. Her brother and husband (Harvard, 1743 and 1745, respectively) were both students of John Winthrop. For her poems and plays, see *The Plays and Poems of Mercy Otis Warren*, comp. and intro. Benjamin Franklin V. (Delmar, N. Y.: Scholars' Facsimiles & Reprints, 1980). Warren's literary works, correspondence with Revolutionary leaders, and patriotic activities have garnered scholarly attention from the mid-19th century on; for a concise recent biography that also evaluates earlier sources in relation to her literary life and works and includes a valuable annotated bibliography of all secondary sources, see Jeffrey H. Richards, *Mercy Otis Warren*, New York: Twayne Publishers, 1995; for her writings as a source of the ideal of "Republican Motherhood," see Linda Kerber, *Women of the Republic: Intellect and Ideology in Revolutionary America*, Chapel Hill: University of North Carolina Press, 1980. For James Warren, see *SHG*, 11:584-606.

Hannah Winthrop's attendance upon her husband's observation of the eclipse and her subsequent remarks to Mercy Warren provide another insight into Newtonian culture in New England. This incident, like that involving Edward Bromfield and his female guest, reminds us that women could participate, albeit through a husband or a mentor, in the practice of science. But more significant are Winthrop's comments to Warren, for they reveal the contemporary attitudes that determined the prescribed extent, nature, and meaning of that participation and the two women's own negotiations between prescription and practice. From her remarks, it is apparent that Mrs.Winthrop's participation in scientific activity was motivated not by fashion's dictates but rather by "rational,"(i.e., "agreeable to reason")[4] and religious concerns. This chapter will examine their correspondence from the late 1760s through the early 1780s in so far as it touches upon their view of themselves and of their "proper" domestic role in order to tease out contemporary attitudes toward women in the context of Newtonian culture. Mrs. Winthrop's participation in the domestic practice of science, however, was not unique. This chapter will look at a few other recorded instances of such female activity, against the backdrop of male activity examinined in the preceding chapters, as a means of highlighting the differences and similarities in female and male roles, intentions, and results in the practice of science.

Like Mercy Warren, Hannah Winthrop was a member of a privileged class that allowed the opportunity for education and leisure and, hence, the opportunity to engage in and discourse upon intellectual pursuits. The constraints facing women without these advantages are no better expressed than by Jane Franklin Mecom, the wife of a Boston tradesman, mother of twelve children, and sister of Benjamin Franklin. Reflecting on her life, she wrote to Franklin in 1786, "Dr. Price [her minister] thinks Thousands of Boyles Clarks and Newtons have probably been lost to the world,

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[4]Samuel Johnson, *A Dictionary of the English Language in which the Words are Deduced from Originals* (London, 1755).

and lived and died in Ignorance and meanness, mearly for want of being Placed in favourable Situations, and Injoying Proper Advantage, very few we know is able to beat thro all Impedements and Arive to any Grat Degre of superiority in Understanding." In constrast, both Mercy Warren and Hannah Winthrop, although responsible for child-rearing and household management, were placed in favorable situations and enjoyed their advantages.[5]

Hannah Winthrop's seeming reluctance to reveal her scientific endeavors, even to her closest friend, stems from her awareness that the serious practice of science, as opposed to a polite interest expressed over the tea table, was an activity outside the prescribed occupation of women. Such prescriptions appeared to limit women to what Warren described as "the little circle of domestic life . . . the sphere that Providence has wisely assigned our sex to walk in."[6] The concept of "separate spheres," articulated by scholars as a metaphor to delineate the position of women separate from that of men explained, for instance, the limited breadth and depth of women's education which was confined to religious subjects and to the polite and domestic arts, that is, to learning that would be placed in service to their families.[7] By the Revolutionary era in which Warren and Winthrop

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[5]Quoted in Anne Firor Scott, "Self Portraits: Three Women," in *Uprooted Americans: Essays to Honor Oscar Handlin*, ed. R. L. Bushman et al (Boston: Little, Brown and Company, 1979), 55. For a biography, see Carl Van Doren, *Jane Mecom: The Favorite Sister of Benjamin Franklin* . . . (New York: The Viking Press, 1950). Warren's child-rearing burdens were lessened in that her actual child-bearing years (from age 29 to 42) were less that half that of many of her peers; Richards, *Mercy Otis Warren*, 5. Winthrop was spared the burden of pregnancy and infant care, since at the time of her marriage to John Winthrop, his children were ages 3 to 8.

[6]Warren to Winthrop, Mar. 1774; W-W Papers.

[7]According to the concept of separate spheres, social mores, reinforced by religious strictures, made women's roles synonymous with their gender and their duties as wives and mothers. For an historiographical assessment, see Linda Kerber, "Separate Spheres, Female Worlds, Women's Place: The Rhetoric of Women's History," *Journal of American History* (June 1988): 7-39. Recent scholarship, building on the insights of Amanda Vickery ("Golden Age of Separate Spheres? A Review of the Categories and Chronology of English Women's History," *The Historical Journal* 36 [1994]: 383-414), has challenged the exclusivity of "public" and "private" as understood in the 18th century. For an explication and caution that "private and the public did not correspond to the distinction between home and not-home," see Lawrence E. Klein, "Gender and the Public/

were corresponding, those prescribed duties might embrace a political role but only within the limited framework of the home (in which the "Republican Mother" would infuse male family members with the requisite Republican virtue).[8] Hence, the approved "place" of women as well as their lack of proper education acted together to suppress their actual practice of science.[9] Lecturers sought women's attendance at scientific demonstrations and booksellers sought their business (as seen in chapters four and one), but both tacitly acknowledged women's (and most men's) lack of science education by advertising demonstrations and introductory texts, made "plain

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Private Distinction in the Eighteenth Century: Some Questions about Evidence and Analytic Procedure," *Eighteenth-Century Studies* 29 (1995): 97-109, quote, 103.

[8]For the seminal work on republican motherhood, see Linda Kerber, *Women of the Republic: Intellect & Ideology in Revolutionary America* (Raleigh, University of North Carolina Press for the Institute of Early American History and Culture, Williamsburg, Va., 1986), for Mercy Otis Warren as a model for combining domestic and intellectual endeavors, see, 251-57. Although some features of republican motherhood had their origins in the multiple normative and behavioral roles of colonial women, the overall effect was to constrict the multiplicity of colonial women's roles as defined by Laurel Thatcher Ulrich, *Goodwives: Image and Reality in the Lives of Women in Northern New England, 1650-1750*, (New York: Alfred A. Knopf, 1982). For a study that finds the intellectual origins of republican motherhood in the Anglo-American reevaluation of women's roles from mid-18th-century, borrowing from both European enlightenment thought and Revolutionary rhetoric, see Rosemarie Zagarri, "Morals, Manners, and the Republican Mother," *American Quarterly* 44 (1992): 192-215.

[9]Only one woman in the northern colonies, Caroline Colden Farquher (1726-1766), daughter of Lt. Gov. Cadwallader Colden of New York, has been recognized by historians of science and social historians as a "scientist." Introduced to botany by her father, Colden (as she is known to historians) collected specimens and corresponded through him with European natural historians, Joan Hoff Wilson, "Dancing Dogs of the Colonial Period: Women Scientists," *Early American Literature*, 7 (1973), 225-27. Significantly, Colden engaged in these activities as a single woman, for she abandoned her botanical pursuits after her marriage in 1759, Margaret W. Rossiter, *Women Scientists in America, Struggle and Strategies to 1940* (Baltimore: The John Hopkins University Press, 1982), 2-3. Applying a 20th-century concept of "scientist" (i.e, one who publishes or teaches), Rossiter regards Colden as the "America's pioneer (and only) woman scientist for almost ninety years," (Ibid, 3), while Wilson, using a more inclusive approach, lists 9 colonial women "scientists" active in agronomy, horticulture, and botany, "Dancing Dogs," 225-351, esp. 232, n. 3. For her scientific work, see Jane Colden, *Botanic Manuscript*, ed. H. W. Rickett (New York: Canticleer Press, 1963). For southern women scientists and their books, see Kevin J. Hayes, *A Colonial Woman's Bookshelf* (Knoxville, The University of Tennessee Press, 1996), Chap. 6.

and evident" for the benefit of those "who have not made Philosophy a previous study."[10]

Nonetheless, the passage in which Winthrop relates her experience makes clear that Newtonian astronomy exerted a special appeal for her and provided her a special opportunity as well. As her husband's "humble Attendant," Hannah Winthrop had access to the apparatus and knowledge necessary for the practice of astronomy. Her brief description of the eclipse, while couched in the language of polite discourse, hints at what her astronomical activities may have comprised.[11] "The Sky at the beginning of the Eclipse," she reported to Mercy Warren,

> was unkindly overspread with Clouds but soon Cleard off, and gave so good a View as to be able to judge with Precision the Quantity and duration of the Moon's path over the Sun. He has also this fall taken a trip with little Mercury across the Sun similar to the Transit of Venus. I think it a beautiful Sight.

With this description Winthrop relates the atmospheric conditions at the time of the sighting, alludes to the precise scientific measurements involved, suggests her familiarity with a recent transit of the sun by the moon and Mercury, and compares the latter to the transits of Venus that had occurred in 1761 and 1769. Winthrop does not specify what measurements she assisted in taking. Nonetheless, her remark that they concerned the "Quantity and Duration of the Moon's path across the sun" leads to the conclusion that she may have had the knowledge to make sightings and readings that required a telescope, an astronomical quadrant, and a clock. For these observations, Winthrop and her husband probably used the family clock, a standing quadrant borrowed from the Harvard apparatus

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[10]Ad for "Two LECTURES on PNEUMATICS," *BNL*, 21 and 28 June 1770.

