Sci

His

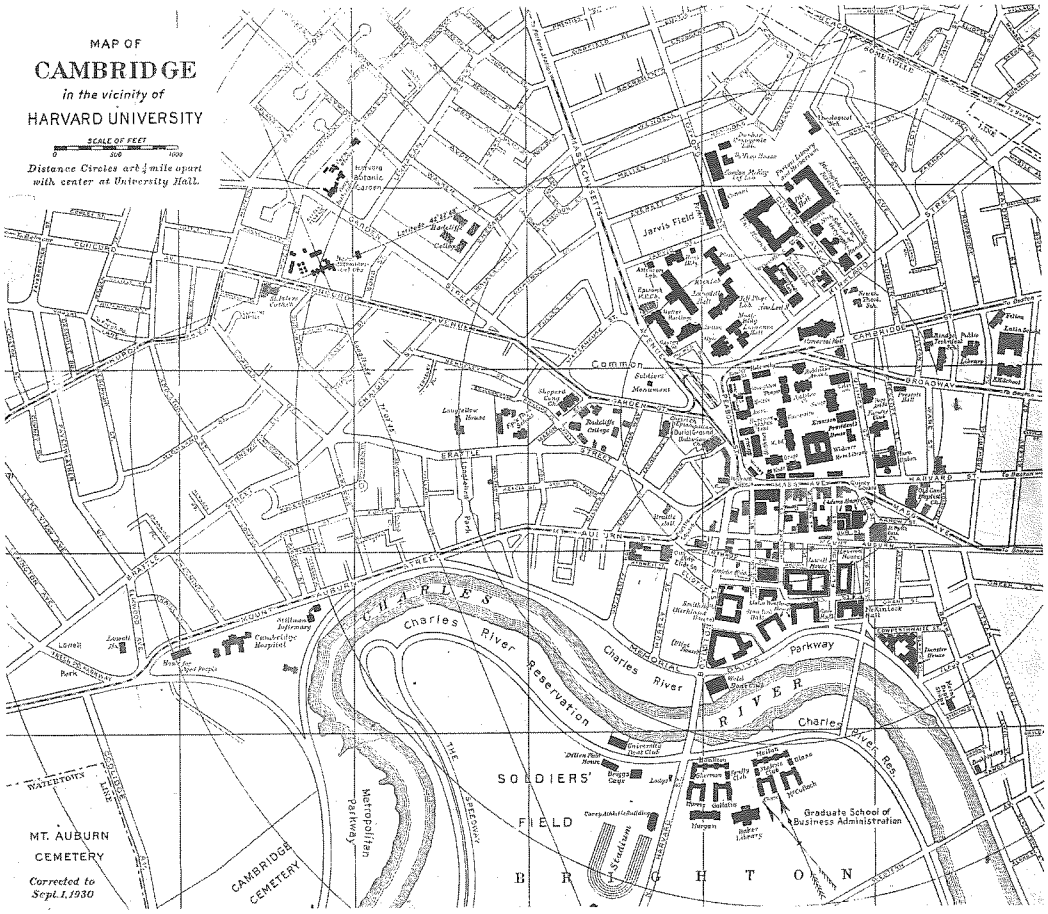
Edited
and M

This c
says exa
between
academi
viewed f
a group
Harvard
ponent o
the essay
collectiv
science i
ducting t
used a v
the Harv
ries.