[11]Early in their correspondence, Winthrop, wondering if Warren shared her letters with her husband, expressed self-consciousness about her literary style. Winthrop concluded, however, that "our Consorts have goodness & Candor enough to make allowances for Female Diction," 29 Apr. 1769, W-W Papers. Winthrop's style was an extreme example of conversational politeness whose object was to achieve "verbal agreeableness" through the "dextrous management of words," Lawrence Klein, *Shaftesbury and the Culture of Politeness: Moral Discourse and Cultural Politics in Early Eighteenth-Century England* (Cambridge, Cambridge University Press, 1994), 4.

collection, and telescopes belonging to her husband and to the Harvard collection.[12] The diagram made by Professor Winthrop of a lunar eclipse of 1747 indicates the close attention and precise readings required of Hannah Winthrop's "attendance" at such observations: five sightings taken over the course of twelve hours were necessary to plot the path of the moon and the angle of its course, from the moment of ingress to the moment of egress across the face of the sun (fig. 5.1).

In the manner of ministers and poets, Hannah Winthrop "improved" the incident by "expiating" on the meaning of this particular incident as well as astronomy in general.[13] As in the case of ministers and poets, her defense of astronomical practice rested on its teleological message. "I assure you," she emphasized, "these are great Points to an astronomer, tho the greater part of Mankind are so inattentive to these Glorious works of an almighty Creator that they rise and shine and perform their amazing Circuits without any other observation than its being sometimes a fine sunshine day, or a fine Starlight Evening." Here Winthrop suggests the "great points" appreciated by astronomers embrace knowledge not only of specific celestial phenomena but also of the "almighty Creator" who has produced them. Acquired through the guidance of her husband,

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[12] Winthrop's husband, as the Hollis professor of natural philosophy and mathematics, had the privilege of borrowing various instruments from the college apparatus to conduct experiments and observations at home. Among 11 entries in the catalogue of instruments taken 20 May 1779 "*At the House of Mrs.* WINTHROP" following Professor Winthrop's death were "A standing Quadrant of 2 feet Radius," "An ac[h]romatic Telescope . . .." and "A large reflecting Telescope." The catalogue was added to a separate inventory of the college apparatus and is published in I. Bernard Cohen, *Some Early Tools of American Science . . . at Harvard University*, (1950, reissue, New York: Russell & Russell, 1967), App. II.

[13] Winthrop used these terms in a letter to Warren, 10 Nov. 1773, in which she described the "beauties of creation" viewed on a trip from Portsmouth to Dover, N.H., stating that if she had the "poetic Genius" of Warren, she "might have improvd the happy opportunity of expatiating on the beauteous scene," W-W Papers. Four years later, Warren herself improved Winthrop's description with a poem, entitled "To Honoria, on her Journey to Dover, 1777." Moving from a description that "trace[s] the scene" described by Winthrop, Warren contemplates the "august design" marked out by heaven for the "happy land." Here, where truth and genius rule, "other Boyles or Newtons yet may rise, / And trace the wonders of the western skies," *Poems, Dramatic and Miscellaneous*, 216-17, in *Plays and Poems of M. O. Warren* (hereafter *Misc. Poems*).

Winthrop's knowledge of astronomy, no matter how rudimentary, provided her with a heightened awareness that allowed her to appreciate the glories of the universe manifested in its daily, not just extraordinary, operations. Moreover this was privileged knowledge, because it drew Hannah into a sphere of learning set apart from the "greater part of Mankind," and defined not by gender but by what her contemporaries viewed as a "superiority of understanding."[14]

Yet astronomy had an even more poignant appeal. By turning her gaze to the celestial world, Winthrop found escape from the very real uncertainties that surrounded her: the disorder, dislocation, and depredations brought on by the civil war now in its second year.[15] In referring to the celestial world, she marveled, "However enwrapt in incertainty the events in which we of this Terrestrial ball are interested a perfect regularity reigns there. No intervening accident can prevent the Completion of their appointed route." Thus the "appointed" order and constancy—what natural philosophers spoke of as the "design" of the natural world—evident even in extraordinary celestial phenomena, offered solace that could be found nowhere else in the disordered times brought on by the "unnatural" condition of war conducted by England, the "mother country" against her colonial subjects. Winthrop reinforced this idea in the closing sentence of this passage, when she proffered the hope that " the inhabitants of those States [i.e.the planets and stars] are better employd than in spreading devastation and death among their Loyal Subjects and brethren."[16] Winthrop's report of the eclipse reflected her own synthesis of astronomy, religion, and politics. Her " improvement" upon it validates her modest claim to "dabbling" in astronomy, while it also elucidates the

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[14]Jane Franklin Mecom used this phrase in describing the obstacles faced by "thousands" in 18th-century society who lacked such understanding, see n. 5 above.

[15]Hannah Winthop's description of the evacuation of Boston following the Battle of Bunker Hill is one of the most vivid eyewitness accounts of the war, see Winthrop to Warren, [April or May] 1775 in "W-A Letters" 1:409-11.

[16]Winthrop evidently subscribed to the belief that the planets were inhabited, a belief common in the 18th century, see Chap. II above.

ingeniousness of her disclaimer, "Now I have incurrd your Censure pray pass Sentence."

One of the bonds that enriched the friendship between Warren and Winthrop was that each regarded the other's husband with equal affection and respect. But more important than affection born of external achievements was that engendered by the friends' mutual awareness that, as Mercy Warren once remarked, "We are both happily united to such companions as think we are capable of taking part in whatever affects themselves." Mercy, therefore, felt confident in asserting her political views, frankly telling Hannah, "Nor shall I make an apology for touching on a subject a little out of the line of female attention."[17] Winthrop, writing sometime later in a similar vein to her "sister Heart," praised their spouses for allowing them a role beyond mere "domestick use":

> Dear Mrs. Warren I often contemplate Your & my happy Lot in the kind disposition of Providence in our dear Consorts formed with disinterested enlargd minds, not only pursuing the happiness of Mankind in general, but making happy Domestic life, not keeping that awful distance some persons imagine Heaven designd between the social Tye, who look upon Wives only fit for domestick use. I am sure we may bless our selves in Consorts who delight in forming ideas & in Communicating Intellectual Pleasure.[18]

Winthrop's remarks reveal the enjoyment and value she found in the intellectual companionship provided by her husband. This encompassed both study and conversation, upon which she depended for "forming ideas," an eighteenth-century awareness of the mutuality of discourse that "divulges the Sentiments of the Mind, and expresses the Emotions of the Heart, what begins and continues . . . Friendship."[19] For Hannah conversation enlarged what she characterizes here as an

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[17]Warren to Winthrop, [?] 1774, Mercy Warren Letter Book, Mercy Warren Papers (microfilm), MHS, 71, (hereafter MW Letterbook). Winthrop expresses a similar willingness to contravene "the sphere of female life" that precludes being "any way active in the manoeuvres of state" by making "observations" on the patriotic activities of fellow Bostonians; Winthrop to Warren, 14 June 1774, W-W Papers.

[18]Winthrop to Warren, 23 June 75, W-W Papers.

[19]"Of the Use and Benefit of Conversation," *AMHC* (Sept. 1745): 441.

"imagined," that is, "prescribed" domestic sphere. [20] In *her* sphere, enlarged by conversation, she can engage in the practice of science, thereby both domesticating natural philosophy and demonstrating the permeability of the domestic sphere. For Winthrop the practice of science falls within the realm of "rational" rather than "polite" pursuits. Indeed she tells Warren that she is "unacquainted with Polite Life, the encreasing dissipation, the round of Elegant amusements which are becoming the work of every Evening." Although Boston offers "balls, concerts, and most recently "Morgan's Lecture on Buffoonery," she muses, "What a different circle do we tread?, immured in the Country and yet happy perhaps in . . . improving our Ideas by the rational Conversation of our Dear Preceptors."[21]

Mercy Warren shared her friend's distaste for merely "polite amusement," as her response to Hannah Winthrop indicated. "I would not exchange my retired manner of life for the elegant refinement of modern dissipation," she wrote several months later. "Indeed I am at present so distant from the centre of polite amusement, that I know not what you mean by a late lecture on buffoonery."[22] Like Winthrop, Warren prided herself on her ability to enter into rational activity and discourse, thus transcending the superficiality often ascribed to female pursuits. Removed from the "centre of polite amusement" (Boston) and from the "Seat of Literature and Learning"(Cambridge) where Hannah Winthrop had the opportunity to engage in scientific pursuits, Warren occupied herself with supporting the political endeavors of her husband and brother and their influential circle of patriotic friends. Despite her avowal of "retired life," Warren was far from being secluded; rather,

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[20]Winthrop's awareness here is remarkably akin to Klein's description of reason as a "habit actuated in the practice of conversation"; unspoken in Winthrop's letter is Klein's observation of participants as "agents [who] resisted the passivity of mere listening," Klein, *Shaftesbury*, 98.

[21]Warren to Winthrop, 12 Apr. 1773, W-W Papers; MHS *Coll.*, 73:17.

[22] Warren to Winthrop, Aug. 1774, MW Letter Book. Despite a search of Boston newspapers for Feb.- Aug. 1773, Morgan's lecture remains a mystery.

through her literary endeavors and her personal association and correspondence with contemporary political activists, she negotiated an "associative, public sphere," a sort of middle sphere of "social, discursive, and cultural production."[23] Unlike Winthrop, Warren made no conventional bow to the proprieties concerning women's prescribed role. Concluding a long letter to Winthrop on the infringement of despotic rulers on the natural rights of those whom they governed, she protested, "As for that part of mankind who think every rational pursuit lies beyond the reach of a sex too generally devoted to folly, their censure or applause is equally indifferent to your sincere friend."[24]

Moreover, for Warren ,"rational pursuits" were inextricably tied to the pursuit of both knowledge and moral goodness, as she made clear in a letter to Winthrop prompted by the governmental crisis of 1773.[25] Without moral goodness and knowledge, she maintained, the "path of Rectitude" would be beset by "Anarchy & darkness"especially now when the "enemies of America" were "sacrificing the rights of Posterity to . . . Ambition & Avarice." She advised Hannah

> Let us turn our eyes to the more rational satisfaction of the good man who exerts his talents for the good of society. . . . [who]
>
> Tracing the depth of Nature's hiddden Laws
> With Godlike Newton, mounts beyond the stars,
> And ranging o'er the vast etherial plain
> Surveys each System of the wide domain.

Warren coyly concluded, "If you know a person who answers to this Character, I hope you will not fail to make my respectful regard acceptable to him." Warren knew her friend would pass her compliment on to her husband, the Hollis professor of natural philosophy. In Warren's view, John Winthrop's particular provenance as a natural philosopher privileged his knowledge, for he plumbed the depths of the natural world, finding there "Nature's hidden Laws,"that is, Newtonian order and

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[23]Klein, "Gender and Public/Private Distinction," 9.

[24]For an insightful analysis of Warren's correspondence, see Richards, ***Warren***, Chap .2.

[25]Warren to Winthrop, [?] Feb. 1773, MW Letterbook..

design—the opposite of the anarchy that now threatened the temporal world they inhabited. And she made clear that his activities effected a greater good than either the pursuit of personal fulfillment or the mere avoidance of "Ambition & Avarice" movitivated by unseemly political power.

Following John Winthrop's death in 1779, Warren expressed her condolences to Hannah in the form of a poem in which she not only eulogized her friend's husband but also exhibited her own awareness of Newtonian philosophy in verses adorned with scientific allusions. Her litany of philosophic sages extended from the ancients to the moderns—Socrates and Plato to Newton, Boyle, and Locke, Huygens and s'Gravesande. Yet she regarded their truths as a poor substitute for the "reveal'd" truths of "Christian faith and hope," which she identified as,

. . . the perfect code,
Seal'd by a messenger divine,
The sacred son of God.[26]

John Winthrop was the perfect "guide to Harvard's youth," because, in Warren's view, he successfully combined the rational truths of philosophy with the revealed truths of Christianity. This felicitous blend of religion and natural philosophy mirrored Warren's own accommodation of piety and science which was rooted in her Puritan religious heritage.[27]

The gift of Warren's poem was balm to Hannah Winthrop whose loneliness was heightened by the loss of the intellectual stimulation her husband had always provided: "That fatal fall from the Sublime pleasures of the most engaging Converse to the trifling," as she confided in a letter to

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[26]"On the Death of the Hon. John Winthrop . . .," *Misc. Poems*, 237.

[27]Cheryl W. Oreovicz, "Mercy Warren and 'Freedom's Genius,'" *The University of Mississippi Studies in English*, new ser. 5 (1984-1987): 218. Oreovicz uses Warren's literary works and correspondence to identify her as a "Calvinist republican" who willingly acknowledged God's providential power and to specifically refute the view that she was a "traditional Christian Deist" advanced by Emily Stipes in *The Poetry of American Women from 1632-1945* (Austin: University of Texas Press, 1977), 39-44. The Warren-Winthrop correspondence, not mentioned by Oreovicz, offers further evidence for Oreovicz's argument.

Mercy.[28] Her response to her friend's "Consoling animating ingenious poetic piece" was to share it with her minister who, she informed Mercy, effected its publication (on the front page of the *Independent Chronicle* for 21 October 1779) so that "others might enjoy the Pleasure likewise".[29] Her remark illustrates her awareness that poetry, like natural philosophy, could mediate between the private domain of the home and the public domain of the newspapers, which John Winthrop himself had used so effectively as a spokesman for natural philosophy.[30] The consolation Mercy Warren afforded Hannah Winthrop was short-lived; within five months Hannah's loss of her husband was compounded by the loss of the scientific instruments she had shared with the professor. After being required to surrender the scientific instruments he had housed in their quarters during his academic tenure, she communicated her feelings to Warren in a letter whose polite diction cannot conceal her anguish. "Could you have thought," she asked her friend,

> that after being bereft of my most essential Portion, I should be [so] deeply affected with being derob'd of those emblems, those badges of office that mark'the Astronomer, that gave such pleasing amazement to my dear departed Philosopher[?] ah! My wounded heart was most exquisitely touchd by a requisition of those enlightening Tubes thro which He often led me to View the wonders of creating power, but a Successor must enjoy all those advantages.[31]

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[28]Winthrop to Warren, 24 May 1779, MW Letterbook.

[29]Ibid. The elegiac poem apparently became a favorite of Harvard students, for it was included on the reading list of the Harvard Speaking Club which met biweekly from 11 Sept. 1770 until at least 1781, Albert Goodhue, Jr., "The Reading of Harvard Students, 1770-1781 As Shown by Records of the Speaking Club," *EIHC* 73 (Apr. 1937), App. A. Also on the list were two philosophic poems: Thomson's *Seasons* and Young's *Night Thoughts*, Ibid. Warren's elegy was later published in her *Poems, Dramatic and Miscellaneous* (Boston, 1790).

[30]For Winthrop's contributions to various newspapers and his part in the power struggle to establish the primacy of natural philosophers as spokespersons for the natural world, see Chap. 3.

[31]Winthrop to Warren, 20 Apr. 1780, W-W Papers. For the inventory of instruments in Hannah Winthrop's possession upon her husband's death, see n. 12 above. After Winthrop's death, his family donated two of his own telescopes to the Harvard apparatus collection, David P. Wheatland, *The Apparatus of Science at Harvard, 1765-1800* (Cambridge, Harvard University Press, 1968), 13; one wonders what part Hannah had in this decision.

With the removal of the apparatus by the Harvard officials, Hannah suffered a multiplicity of losses: the overt losses of her husband himself and of the astronomical activities they formerly shared, and the more subtle losses associated with her husband's prestige and his power to evoke the immediacy of creation and hence Hannah's own comprehension of the "creating power" of God. Without the assistance of her husband or the possession of his instruments, Hannah was powerless to pursue even casual astronomical observations. Most important, widowhood accentuated the realization of her dependence upon her husband for "forming ideas" and deprived her of the "intellectual Pleasure"of conversational exchange. Perhaps this new awareness is what led her to re-evaluate women's prescribed role in even the most enlightened marriage. Hannah's correspondence with Mercy Warren suggests that by 1782 she had become an advocate for women's higher education—an education that would insure that "the Fair ones of the present day, be taught to square the Circle, & the important knowledge of the laws of Attraction, & Cohesion." Thus Winthrop would include the study of advanced mathematics and Newtonian natural philosophy for women in fulfilling what she had observed in the early years of the new republic as a "prevailing thirst for acquirement."[32]

The ambivalence Winthrop expressed concerning her prescribed role in marriage vis-a-vis the practice of science and the opportunity for science education reflects the tensions surrounding these issues in society as a whole. A contributor, who signed himself "Alphonsus," in the March 1788 issue of the *American Magazine*, for instance, was emphatic in his declaration that "The same principle which excludes a man from an attention to domestic business, excludes a woman from law,

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[32]Winthrop to Warren, 20 Apr. 1782, W-W Papers. Popular science books designed for women's informal education became widespread in the early 19th century, but not until science entered the curriculum of female seminaries was the systematic study of science available to them, Rossiter, *Women Scientists*, 3-8. For specific curricula developed to meet the popular enthusiasm for science in the mid-19th century, see Deborah Jean Warner, "Science Education for Women in Antebellum America," *Isis*, 69 (1979): 58-67.

mathematics, and astronomy. Each sex feel a degree of pride in being best satisfied for a particular station, and a degree of resentment when the other encroaches upon their privilege."[33] Yet only a few months later, the same magazine made an obvious play to women's interest in science with an article on a "curious" electrical experiment that described two young woman using an "electric pistol" charged with "inflammable air" in a display of "sociable" science in a setting that would be similar to that of an electrical experiment pictured in a popular polite text for young men and women (fig. 5.2). The directions for performing the experiment were followed by a couplet that invoked the sanction of Isaac Newton, with the writer's exclamation, "How would Newton himself have contracted his brow, on being shown lightning enclosed in a Leyden phial."[34]

Hannah Winthrop was not alone in the domestic practice of natural philosophy nor in experiencing the frustration due to the limits of women's education. From her thirteenth to her twenty-first years of age (from 1771through 1779), Betsey Stiles, the oldest daughter of the Rev. Ezra Stiles, maintained the family's annual "Thermometrical Registers." Begun by her father in 1763 following receipt of a thermometer brought at his request from London by Benjamin Franklin, the registers comprised a record of the day of week (entered as an astronomical sign) and month, hour, temperature, wind direction, and precipitation and general weather conditions with readings entered three or four times per day.[35] With its carefully penned title and record of observations, the cover of Betsey's first register (fig. 5.3), compiled when she was thirteen years of age, conveys a sense of pride and confidence:

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[33]"An Address to the Ladies," *The American Magazine, . . . calculated both for instruction and amusement* (Mar. 1788): 241.

[34]"Curious Experiments in Electricity, not hitherto noticed," *The American Magazine* (July 1788): 579-80.