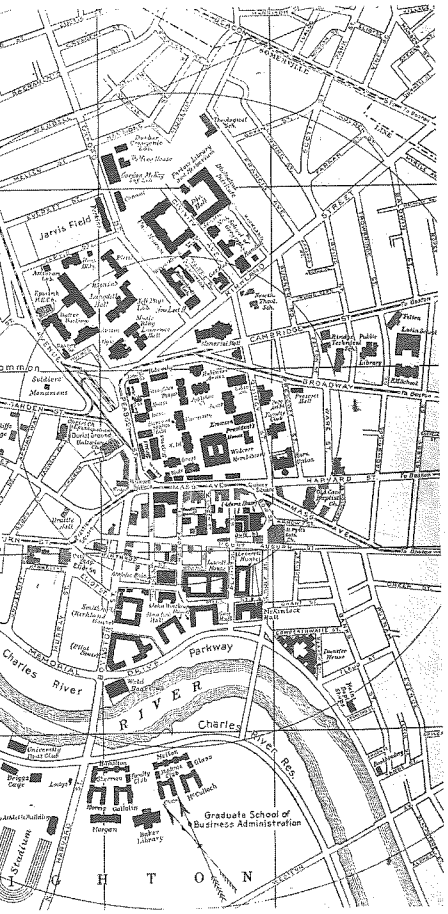
The vo
troductio
ing the p
in the sev
suggestin
vard rela
of scienc

The su
ally chro
with Sar
attitudes
early Ha
functions
beginnin
and Bruc
with a c
Harvard.

Toby
fries Wy
that pers
tional hi
trates on
Peabody
anthropo



Harvard University, 1930. *Courtesy of Harvard University Archives.*



ard University Archives.

Science at Harvard University

Historical Perspectives

Edited by Clark A. Elliott
and Margaret W. Rossiter

Bethlehem: Lehigh University Press
London and Toronto: Associated University Presses

Scien
U

Histor

Edited by
and MAR

This collec
says examine
between scie
academic ins
viewed from
a group of sc
Harvard Uni
ponent of th
the essays ar
collectively t
science in an
ducting their
used a wealt
the Harvard
ries.

The volum
troduction b
ing the pictu
in the several
suggesting w
vard relates t
of science in

The subse
ally chronol
with Sara S
attitudes tov
early Harvar
functions. M
beginnings o
and Bruce S
with a comp
Harvard.

Toby App
fries Wyman
that persona
tional histor
trates on fa
Peabody Mu
anthropolog

(Con

Associated University Presses
440 Forsgate Drive
Cranbury, NJ 08512

Associated University Presses
25 Sicilian Avenue
London WC1A 2QH, England

Associated University Presses
P.O. Box 39, Clarkson Pstl. Stn.
Mississauga, Ontario,
L5J 3X9 Canada

The paper used in this publication meets the requirements of the American National Standard for Permanence of Paper for Printed Library Materials Z39.48-1984.

Library of Congress Cataloging-in-Publication Data

Science at Harvard University: historical perspectives / edited by Clark A. Elliott and Margaret W. Rossiter.
p. cm.
Includes bibliographical references.
ISBN 0-934223-12-2 (alk. paper)
1. Science—Massachusetts—Cambridge—History. 2. Harvard University—History. I. Elliott, Clark A. II. Rossiter, Margaret W.
Q127.U6S3163 1992
509'.744'4—dc20 89-64067
CIP

PRINTED IN THE UNITED STATES OF AMERICA

quirements
nence of Paper

Data

ectives / edited by
r.

-History. 2. Harvard
. II. Rossiter, Margaret W.

89-64067
CIP

Contents

From Heaven's Alarm to Public Appeal
Comets and the Rise of Astronomy at Harvard

SARA SCHECHNER GENUTH

Until the eighteenth century, comets were seen as celestial hieroglyphs that could be deciphered by observers wishing to forecast the fate of a community. As if in deference to this ancient opinion, the bright comets that blazed over Boston during Harvard's first two centuries punctuated key chapters in the history of astronomy at Harvard. From the college's inception in 1636 until the endowment of its observatory in 1843, in which a comet played no small part, comets were the subject of intense study by Harvard faculty and students. This essay will use the history of cometary research as an index of the intellectual and institutional changes that made astronomy an independent field of study within Harvard and the object of financial support from outside Harvard.

Beyond the disciplinary development of astronomy at Harvard is the larger issue of the changing mission of the school. The integration of teaching and research is a hallmark of the modern university, but not a distinguishing characteristic of seventeenth- and eighteenth-century Harvard. One way to explore the means by which the modern research university emerged from the college dedicated to teaching is to examine the question of why, despite an early, deepseated interest in astronomy, did it take two hundred years to establish an observatory. The reasons for the delay reside in the interdependent yet dynamic relationship of the faculty's religious commitments, teaching, research, and liaisons with the public. These factors, which were interconnected with the disciplinary development of astronomy, are revealed historically through the changing pattern of cometary studies at Harvard.