[35]Franklin to Stiles, 19 Dec. 1762; Morgan, *Gentle Puritan, 135.*

Meteorological Register 1771 • Therm. Fahrenheit
By Elizabeth Stiles jun. Atat. 13.
Newport, Rhode Island.[36]

Ezra Stiles enthusiastically advocated the systematic recording of meteorological data throughout the colonies, although his suggestion, conveyed by Benjamin Franklin to the Royal Society, that the Society provide all the "philosophical gentlemen" throughout the American continent with thermometers for a systematic compilation of meteorological data was never realized.[37] Stiles, nevertheless, saw the value of a comprehensive base of information in "regulating the plantation and future Improvement of America," as he advised readers in an article published in the 18 February, 1764 *Newport Mercury*. Stiles used the *Mercury* to recommend that readers take daily readings and maintain their own private records. By entrusting this task to Betsey, he encouraged and tacitly acknowledged the value of women's participation in the practice of science. Presumably, Betsey would have followed the instructions her father imparted in the *Mercury* to "Gentlemen, of Ingenuity," whom he urged to "give themselves the Trouble, for *one* Year at least" of keeping a meteorological record.

The "trouble" Ezra Stiles entrusted to his daughter Betsey entailed taking three readings a day (shortly before sunrise, at two o'clock in the afternoon, and nine o'clock at night) after "exposing" the thermometer for fifteen to thirty minutes before each reading. If she were a "curious Observer," on days of "remarkable" heat and cold, Betsey would make more than three readings in order to note the "greatest Ascents and Descents" of the mercury. She would take care to suspend the thermometer "in free and open air," placing it out of the wind, either under the shade of a tree or

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[36]Stiles Papers, Meteorological Journals, Microfilm, Reel 12, 183. Elizabeth (1758-1795), called Betsey, was the child of Ezra and his first wife Elizabeth Hubbard Stiles (1731-1775). Her siblings were: Ezra, Jr., (1759-1784), Kezia (1760-1785), Emilia (1762-1833), Isaac (1763-c.1795), Ruth (1765-1808), Mary, called Polly, (1767-1795), and Sarah (1769-1769).

[37]Edmund S. Morgan, *The Gentile Puritan, A Life of Ezra Stiles, 1727-1795* (New Haven: Yale University Press, 1962), 135.

from a window on the north or west side of the house," and note its location in the register. Only in stormy weather could she take readings in the house. Betsey's registers reveal the conscientious work of a young woman of ingenuity with readings taken and recorded day-in and day-out for nine years, during which time the family moved from Newport, Rhode Island to Portsmouth, New Hampshire to New Haven, Connecticut.

Among Stiles's correspondents who maintained meteorological records was John Winthrop. The professor's "Meteorological Journal," which he maintained from 11 December 1742 through 19 April 1779, only a few days before his death, contains minutely detailed and charted information. In addition to the kind of readings the Stileses took, Winthrop took daily barometric readings, and included in each annual register, charts of the mean, "greatest," and "least" temperature by month, tables of the mean morning and evening temperatures, and charts of the monthly wind direction.[38] The contrast between his records and those of Betsey Stiles and her father illustrate one difference between the professional and amateur practices of science. Both evince the systematic observation and collection of data, but the former lacks the application of analysis, evident in Winthrop's journals. Both Stiles and Winthop occasionally published their data in the public prints, but Stiles was unable to pursue his goal of establishing a central bank of meteorological data.[39]

In addition to making meterological observations, Betsey Stiles may have routinely observed the various celestial phenomena that her father so avidly watched and recorded.[40] Stiles's

[38]See, for instance, calculations for 1743 and 1744, "Winthrop's "Meteorological Journal [1742-1779]," Harvard University Archives, Cambridge, Mass., 34, 37.

[39]For current research that makes use of historical meteorological information, see Barry Keim and Greg Zielinski, *The Changeable Weather and Climate of New England* (forthcoming).

[40]Stiles compiled various notebooks on astronomy, including observations he made, read in books and newspapers, or gathered from friends; his most ambitious project was directing a team of eight friends to observe the transit of Venus in 1769, which occupied a notebook of 268 pages,

journal entries are usually silent as to family participants in his observations of comets, eclipses, and other celestial displays. Nevertheless, an occasional reference to his wife and Betsey does occur, apparently when they have brought Stiles's attention to something out of the ordinary which suggests he may have quietly passed over their presence at most observations. For instance, on an occasion in November, 1769 when Betsey and her father were joined by two friends to observe a comet, Stiles relied on the observation of Betsey and the other men. When recording the event, Stiles noted, "Comet seen by Mr. Ellery, Major Otis and my Daughter Betsy : but I could not discern it with certainty, tho shewed nearly its place."[41]

That Betsey felt she had a responsibile role on these occasions is evident in a letter she wrote to her father in order to record the sighting, of an "extrordinary Northern-Light," or aurora borealis, which she observed in New Haven while Stiles was traveling away from home.[42] Betsey accompanied her account of the sighting with observations recorded from just after six o'clock to ten o'clock in the evening of 25 September 1781 which noted four "stages" of progression in the appearance of the Northern Lights. She also included a sketch that, she explained, delineated its "appearance . . . as to my eye" which consisted of three arches of lights, "about ten degrees above each other," hovering over white and red "strokes" and "flashings" of light (fig. 5.4). Her account noted the arch was "about 20 degrees above the Horizon . . . the Coruscations tended towards a Point in the Zenith til X [10 o'clock] [when] the sky was rather bright but in the North black heavy clouds."[43] Despite her painstaking account, Betsey was unsure of the accuracy of her efforts, adding,

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Morgan *Gentle Puritan*, 153, 55. His astronomical and meteorological records can be accessed through Harold E. Selesky, *A Guide to the Microfilm Edition of the Ezra Stiles Papers at Yale University* (New Haven: Yale University Library, 1978).

[41]Meteorological Journals, Microfilm, Reel 12, 242.

[42]Betsey Stiles to Ezra Stiles, 13 Oct. 1781, Itineraries, Microfilm, III: 515-17.

[43]Ibid., 516.

> now Papa I hope you'l not laugh at the simplicity of your Daughter Betseys observations. if I have misapply'd words, I shall have the Pleasure of being rectify'd by him who I only wish to Please. . . . if there is any more of these strange lights to appear I must be taught how to take Observations, I fear I've done it so bad that Papa can scarc[e]ly find out my meaning, but I've done my Best. and I hope twill be Accepted as such from Papa's ever Dutiful Daughter.

Ezra Stiles apparently had no trouble in taking the meaning of his daughter's observations, although he thought Betsey may have not taken into account the sound usually associated with the aurora borealis. Thus he evidently queried her and "Mr. Prudden"who, Stiles made clear, had only "assisted" Betsey in making the observations. Yet he seemed satisfied that even though Prudden had heard a "soft, whizzing kind of noise," Betsey, herself, "was not sensible of hearing it," and thus her account could stand on its own merit.[44]

Betsey's remarks reveal, however, that until this time, her participation in astronomical observations had been limited to that of an observer, although one of acute sensibility. Schooled only in what her father said "is taught to boys, petit Maitres & Ladies," which produced only a "very slight Insight into Math[ematics] & nat[ural] Phil[osophy] & Astronomy," she lacked the vocabulary as well as the technical skills afforded by higher education.[45] Yet when she assumed full responsibility for making the observations of the aurora borealis, she could draw on a competency grounded in the domestic practice of natural philosophy and structured within the framework of Newtonian methodology. As in the case of Hannah Winthrop (and Edward Bromfield and his guest), Betsey Stiles's participation in science took place within the home. The domestic practice of science, however, could be a "sociable" or participatory event, although contained within the "little circle of domestic life" Mercy Warren had identified. This is evident in the two recorded instances of

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[44]Ibid.

[45]Stiles drew this characterization of elementary education in describing the poor science education of Dr. Cooper, President of Rhode Island College, in his assessment of the "character" of the presidents of various colonial colleges whom he personally knew, *Literary Diary*, 24 May 1779.

Betsey's participation in astronomical sightings: her observations of the Northern Lights and the 1769 comet were both attended and assisted by at least one person outside the family circle.

These "found" examples of colonial women's scientific activities do not, of course, establish a hitherto unknown cadre of colonial American women scientists nor even a pattern of the practice of science by women in the eighteenth century. Nevertheless, the activities of Hannah Winthrop and Mercy Warren as well as Betsey Stiles are suggestive. Evident in their activities is the "domesticating" of natural philosophy, that is, the bringing of natural philosophy within the domestic, but not necessarily private, setting and within the cognizance and use of those most closely associated with the home. Betsey Stiles left no written record that can flesh out a deeper meaning of science in her life, but the correspondence of Hannah Winthrop and Mercy Warren does allow a unique perception of the impact of the new science on the lives of women. Educated, articulate, and above all, reflective, the two women not only confided to each other the itimacies of their daily lives but also "improved" their meaning. Winthop did not envision herself a natural philosopher any more than Warren styled herself a philosophical or physico-theological poet, nor does their correspondence allow one to make these claims on their behalf. Their letters and Warren's poetry, however, do show that Newtonian philosophy played a significant role in their lives. On an intellectual level, it allowed them to participate in "rational discourse"; on the spiritual level, it afforded them the reassurance of the rational conjoining of piety and moral goodness; on a social level, it connected them through the culture of print to a public audience; while in the war-torn reality of everyday life, it offered them the consolation of regularity and order. Thus by accommodating the new science to the circumstances of their everyday lives, Hannah Winthrop and Mercy Warren enriched and expanded the bounds of their "little circle of domestic life."

Hannah Winthrop's, Mercy Warren's, and Betsey Stiles's use of science did not extend to what has traditionally been viewed as the "public sphere," unlike that of Hannah's "Philosopher" and "Dear Preceptor," John Winthop, or the cohort of science preceptors whom history has recognized, notably Winthrop and his fellow professional practitioners, Isaac Greenwood and Benjamin Franklin or even the gentlemen-amateurs, such as Thomas Prince and Ezra Stiles. Although more difficult to recover, their stories *do* suggest that women had a place in the history of early American science. Furthermore, they also suggest a revised approach for considering their role. Re-phrasing the question, "What was the place of women in science?" to "What was the place of science in the lives of women?" provides a new starting place to look for the practice of science by women. It also provides a new conceptual framework that is capable of broadening our understanding of the incorporation of Newtonian natural philosophy into eighteenth-century New England culture. In the home, in women's domestic *space*, it became a meaningful part of the lives of some women as each appropriated its intellectual goals and metaphysical ideals according to her individual needs and desires. "Domesticating" natural philosophy was in itself an inclusive cultural production that illuminates the expandable dimensions of the "little circle of domestic life" women occupied. Rather than being constrained by the prescribed strictures of the domestic sphere, natural philosophy provided an entrance to a sociable sphere—the "wide domain" where both women and men engaged in scientific discourse and observation.

## CHAPTER VI

## CONCLUSION

This dissertation began with the proposition that we as twenty-first-century Americans could look back to the period between 1727 and 1779 for the establishment of the Newtonian world view that informs our own view of the universe and of scientific truth. During these critical years, the new science of Isaac Newton expanded from the exclusive locus of colonial colleges (the original site of systematic instruction in Newtonian theory) to new sites of science discourse, practice, and performance and to new audiences. Because eighteenth-century Anglo-Americans viewed Newtonian natural philosophy as an expansive system of knowledge, especially able to amplify religious ideas in explaining the natural world, Newtonian philosophy and metaphysics provided the framework for a multiplicity of endeavors that occurred during the middle six decades of the century. Both women and men appropriated and exploited the theories, methods, and goals of Newton and his disciples, using them to inform religious and polite, as well as scientific practices. Hence this study has examined a series of actions and events, each connected to a specific vehicle—whether mezzotints, books, and social libraries; almanacs and newspapers; or science demonstrations and observations—that popularized Newton and his philosophy.

In the search to recover the meaning of each event from its historical context and the perspective of its participants, three sub-themes—piety, politeness, and power—emerged as the nexus that connect the diverse behaviors examined here. For instance, they elucidate and connect the power play in the public prints that engaged Thomas Prince and John Winthrop with the sociable afternoon's entertainment that engaged Edward Bromfield and his female guest. As cultural practices, in themselves endemic to eighteenth-century New England, they provide a context for understanding how and why Newtonian philosophy entered private lives and public discourse, appended as it were to individuals' often co-mingled desires to gain scientific knowledge, enhance their religious belief and practice, demonstrate polite learning and refined living, and re-inforce or challenge traditional hierarchies. The synthesis of these practices and of Newtonian philosophy and its various permutations (that is, the natural philosophy set forth by Newton in the *Principia* and the *Opticks*, the post-Newtonian science that embraced his thought, methods, and results, and a rational Newtonianism that adapted the rational outlook and critical assessment of evidence characteristic of the new system of science promulgated by his disciples) created a cultural layer that I have termed a "Newtonian culture."

Certain rubrics have provided the conceptual framework for exploring the "webs of significance" the men and women in this study of early American science created around their use of Newtonian philosophy. This approach has proven fruitful in examining the sites where cutural synthesis occurred, in recovering their participants, and in teasing out their meaning. Trafficking, accommodating, appropriating, performing, and "domesticating" all describe actions and behaviors that both reveal and reconcile the tensions of society under change as opposing religious, intellectual, and social forces converge. In "improving" the meaning of these actions, I propose the following observations merit "chewing over" and "digesting."

Trafficking in Newtonian intellectual and material culture occupied Anglo-Americans eager to assimilate British cultural values and participate in Britian's empire of goods. By mid century, imported Newtonian literature as a literary genre constituted a significant core of booksellers' and social library collections, imparting the new science by way of scholarly, polite, and pious works. The popularity of scholarly texts waned as the century progressed, while polite works increased in popularity and the demand for pious or physico-theological works remained constant. Physico-theological works, philosophical poetry, and polite texts crossed the bounds of natural philosophy, religion, and polite literature often integrating the cosmopolitan goals of genteel readers and the pious goals of vernacular or common readers. Moreover, the language of Newtonian literature provided a new "philosophical" vocabulary common to men and women of both genteel and vernacular reading traditions. Consequently, despite their varied audiences, persons as diverse as almanac makers, advertisers of science demonstrations, and anonymous writers of newspapers and magazine verses could confidently employ metaphors and images that implicitly recalled the wonders and the rationality of the Newtonian universe .

The *Ames's Almanacks* trace the on-going tensions and accommodations between the genteel and vernacular traditions as a rational world view competed with a providential world view to provide a basis for explaining extraordinary natural phenomena. Dr. Nathaniel Ames and his son each created his own accommodation of a distinctive brand of Newtonian science and metaphysics (sometimes little-related to the scientific theory of Newton) to the traditional lore, with its overtones of providential and astrological beliefs, embraced by many readers of the *Astronomical Diary*. This process changed over the course of five decades, as both almaanc makers sought to reconcile the new science with changing expectations of their readers. By the mid 1760s the elder Dr. Ames acknowledged that his belief in natural astrology (for which he had laboriously tried to fashion a rational explanation) was out of step with the times, while the younger Dr. Ames discreetly abandoned his father's providential explanations. Their actions broadly suggest that a rational view of the universe had won acceptance among the generality of vernacular as well as learned almanac readers. At the very least, they suggest that from the mid-1760s forward the beliefs and goals of genteel culture would determine the public explanation of extraordinary events.

The incidents examined in this study disclose an apparently uncontested acceptance of Newtonian scientific theory as the explanation of the secondary causes, if not the primary cause, of natural events by members of learned culture, which dated from the late 1720s. Nevertheless, conflict surrounded competing claims to the rightful appropriation of the active powers of nature.

Hence, the newspaper debate between the Rev. Thomas Prince and the Harvard professor, John Winthrop, concerning the 1755 earthquake, discloses tensions that existed among ardent promulgators of the new science regarding the qualifications needed to mediate Newtonian powers and speak for the natural word. Winthrop's public exposure of his clerical opponent's faulty scientific knowledge established the legitimacy of his own claim to speak for nature and signaled the shift in scientific authority that occurred just after the mid-century mark. Even though the public arena of natural philosophy subsequently widened as more people participated in scientific discourse via the public prints, *bona fide* practitioners of science were vigilant in their calculated use of the newspapers to correct the deviant views of unenlightened contributors.

Performing science took center stage when demonstrators, first of Newtonian mechanics and astronomy and then of the post-Newtonian sciences, electricity and pneumatics, marketed the various branches of natural philosophy through demonstrations and lectures touted in the public prints. As time elapsed in the fifty-year history of public science demonstration in pre-Revolutionary era New England, their purpose gradually changed from one of education and the pious explication of the natural world to outright entertainment as academically trained demonstrators, such as Isaac Greenwood, yielded the stage to peripatetic demonstrator-entrepreneurs concerned with meeting the expectations of their fashionable audiences. The success of the science demonstrators suggests that the popular reception of Newtonian and Newtonian-inspired natural philosophy rested on the ability of the new science to create its own alternative system of wonders. Paramount in its production was the demonstrators' artful manipulation of apparatus to make sensible the re-creation of Newtonian natural powers and to enhance their prestige as mediators between their audiences and the principles of nature.

The correspondence of Hannah Winthrop and Mercy Warren as well as that of Elizabeth Stiles and her father, Ezra Stiles, suggests that bringing natural philosophy within the home and the ken of the family—that is, "domesticating" natural philosophy—was a cultural practice that mediated prescribed notions of gender and place. "Domesticating" natural philosophy was in itself an inclusive cultural production that expanded the dimensions of the "little circle of domestic life" women occupied, providing them entrance to a sociable sphere where the practice of science was pursued. Looking for the meaning of science in women's lives rather than looking for women in science is a new, inclusive approach to the history of science that takes into account the cultural significance of scientific knowledge in all the domains where it was pursued.

Considered as a whole, the formation of a Newtonian culture was an incremental process that depended upon the interaction of the societal forces exposed in the discrete events and actions described above. Certainly, the desire to emulate cosmopolitan taste, manners, and discourse, the availability and consumption of imported goods, and the explosion of print culture all played a vital part in its development. Just as certainly, the potency of Newtonian thought in producing a method of scientific inquiry, affirming the truths of revealed religion, and providing a moral imperative and a rational explanation of the natural world was essential to its success. Yet its formation was not a straightforward process. Rather than cutting directly through opposing forces, it wended its way through them—now expanding, now contracting in response to their pressures—for Newtonian culture possessed a persuasive appeal to a diverse group of men and women and the malleability to adapt to their needs and aspirations.