Seventeenth-Century Astronomy at Harvard

Although Harvard was not founded as a religious seminary, its key mission was to prevent the formation of an ignorant clergy by giving a general education to future candidates for the ministry.[1] Astronomical studies were not incompatible with this program and were held in high esteem from the

start. As early as 1640, seniors recited astronomy.[2] In 1642, the year of the first commencement ceremonies, "The Laws, Liberties and Orders of Harvard College" stipulated that candidates for the masters degree must "giveth up in writing a synopsis or summary of Logic, Natural and Moral Philosophy, Arithmetic, Geometry, and Astronomy," and be ready to defend their theses.[3] From 1642, astronomical propositions to be defended publicly by the students appeared among the *theses physicae et mathematicae* printed in commencement broadsides.[4]

As preserved in the broadsides, these one-line theses provide only slender evidence of the content of astronomical instruction at Harvard; more substantial evidence is gleaned from the almanacs that issued from the little printing press in Harvard Yard.[5] From as early as 1646, the Cambridge printer selected a recent graduate (often a tutor or fellow) to calculate and compile the almanac's astronomical entries. Entitled to fill up blank pages with original poems and essays, young Harvard authors often used the almanacs to teach astronomy. Popular topics included comets, Copernican heliocentrism and Keplerian astronomy, telescopic discoveries, and meteorology.[6]

Perhaps the most striking thing one learns from these almanacs is not what topics were taught at Harvard, but how they were taught.[7] Almanac authors did not speak in a single voice. The cometary essays, for example, reveal a latitude of opinion at Harvard. Inspired by the 1664 comet, Alexander Nowell (A.B. 1664) wrote that comets were heavenly bodies coeval with the stars.[8] William Williams (A.B. 1683), however, dismissed such new ideas as "far more difficult to a rational head" than the older Aristotelian view that comets were ephemeral meteors.[9] For Williams, comets were ignited terrestrial exhalations drawn up into the atmosphere and starry spaces by virtue of the heavenly bodies. This ancient theory was all but obsolete in learned circles of Williams's day. On the other hand, Williams broke with tradition by omitting discussion of comets as divine portents or natural causes of local calamities, whereas Nowell, for all the novelty of his physical theory, insisted that "experience Attests, and reason Assents, that they [comets] have served for sad Prologues to Tragical Epilogues." Proceeding from natural causes, but preceding preternatural effects, comets, for Nowell, were a sign to all in whose horizon they appeared. A third essayist, Henry Newman (A.B. 1687, Harvard librarian, 1690–93), took yet a different tack. He found intrinsic interest not in cometary significance or composition, but in the possibility that the observed paths of comets might prove the earth's revolution around the sun.[10] Although Harvard sponsored the almanacs, the president and Corporation did not seem to insist on a single outlook.

The essays also reveal Harvard's scientific "errand into the wilderness." Almanacs were the most widely distributed item to issue from the colonial press. Prior to the advent of newspapers in the eighteenth century, almanacs were the sole form of periodical literature in New England. Thereby intended

Thus, the seeds, for more extensive astronomical pursuits were sown in the seventeenth-century Harvard soil. Although the college did not emphasize astronomical studies, it taught recent theories and condoned debate among tutors preparing almanacs. From printed page and pulpit, scholars diffused the new learning. Acquisition of a telescope and later other instruments allowed scholars to begin to prove their mettle as researchers. By communicating their work and earning respect, Harvard scholars began to forge links with natural philosophers abroad, and the merits and pleasures of scientific society were reinforced by the activities of the Philosophical Society at home.

Puritan Astronomy

Some insight into the content of and motivation for scientific teaching and research can be gained through inspection of Harvard's religious underpinnings. In Harvard's first century, Puritanism predominated and strongly colored astronomical pursuits by focusing attention on God's manifest activity in the natural world. By contrast, eighteenth- and nineteenth-century scientific work shows greater reliance on the argument from design, and less on the decipherment of religious emblems in the natural world.

At the heart of the Puritan approach to scientific inquiry was the doctrine of divine providence.[30] The natural world reflected a divine order and exhibited God's providence in operation. The Puritan scholar was free to study nature only insofar as he remembered to behold divine purpose there. It was inappropriate to study astronomy or meteorology solely for practical purposes of navigation or weather forecasting. In the words of John Cotton:

> It is not utterly unlawfull for men to make observation of the estate of the weather, and face of the sky; our Saviour doth not reproove it in them, but onely reprooves this, in that they were better skilled in the face of the sky, and signes of the weather, then in the signes of the times.[31]

The natural world was a divine ledger in which the devout natural philosopher was to read the signs of the times.

Moreover, according to Puritan cosmology, God "usually made this world to be a mappe and shadow of the spirituall estate of the soules of men."[32] In *The Scarlet Letter*, Nathaniel Hawthorne aptly captured this belief in a correspondence between the natural and spiritual worlds. On the night of Governor Winthrop's death and Arthur Dimmesdale's remorseful vigil at the pillory, a ruddy meteor spread its sickly streams in the shape of the letter "A" across the sky. Pious townsmen interpreted the great red letter to stand for "Angel." Since Winthrop was made an angel, it was fitting for it to be recorded in the heavenly scroll. Yet, for Dimmesdale, the suffering and

undisclosed adulterer, the fiery meteor was a brand of his sin and prefigured God's impending judgment.[33]

Meteors were just one sign of divine wrath in the Puritan landscape. Others included comets, earthquakes, whirlwinds, floods, and fire. Often God worked within his natural laws to admonish sinners with such portents. Yet, when God saw fit to abrogate his laws, divine intervention in local affairs was possible. Many New England publications recorded preternatural events including monstrous births, evils inflicted by demons and witches, even terrible storms.[34]

Nowhere is the Puritan view of nature so well articulated as in the literature on comets. The essays of Increase Mather, Cotton Mather, and Charles Morton, in particular, suggest views that Harvard College wished to inculcate in its students. Since 1674, when Increase had been elected a fellow, he was active in the administration of the college and occasionally observed stars and comets through Harvard's telescope.[35] As president and rector (1685–1701), he rode to Cambridge once or twice weekly to preach to the students, moderate disputations, and conduct commencement ceremonies. The college also adopted Mather's program of study, when in 1694 the Harvard Corporation and the Cambridge ministers association jointly sponsored a proposal to record unusual events in the heavens, earth, and water, and divine judgments and deliverances.[36] Although as a student and fellow (1690–1703), Cotton's ties to Harvard were less formidable than his father's, his work on comets in the *Christian Philosopher* (1721) was acquired by Harvard's library, and influenced later generations of students, including a young John Winthrop, future Harvard professor of natural philosophy.[37] The views of father and son also flesh out those abbreviated in the manuscript textbook, *Compendium physicae*, written by Charles Morton (fellow, 1692–97, vice-president, 1697–98) and used in the college from 1687 until 1728.

In the 1680s Increase Mather preached and published that comets were "Heaven's Alarm" to sinning citizens of Boston. Pride, profaneness, worldliness, iniquity, and an undeserved sense of general security infected the people. Too many women, Mather fumed, "have *the Attire of an Harlot*." They "lay out their Hair, and wear their false Locks, their Borders, and Towers like *Comets*, about their heads." Worse yet, there was "such a multitude of *Licensed Drinking-Houses* (and Town-dwellers frequenting them) to the Shame of *Boston*, and to the Infamy of *New-England*." When confronted with recent visitations—King Philip's War (1675–76) and Indian uprisings, smallpox, and fires in 1676 and 1679—these sinners had not reformed their tippling, wig-wearing ways. No wonder God saw fit to brandish the comets of 1680 and 1682 over their heads![38] Mather pleaded that "the Voice of God in Signal Providences, especially when repeated and Iterated, ought to be Hearkned unto."[39]