How widespread was the acceptance of Newtonian culture defies quantifying. There is additional evidence that Newtonian inquiry and practice enjoyed grassroots support. For instance, such support apparently impelled the legislative house of the provincial government of the Massachusetts to assist in sending John Winthrop to Newfoundland in order to establish an observation post for viewing the Transit of Venus in 1761.[1] The government's backing of Winthrop's scientific expedition and the attendant newspaper and almanac coverage indicate the practice of Newtonian science was a matter of Anglo-American prestige as well. There is also more subtle evidence that Newtonian thought became current in public discourse. This can be discerned in the philosophical poetry found in contemporary newspapers and magazines. The anonymous writers of verses, such as "On a Watch" and "A Hymn to Providence," overlaid polite sentiments with Newtonian images, or like the well-known poet, Phillis Wheatley, adorned her moral voice and religious sentiment with Newtonian metaphors.[2]

This study of various aspects of the dissemination of science in eighteenth-century New England has broadened our understanding of the practice of science in Anglo-America, for when science is viewed as a cultural practice, it is possible to explode the bounds that have traditionally circumscribed its locus and practitioners. Therefore this study challenges the narrow confines around the meaning, site, practice, and practitioners of science set by traditional accounts of the history of early American science which date back to the *cause célèbre* of eighteenth-century New England science, the Prince-Winthrop debate. Not only does this study introduce an alternative meaning of that debate, it puts a new face on the changes affecting mid-eighteenth-century Anglo-American society by introducing the personages who dealt with them in the context of their various

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[1]John Winthrop, *Relation of a Voyage from Boston to Newfoundland, for the Observation of the Transit of Venus, June 6, 1761* (Boston, 1761), 7-8. The Transit of 1761 and the Transit of 1769, which occasioned observations by scientists and amateurs throughout Anglo-America, are well-covered by historians of science; see, for instance, Brooke Hindle, *The Pusuit of Science in Revolutionary America, 1735-1789* (Chapel Hill: The University of North Carolina Press, 1956), 98-101 and Chap. 8.

[2] *AMHC* (Sept. 1745): 457; Ibid., (Mar. 1746): 135-36; and see, for example, Phillis Wheatley, "Thoughts on the Works of Providence," and " A Funeral Poem on the Death of E. E. An Infant of Twelve Months" in *Poems on Various Subjects, Religious and Moral* (London, 1773), repr. in William H. Robinson, *Phillis Wheatley and Her Writings* (New York: Garland Publishing, Inc., 1984), 43-50 and 69-71, respectively.

uses of Newtonian natural philosophy. A disparate group of men and women, they include philosophers and divines, poets and almanac makers, as well as traveling showmen, literary gentlemen, young misses and society matrons. They read, discussed, observed, performed, and poeticized natural philosophy not only in booksellers' shops, social libraries, and gentlemen's studies, but also in boarding houses and tradesmen's shops, concert halls and farmers' kitchens, at the pulpit, the lecture podium, and the tea table, and under the shade of a tree or leaning out of a window. Whether natural philosophers, science devotees, or lay persons, motivated by scholarly, pious, or polite concerns, they each used Newtonian philosophy to negotiate the cultural tensions within eighteenth-century Anglo-America.

In reconciling the tensions between learned and vernacular beliefs, cosmopolitan and provincial aspirations, rational and providential world views, natural and revealed truths, and public and domestic spheres, these men and women acted within a framework that drew upon the theories, the methods, and the goals of Newtonian philosophy. Contributing to their formation of a Newtonian culture were the forces of piety, politeness, and power, themselves in a state of flux and therefore all the more amenable to incorporation in new cultural practices. Therefore, this account of early American science comprises a galaxy of new faces, new sites, and new practices. The story of the formation of a Newtonian culture in New England is embedded in their story, a story of active forces held in check by the attractive force of Newtonian philosophy.

*finis*

# APPENDICES

# APPENDIX I

## BOOKSELLER AND SOCIAL LIBRARY CATALOGUES AND NUMBER AND PERCENT OF NEWTONIAN LITERATURE TITLES

| Cat. # | Catalogue | Place | Cat. Date | Type | # All Titles | # Newtonian Literature Titles Acad. | P-the. | P'try | aMode | Ref. | Total N'tn | % All Titles |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | S.Gerrish | Boston | 1725 | Auction | 695 | 3 | 1 | 0 | 0 | 0 | **4** | .58 |
| 2. | T.Cox | Boston | [1734] | Bkslr | 856 | 8 | 5 | 1 | 3 | 1 | **18** | 2.10 |
| *3.* | *Redwood Lib. Company* | *Newport, R.I.* | *1750* | *SL* | *866* | *14* | *6* | *3* | *8* | *3* | ***34*** | *3.93* |
| *4.* | *Portsmouth Social. Lib.* | *Portsmouth, N.H.* | *1750* | *SL* | *102* | *2* | *1* | *2* | *2* | *1* | ***8*** | *7.84* |
| *5.* | *Salem Social Library* | *Salem, Ma.* | *1761* | *SL* | *343* | *6* | *6* | *3* | *4* | *2* | ***21*** | *6.12* |
| 6. | B. Arnold | New Haven, Ct. | 1763 | Bkslr | 150 | 0 | 0 | 2 | 3 | 0 | **5** | 3.33 |
| 7. | A. Barclay | Boston | [1765] | Bkslr | 150 | 0 | 0 | 2 | 0 | 0 | **2** | 1.33 |
| 8. | J. Mein | Boston | 1765 | CL/Bkslr | 750 | 1 | 3 | 3 | 4 | 3 | **14** | 1.87 |
| 9. | J. Mein | Boston | 1766 | Bkslr | 1741 | 2 | 3 | 3 | 7 | 3 | **18** | 1.03 |
| *10.* | *Providence Library* | *Providence, R.I.* | *1768* | *SL* | *375* | *7* | *6* | *2* | *7* | *3* | ***25*** | *6.67* |
| 11. | J. Condy | Boston | 1768 | Bkslr | 308 | 2 | 2 | 1 | 8 | 1 | **14** | 4.55 |
| 12. | Cox & Berry | Boston | [1772] | Bkslr | 1400 | 1 | 4 | 3 | 10 | 5 | **23** | 1.64 |
| 13. | H. Knox | Boston | 1773 | Bkslr | 800 | 3 | 2 | 3 | 10 | 1 | **19** | 2.38 |
| 14. | Smith & Coit | Hartford, Ct. | [1773] | Bkslr | 375 | 0 | 2 | 3 | 4 | 1 | **10** | 2.67 |

**Abbreviations: Bkslr=Bookseller, CL= Circulating Library,** ***SL= Social Library,*** **Acad.=Academic Works, P-the.=Physico-Theological Works, P'try=Philosophical Poetry, aMode=Introductions "a La Mode," Ref.=Reference, N'tn=Newtonian Titles. For individual titles in each category, see App. II.**

**All information (except for catalogues noted below and for Newtonian Literature information), Robert B. Winans,** ***A Descriptive Checklist of Book Catalogues Separately Printed in America 1693-1800*** **(Worcester, MA: AAS, 1981). Brackets indicate date assigned by Winans.**

**Newtonian Literature information is based on my analysis of catalogues reproduced in** ***Early American Imprints, 1639-1800 Series,*** **ed. Clifford K. Shipton (New York: Readex Microprint Corporation, 1963-) and as noted below:**

**Redwood Library Company:** ***The 1764 Catalogue of the Redwood Library Company at Newport, Rhode Island,*** **ed. Marcus A. McCorison (New Haven: Yale University Press, 1965). The 1764 catalogue is the printed version of the orginal 1750 manuscript catalogue, thus the earlier date is used in the table.**

**Portsmouth SL: "Portsmouth Social Library Catalogue" (1750 with 1755 additions), Small Manuscript Colls., Portsmouth Athenaeum, Portsmouth, N. H.**

**Salem Library: "Alphabetical Catalogue of Books . . . 1761 . . . ," Salem Athenaeum Coll., Essex Institute Library, Salem, Ma.**

**J. Condy: probate inventory of his bookstore taken in 1768, Elizabeth A. Reilly, "The Wages of Piety: The Boston Book Trade" in** ***Printing and Society in Early America,*** **ed. William L. Joyce, et al (Worcester: American Antiquarian Society, 1983), 126-131. Winans notes an extant printed catalogue [1766] with a total of 160 titles (Winans #56), known only by a photostat reproduction in an American Art Association auction catalogue that has since disappeared.**