Mather backed up his sermons with research. After soliciting cometary observations from colleagues and reading widely,[40] he wrote and published

his respected *Kometographia* (1683). Although Mather commenced his book with a discussion of the nature, motion, form, and duration of comets, his primary object was not to convince men that comets were celestial conglomerations of fiery, lucid particles, but to prove that these natural bodies were "portentous signs of divine anger, and prognosticks of great evils hastening upon the world."[41] Specifically, comets were signs of political and religious commotion, and causes of agricultural and medical calamities. While God preconfigured political events to follow apparitions, the comets themselves could blast the earth. When a comet tail brushed the planet, it caused drought, caterpillars, tempests, inundations, earthquakes, and disease respectively in different localities according to the occult qualities inherent in those regions.[42]

Whether signal or causal, a comet remained a kind of "Warning-piece" that God discharged before his "Murdering-pieces" went off.[43] Judgment was at hand, and men had best repent and prepare for the worst. To prove his point by historical induction, Mather compiled a checklist of all comets and ensuing disasters from the Creation down to 1683. The bloody catalog filled a hundred pages. What political "vials of wrath" God intended to pour on New England after the 1682 comet, Mather refused to predict, for he eschewed judicial astrology. Yet, he felt physical theory was sufficiently grounded for him tentatively to prophesy "a cold and tedious Winter, much snow, and consequently great Floods; Malignant and Epidemical Diseases; in special the Plague."[44]

Although Cotton Mather's thinking in the *Christian Philosopher* was informed by the naturalistic theories of Newton, Halley, and contemporary English philosophers,[45] he did not fully dismiss the involvement of angels and spirits. "The *Heavens do Rule*, and the *Invisible World*, has an astonishing share in the Government of *Ours*."[46] Like his father, he observed that comets encouraged men to prepare for the Day of Judgment and "that Grand REVOLUTION."[47] Mather darkly held that God directed comets toward sinful planets so that poisonous tails would pollute planetary atmospheres. Truly evil worlds met a worse fate. God set them ablaze and hurled these hells into cometary orbits. Thus, a comet was a "wicked World *made a fiery Oven in the Time of the Anger of GOD!*" A comet's inhabitants lived in a state of punishment.[48]

With this image of souls tortured in celestial bonfires, even a "Serious Christian" might be dismayed by a comet. A total contempt of celestial prodigies was foolhardy even among the most devout, he concluded. "Something may be *Read* sometimes by the *Light* of those *Fires*. There is *not* always *Nothing* in them."[49] Nevertheless, Mather parted company with his father's older attitude and insisted that comets were not necessarily harbingers of all ensuing devastation. People were too predisposed to prognosticate from heavenly signs, he lamented. If they sincerely wished to see "*certain Omens* of *Evil to come*," they need look no further than the glaring sins of local

igh Mather commenced his book
rm, and duration of comets, his
ien that comets were celestial
to prove that these natural bodies
and prognosticks of great evils
omets were signs of political and
ıral and medical calamities. While
ollow apparitions, the comets
comet tail brushed the planet, it
dations, earthquakes, and disease
to the occult qualities inherent in

d a kind of "Warning-piece" that
ces" went off.[43] Judgment was at
for the worst. To prove his point
hecklist of all comets and ensuing
he bloody catalog filled a hundred
intended to pour on New England
predict, for he eschewed judicial
as sufficiently grounded for him
dious Winter, much snow, and
l Epidemical Diseases; in special

the *Christian Philosopher* was
ewton, Halley, and contemporary
niss the involvement of angels and
visible World, has an astonishing
is father, he observed that comets
of Judgment and "that Grand
hat God directed comets toward
ld pollute planetary atmospheres.
them ablaze and hurled these hells
"wicked World *made a fiery Oven*
net's inhabitants lived in a state of

elestial bonfires, even a "Serious
et. A total contempt of celestial
he most devout, he concluded.
e *Light* of those *Fires*. There is *not*
Mather parted company with his
ets were not necessarily harbingers
predisposed to prognosticate from
ely wished to see "*certain Omens*
ther than the glaring sins of local

society. Comets should not alarm a devout nation; sectarianism, immorality, and Arianism should.[50]