## APPENDIX II – NEWTONIAN LITERATURE IN NEW ENGLAND BOOKSELLER AND SOCIAL LIBRARY CATALOGUES, 1725-1773

| **Catalogue #**[1] | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Catlogue Date, 17. .** | 25 | 34 | 50 | 50 | 60 | 63 | 65 | 65 | 66 | 68 | 68 | 72 | 73 | 73 |
| **ACADEMIC TEXTS**[2] | | | | | | | | | | | | | | |
| **Newton: Original Sources** | | | | | | | | | | | | | | |
| *Principa* | | | | | | | | | | x | | | | |
| tr. Motte, 1729 | | | x | | | | | | | | | | | |
| *Opticks*, 1704 | | | | | x | | | | | x | | | x | |
| *Optical Lectures*, 1728 | | | | | | | | | | x | | | | |
| *System of World*, 1728 | | | x | | | | | | | | | | | |
| **Podium Lectures** | | | | | | | | | | | | | | |
| Clarke, 1730 | | x | | | | | | | | | | | | |
| Desaguliers, 1744 | | | x | | | | | | | | | | | |
| Ditton, 1705 | | | | | | | | | | x | | | | |
| Emerson, 1758, *Mechanics* | | | | | x | | | | | | x | | | |
| Emerson, 1768, *Opticks* | | | | | | | | | | | | | x | |
| Gravesande, tr., 1720, '20, '35 | | x | x | | x | | | | x | x | x | | | |
| Gregory, 1715 | | x | x | x | x | | | | | | | | | |
| Halley, 1697 | | | | | | | | | | | | | x | |
| Hauksbee, 1709 | | | x | | | | | | | | | | | |
| Keill, 1702, *Physicum* | x | x | | | | | | | | | | | | |
| -- tr.., 1720 | | x | x | | x | | | | | x | | | | |
| Keill, 1718, *Astrono.* | | | x | | | | | | | | | | | |
| -- tr., 1721 | x | x | x | | x | | | x | x | | | x | | |
| Rouhault, 1697 | x | x | x | | | | | | | | | | | |
| -- tr., 1723 | | x | x | | | | | | | | | | | |
| Smith, 1738 | | | x | | | | | | | | | | | |
| Whiston, 1715, *Astrono.* | | | x | x | | | | | | x | | | | |
| Whiston, 1716, *Math.* | | | x | | | | | | | | | | | |
| **Sub-total** | 3 | 8 | 14 | 2 | 6 | 0 | 0 | 1 | 2 | 7 | 2 | 1 | 3 | 0 |
| **PHYSICO-THEOLOGICAL WORKS (Pulpit Lectures)** | | | | | | | | | | | | | | |
| Burnet, 1737 | | | x | | x | | | | | | | | | |
| Cheyne, 1705 | x | | | | | | | | | | | | | |
| Clarke, 1705, *Attributes* | | | | | x | | | | | x | | | | |
| Clarke, 1705, *Obligations* | | | x | | | | | | | | | | | |
| Clarke, 1717, *Papers between* | | x | | | x | | | | | | | | | |
| Derham, 1713, *Physico-Theo.* | | x | x | | x | | | x | x | x | | x | x | x |
| Derham, 1715, *Astro-Theo.* | | x | x | | x | | | x | x | x | | x | x | |
| Nieuwentyt, 1715 | | x | x | x | | | | | | x | x | x | | |
| Whiston, 1717 | | | | | | | | | | x | | | | |
| Wollaston, 1722 | | x | x | | x | | | x | x | x | x | x | | x |
| **Sub-total** | 1 | 5 | 6 | 1 | 6 | 0 | 0 | 3 | 3 | 6 | 2 | 4 | 2 | 2 |
| **PHYSICO-THEOLOGICAL POETRY** | | | | | | | | | | | | | | |
| Blackmore | | x | | | | | | | | | | | | |
| Pope | | | w | w | x | w | | w | w | | | x | x | x |
| Thomson | | | w | w | x | x | x | x | x | w | x | x | x | x |
| Young | | | x | | x | | x | w | x | w | | x | w | x |
| **Sub-total** | 0 | 1 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 1 | 3 | 3 | 3 |

| **Catalogue #** | **1** | **2** | ***3*** | ***4*** | ***5*** | **6** | **7** | **8** | **9** | ***10*** | **11** | **12** | **13** | **14** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Catlogue Date, 17..** | 25 | 34 | *50* | *50* | *60* | 63 | 65 | 65 | 66 | *68* | 68 | 72 | 73 | 73 |
| **SCIENCE A LA MODE** | | | | | | | | | | | | | | |
| **Transitional** | | | | | | | | | | | | | | |
| Maclaurin, 1748 | | | x | | | | | | | | | | | |
| Pemberton, 1728 | | | x | x | x | | | | | x | | | | |
| Voltaire, 1733 | | | x | | x | | | x | x | x | | x | | |
| **Polite Introductions** | | | | | | | | | | | | | | |
| Harris, 1719 | | | | | | x | | | | | | | | |
| Ferguson, 1768 | | | | | | | | | | | | x | | |
| Martin, 1759 | | | | | | | | | | | | x | x | |
| Pluche, 1733 | | | | | | | | x | x | x | x | x | x | |
| Telescope, 1761 | | | | | | | | | x | | | x | | |
| **Easy Introductions** | | | | | | | | | | | | | | |
| Dodsley, 1758 | | | | | x | | | x | x | | x | | x | x |
| Ferguson, 1756, *Astronomy* | | | | | | | | | | | x | x | x | |
| Ferguson, 1760, *Mechanics* | | | | | | | | | | | | | x | |
| Martin, 1735, *Grammar* | | | x | | | x | | | x | x | x | | x | x |
| Martin, 1743, *Course* | | | x | | | | | | | | | | | |
| Martin, 1747, *Britannica* | | | | | x | x | | | | x | x | x | x | x |
| Watts, 1725 | | x | | | | | | | w | | x | x | x | x |
| Wells, 1712, *Mathematicks* | | x | x | x | | | | | | | | | | |
| Wells,1736, *Astronomy* | | | | | | | | | | x | x | | | |
| **Guides to Newtonian Apparatus** | | | | | | | | | | | | | | |
| Baker, 1742 | | | x | | | | | | | x | | x | | |
| Fenning, 1769 | | | | | | | | | x | | | x | x | |
| Harris, John, 1703 | | x | | | | | | | | | | | | |
| Harris, Joseph, 1731 | | | x | | | | | x | | | | | x* | |
| Martin, 1762 | | | | | | | | | | | x | | | |
| **Sub-total** | 0 | 3 | *8* | *2* | *4* | 3 | 0 | 4 | 7 | *7* | 8 | 10 | 10 | 4 |
| **DIGESTS AND REFERENCE WORKS** | | | | | | | | | | | | | | |
| **Periodicals** | | | | | | | | | | | | | | |
| *Philosophical Trans.* | | x | x | | | | | | | | | x | | |
| *Critical Review* | | | | | | | | x | x | x | | | | |
| **Biographical Dictionaries** | | | | | | | | | | | | | | |
| Anon. 1760, *Biog. Britannica* | | | | | x | | | | | | | | | |
| Anon. 1761, *General Biog.* | | | | | x | | | x | | | | | | |
| Bayle, 1738, *Hist., Critical* | | | x | | | | | | | x | | | | |
| Martin, 1764, *Biog. Philos.* | | | | | | | | | | | | x | | |
| **Dictionaries of Arts and Sciences** | | | | | | | | | | | | | | |
| Harris, 1704, *Lexicon Tech.* | | | x | x | | | | | x | x | | x | | |
| Chambers, 1728, *Cyclopedia* | | | x | | | | | | | | | x | | x* |
| 1764, *Complete* | | | | | | | | | | | x* | | x | |
| 1764, *New and Complete* | | | | | | | | x | x | | | x | | |
| **Sub-total** | 0 | 1 | *3* | *1* | *2* | 0 | 0 | 3 | 3 | *3* | 1 | 5 | 1 | 1 |
| **TOTAL Newtonian Titles** | **4** | **18** | ***34*** | ***6*** | ***21*** | **5** | **2** | **14** | **18** | ***25*** | **14** | **23** | **19** | **10** |

**Note 1: Catalogue # identification: 1-Gerrish, 2-Cox, *3-Redwood Lib. Company, 4-Portsmouth Social Lib., 5-Salem Social Lib.*, 6-Arnold, 7-Barclay, 8-Mein (Circulating Lib. and Bookseller), 9-Mein (Bookseller), *10-Providence (Social) Lib.*, 11-Condy, 12-Cox & Berry, 13-Knox, 14-Smith & Coit. Also see Table1.1.**

**Note 2: For bibliographical information, see App. III. Symbols: x-individual title; w-title found only in collected works; x*-ambiguous short title assigned to most likely source. *Italics*-Social Library entry.**

# APPENDIX III – CHECKLIST OF IMPORTED NEWTONIAN LITERATURE

## ACADEMIC TEXTS

**Original Sources**

Newton, Isaac. 1687. *Philosophiae Naturalis Principia Mathematica.*
– Motte, Andrew, tr. 1729. *The Mathematical Principles of Natural Philosophy.* . . ., 2 V.
– *1728. A Treatise of the System of the World.* . . . (Book 3 of *Principia* tr. from early Ms. version)
– *1704. Opticks; or, A Treatise of the Reflexions, Refractions, Inflexions and Colours of Light.* . . .
– *1728. Optical Lectures Read in . . . Cambridge . . . 1699.* (tr. from Latin Ms)

**Podium Lectures: Interpretations, Explications, Demonstrations**

Clarke, John. 1730. *A Demonstration of some of the Principal Sections of Sir Isaac Newton's Principles of Natural Philosophy.*
Desaguliers, John Theophilus. 1734-44. *A Course of Experimental Philosophy*, 2 V.
Ditton, Humphrey. 1705. *The General Laws of Nature and Motion; . . . Being a Part of the Great Mr. Newton's Principles . . .*
Emerson, William. 1758. *The Principles of Mechanics.*
– 1768. *The Elements of Opticks.*
s'Gravesande, Willem. 1720. *Philosophiae Newtonianae Institutiones* . . ., 2 V. (Leyden).
– John Theophilus Desaguliers, tr. 1720. *Mathematical Elements of Natural Philosophy Confirmed by Experiments: . . . Introduction to . . . Newton's Philosophy* . . ., 2 V.
– John Keill, tr. 1720. *Mathematical Elements of Physics Prov'd by Experiments: . . . Introduction to . . . Newton's Philosophy.*
– Fellow of Royal Society [John Stone], tr. 1735. *An Explanation of the Newtonian Philosophy.*
Gregory, David. 1715. *The Elements of Astronomy, Physical and Geometrical.* . . ., 2 V.
Halley, Edmund. 1697. *The true Theory of the Tides, extracted from . . . Newton, . . . Principia; . . .*
Hauksbee, Francis. 1709. *Physico-Mechanical Experiments on Various Subjects; . . .*
Keill, John. 1702. *Introductio ad Veram Physicum.* . . .
– tr. 1720, *An Introduction to Natural Philosophy* . . .
– 1718. *Introductio ad Veram Astronomiam.* . . .
– tr. 1718 *An Introduction to the True Astronomy: . . .*
Rouhault, Jacques. 1697. *Physica.* . . ., notes by Samuel Clarke, 2 V.
– John Clarke, tr. 1723. *Rouhault's System of Natural Philosophy*, notes by S. Clarke, 2 V.
Smith, Robert. 1738. *A Compleat System of Opticks*, . . . 2 V. (Cambridge)
Whiston, William. 1715. *Astronomical Lectures* . . .
– 1716. *Sir Isaac Newton's Mathematick Philosophy More Easily Demonstrated: . . .*

## PHYSICO-THEOLOGICAL WORKS: Pulpit Lectures

Burnet, Gilbert. 1737. *A Defense of Natural and Revealed Religion: being an Abridgement of the Sermons Preached at the Lecture Founded by the Hon^ble^* Robert Boyle, Esq, 4V.
Cheyne, George. 1705. *Philosophical Principles of Natural Religion* . . .
Clarke, Samuel. 1705 *A Demonstration of the Being and Attributes of God* . . .
–1705. *A Discourse Concerning the Unchangeable Obligations of Natural Religion* . . .
–1717. *A Collection of Papers . . . between . . . Mr. Leibnitz, and Dr. Clark . . . Relating to . . . Natural Philosophy and Religion* . . . Also in *The Works of Samuel Clarke*, (1738).