The Harvard textbook, *Compendium physicae* by the Reverend Charles Morton, dovetailed neatly with the opinions of the Mathers. Morton taught Harvard students that heavenly bodies physically influenced the earth with steams carried on light beams. By affecting the weather in this way, planets and stars might engender somatic disease and consequently mental illness. Close scrutiny of old almanacs to discover correlations between the positions of heavenly bodies and the weather would not only ground natural astrology, but would also be of excellent political and economic use.[51] Morton's general reasoning on planetary influences logically extended to comets, which he deemed crystalline planets revolving in eccentric orbits,[52] and his view was compatible with the Mathers' preoccupations with comet beams and steams brushing the earth. Looking beyond the effects of comets, he concluded that the true ends of comets were not to frighten the vulgar, but to teach men about the nature of the heavens, the motion of the earth, men's diminutive knowledge of the universe, and the magnitude of the Creator's glory.[53]

Putting aside minor differences in theory, I wish to emphasize that Morton and the Mathers sought as much to set their students and parishioners on a true Christian path as to instruct them in natural philosophy. Cotton Mather drove this point home in *The Boston Ephemeris* of 1683. After describing the comet of 1682, Mather delivered an essay "for the advancement of *Scripture-Knowledge*, and *Christian Piety*." He explained:

> [This essay is] No unsuitable *Service* for an *Almanack*: but the more *Requisite*, because if we design only to edifie the *Students* of *Astronomy* among us, Alas! there is scarce *One* of a *City* and two of a *Tribe* to be addrest. And because here's a fit place for an happy *snare*.... The very meanest things should have *Holiness* interwoven, and be consecrated unto a *Divine Service*. Reader, a sorry *Almanack* will become Noble, if it may share in such an Honour.... let it not be absurd to beseech the *Readers* of an *Almanack* to become *Christian* Men.[54]

Mather spoke for his Puritan colleagues when he asserted that astronomical studies, even as mundane as an almanac, should be acts of religious devotion.

Eighteenth-Century Harvard Astronomy Secularized

In contrast, eighteenth-century Harvard astronomers surveyed the heavens primarily for practical ends and scientific interest. Although they did not fail to notice God's wise design of the universe, which instilled them with a reverent sense of the deity, they did not look among the stars for messages pertaining to local affairs.[55] This shift in intellectual priorities is clearly seen in the lectures of John Winthrop (A.B. 1732), the second incumbent of the Hollis Professorship of Mathematics and Natural Philosophy.[56]

A descendant of the Connecticut governor who had given Harvard its first telescope, Professor Winthrop hailed from a family already distinguished in politics and science. Yet, Winthrop's reputation did not rest on the stature of his ancestors but on his own impressive scientific career.

Astronomy was Winthrop's forte, and he harbored a life-long interest in comets. The commonplace book that he began as a freshman reveals an early curiosity about comets. In 1729, at age 14, he carefully cited Cotton Mather's, Bernoulli's, and Cassini's cometary works.[57] Almost forty years later, in 1767, Benjamin Franklin presented to the Royal Society Winthrop's *Cogitata de cometis*, which was acclaimed his best paper on physical astronomy. Here he attempted to deduce the masses and densities of comets from the dimensions of the comae and their interactions with the sun.[58] Over the years, Winthrop avidly corresponded with colleagues about comets,[59] recorded observations in his diary,[60] and, according to college lore, suspended his lectures for the duration of each comet in order to study the heavenly visitor.[61] Sometimes he could induce his students to join him. In 1744, Edward Augustus Holyoke (A.B. 1746), son of the current Harvard president, took advantage of a holiday from lectures and assiduously observed a bright comet.[62] At the time, Winthrop himself was inclined to publish a paper on comets, but withheld it when he learned that Thomas Clap (A.B. 1722), the president of Yale, intended his own publication.[63]