Derham, William. 1713. *Physico-Theology; or, A Demonstration of the Being and Attributes of God from his Works of Creation.*

– 1715. *Astro-Theology; or, A Demonstration of the Being and Attributes of God from a Survey of the Heavens.*

Nieuwentyt, Bernard. 1715. *The Religious Philosopher; or,The Right use of contemplating the works of the Creator*, 3 V.

Whiston, William. 1717. *Astronomical Principles of Religion . . .*

Wollaston, William. 1722. *The Religion of Nature Delineated.*

PHILOSOPHICAL POETRY

Blackmore, Richard. 1712. *The Creation, a Philosophical Poem. Demonstrating the Evidence and Providence of a God.*

Pope, Alexander. 1733-34. *An Essay on Man*. Also in *Works* (1742).

Thomson, James. 1726-30. *The Seasons*. Also in *Works* (1738, 1744).

Young, Edward. 1741-45. *Night Thoughts on Life, Death, and Immortality*. Also in *Works* (1741).

**SCIENCE A LA MODE: Popularized Introductions to Newtonian Philosophy and Apparatus**

**Transitional Texts**

Maclaurin, Colin. 1748. *An Account of Sir Isaac Newton's Philosophical Discoveries . . .*

Pemberton, Henry. 1728. *A View of Sir Isaac Newton's Philosophy.*

Voltaire, Francois Arouet de. 1733. *Letters Concerning the English Nation*, tr. J. Lockman.

**Polite Introductions for Adults and Youth**

Harris, John. 1719. *Astronomical Dialogues between a Gentleman and a Lady. Wherein the Doctrine of the Sphere, Uses of the Globes and . . . Astronomy and Geography are explained in a Pleasant, Easy, and Familiar Way. With the Famous Instrument called the Orrery.*

Ferguson, James. 1768. *The Young Gentleman and Lady's Astronomy, familiarly explained in ten Dialogues . . .* [2nd ed., 1769, as *An Easy Introduction to Astronomy, for Young Gentlemen and Ladies*].

Martin, Benjamin. 1759. *Young Gentleman and Lady's Philosophy; . . .*, 3V. [Reissued from series in *The General Magazine of Arts and Sciences*, 1755–]

Pluche, Noel Antoine. 1733. *Spectacle de la Nature; or, Nature displayed: . . . Discourses on Natural History, . . . most proper to . . . form the Minds of Youth*, tr. Mr. Humphries, 7 V.

Telescope, Tom, A. M. (Newberry, J.) 1761. *The Newtonian System of Philosophy Adapted to the Capabilities of Young Gentlemen and Ladies, . . .*

**Easy Introductions for Adults and Youth**

Doddsley, Robert. 1758. *The Preceptor: Containing a General Course of Education. Wherein the first Principles of Polite Learning are laid down . . . for . . . the Instruction of Youth*, 2V.

Ferguson, James. 1756. *Astronomy Explained upon Sir Isaac Newton's Principles and Made Easy to Those Who Have Not Studied Mathematics.*

– 1760. *Lectures on Select Subjects in Mechanics, Hydrostatics, Pneumatics,and Optics; with the use of the Globes . . .*

Martin, Benjamin. 1735. *The Philosophical Grammar; Being a View of the Present State of Experimented Physiology, or Natural Philosophy . . .*

– 1743. *A Course of Lectures in Natural and Experimental Philosophy, Geography, and Astronomy explain'd on the Principles of the Newtonian Philosophy, . . .*

– 1747. *Philosophia Britannica; or, A New System of the Newtonian Philosophy, Astronomy and Geography . . .*, 2V (Reading). [2nd. ed., 1759, 3 V.]

Watts, Isaac. 1725. *The Knowledge of the Heavens and the Earth Made Easy:...*
Wells, Edward. 1712-14. *The Young Gentleman's Course of Mathematicks*, 2 V.
– 1736, 4th ed., *Young Gentleman's Astronomy.*

**Apparatus a La Mode: Guides to Newtonian Instruments**

Baker, Henry. 1742. *The Microscope Made Easy.*
Fenning, Daniel. 3rd, 1770. *A New and Easy Guide to the Use of the Globes* (Dublin).
Harris, John. 1703. *The Description and Uses of the Celestial and Terrestrial Globes.*
Harris, Joseph. 1731. *The Description and Use of the Globes and the Orrery.*
Martin, Benjamin. 1762. *The Description and Use of Both the Globes, Armillary Sphere, and Orrery...*

SCIENCE DIGESTS AND REFERENCE WORKS

**Periodicals**

Royal Society of London. 1687–. *Philosophical Collections and/or Transactions Abridged.*
Anon. c.1750–. *Critical Review and Annals of Literature*, 20 V.

**Biographies**

Anon. 1760. *Biographia Britannica*, 7V.
Anon. 1761. *A New and General Biographical Dictionary....*
Bayle, Pierre. 1738. *A General Dictionary, Historical and Critical Dictionary,... Containing the Lives,... of All the Most Famous Men*, tr. John Peter Bernard, et al., 10V.
Martin, Benjamin. 1764. *Biographia Philosophica Being an Account of the Lives, Writings, and Inventions, Of the most Eminent Philosophers and Mathematicians...*

**Dictionaries of Arts and Sciences**

Chambers, Ephraim. 1728. *Cyclopedia; or, An Universal Dictionary of Arts and Sciences*, 2 V.
Harris, John. 1704-1710. *Lexicon Technicum; or, An Universal English Dictionary of Arts and Sciences*, 2 V.
Crocker, Temple et al, eds. 1764. *The Complete Dictionary of Arts and Sciences.*
Society of Gentlemen, ed. 1764. *A New and Complete Dictionary of Arts and Sciences*, 4 V.

* Place of publication: London, unless otherwise noted. Date of publication: date of first edition.

Bibliographic Sources: Peter and Ruth Wallis, *Newton and Newtonia, 1672-1975: A Bibliography* (Kent, England: Dawson, 1977); David M. Knight, *Natural Science Books in English, 1600-1900* (London: Portman Books, 1989), Chs. 2-4; Henry C. King, *Geared to the Stars: The Evolution of Planetariums, Orreries, and Astronomical Clocks* (Toronto: University of Toronto Press, 1978), Chs. 10 and 11, and Bibliography; John R. Millburn, *Benjamin Martin: Author, Instrument-Maker, and 'Country Showman'* (Leyden, 1976), App. I; and John R. Millburn in collaboration with Henry C. King, *Wheelwright of the Heavens: The Life & Work of James Ferguson, FRS* (London: The Vade-Mecum Press, 1988), App. VIII.

## PRIMARY SOURCES

### Unpublished Works

"An Alphabetical Catalogue of the Books belonging to the Social Library in Salem: Taken the Twenty-eighth Day of May --- Anno Domini 1761 To which is sujorn'd An Account of Donations to the Library," Salem Athenaeum Coll., EIL.

"The First Book of the Records and Proceedings of the Library Society in Portsmouth in the Province of New Hampshire . . . 1750." Small Manuscript Collections, PA.

Mather Papers. MHS.

"Proposals for Beginning a Social Library in Portsmouth [New Hampshire, 1750]." In "The First Book of the Records and Proceedings of the Library Society in Portsmouth in the Province of New Hampshire . . . 1750." Small Manuscript Colls., PA.

Stiles, Ezra. Papers. Yale University Colls. Microfilm Edition, 1978.

Warren, Mercy. Letterbook. Mercy Warren Papers. Microfilm. MHS.

Warren-Winthrop Papers. Mercy Warren Papers, 1709-1841. MHS.

Winthrop, John. Papers. Harvard University Archives, Cambridge, Ma.

### Almanacs and Newspapers

*An Astronomical Diary, or, an Almanack for. . . .* (1726-1775) by Nathaniel Ames, Jr., (1726-1764) and by Nathaniel Ames III (1765-1775). Printed in Boston, Ma. by Bartholomew Green and later by John Draper and others; Portsmouth, N.H., by Daniel Fowle; Newport, R. I.; and New Haven, Hartford, and New London, Ct.

*The Boston Evening-Post.* 1725-75.

*The Boston Gazette.* 1719-98.

*The Boston News-Letter.* 1706-76. (Variously titled after 1726).

*The Boston Post-Boy.* 1735-54.

*The New-England Courant.* 1721-26.

*The New-England Weekly Journal.* Boston. 1721-41.

*New Hampshire Gazette.* Portsmouth, N. H. 1756-1800 on.

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