Mather Byles (A.B. 1725) had no such compunctions. A Calvinist by background, this grandson of Increase and nephew of Cotton Mather, published an alarming, yet very up-to-date poem on comets. Byles argued that a comet tail did not bring famine, earthquakes, pestilence, and war, yet insisted that a comet "all around proclaims / A world in chaos, or an earth in flames." A close-approaching comet had caused Noah's flood and another would cause the end of the world. On the fateful day when that executioner comet reached the earth, midnight would blaze with a midday glare.

> The earth dissolves thro' its disjointed frame,
> Its clouds all lighten, and its Aetna's flame;
> The sea exhales, and in long volumes hurl'd,
> Follows the wand'ring globe from world to world
> Now at the sun it glows, now steers its flight
> Thro' the cold desarts of eternal night,
> Warns every creature thro' its trackless road,
> The fate of sinners, and the wrath of GOD.[64]

On Judgment Day, our globe would become a fiery hell in cometary orbit.

Although Byles's style was a vestige of his Puritan upbringing, his cometary theory was thoroughly modern.[65] Albeit in a different tone, Winthrop countenanced many of the same arguments in two public lectures delivered in Harvard's Holden Chapel to commemorate the first predicted return of Halley's comet in 1759.

vernor who had given Harvard its first
from a family already distinguished in
eputation did not rest on the stature of
ve scientific career.
nd he harbored a life-long interest in
e began as a freshman reveals an early
14, he carefully cited Cotton Mather's,
works.[57] Almost forty years later, in
the Royal Society Winthrop's *Cogitata*
est paper on physical astronomy. Here
and densities of comets from the
ractions with the sun.[58] Over the years,
colleagues about comets,[59] recorded
ording to college lore, suspended his
met in order to study the heavenly
his students to join him. In 1744,
, son of the current Harvard president,
ures and assiduously observed a bright
elf was inclined to publish a paper on
ed that Thomas Clap (A.B. 1722), the
ublication.[63]
such compunctions. A Calvinist by
ase and nephew of Cotton Mather,
ate poem on comets. Byles argued that
earthquakes, pestilence, and war, yet
laims / A world in chaos, or an earth
had caused Noah's flood and another
the fateful day when that executioner
uld blaze with a midday glare.

rame,
me;
rl'd,
to world
light

road,
OD.[64]

ecome a fiery hell in cometary orbit.
f his Puritan upbringing, his cometary
lbeit in a different tone, Winthrop
ents in two public lectures delivered in
morate the first predicted return of

In his regular course of Harvard lectures, Winthrop taught that comets moved in closed, elliptical orbits under the influence of universal gravitation.[66] Nevertheless, he eagerly awaited the return of Halley's comet to confirm Newton's theory more fully, and hoping to compute the exact time of the comet's arrival, he discussed details of planetary perturbations of the comet's orbit with scholars like Ezra Stiles.[67] On 3 April 1759, Winthrop finally spotted the comet, and suspended his natural philosophical lectures. Nine days later, he announced his discovery in the *Boston News-Letter* and later inserted an updated report on the comet's trajectory.[68]

In lieu of his regular lectures, Winthrop delivered two special addresses in which he detailed Newton's theory on the nature of comet orbits, material composition, atmospheres, and tails.[69] His physical account served as a springboard into discussion of divine providence. "It is not to be doubted," Winthrop said, "that the alwise AUTHOR of nature designed so remarkable a sort of bodies for important purposes, both *natural* and *moral*, in HIS creation."[70] The natural uses of comets were of two sorts—regenerative and destructive. With Newton, Winthrop believed that comet tails might replenish consumed planetary fluids, a vital spirit in the air, and solar fuel. "On the other side," Winthrop confided in words reminiscent of Cotton Mather's, "it ought not to be concealed, that they seem fitted to be the ministers of divine justice as well as goodness, and capable of producing very great and destructive changes in the planetary worlds; some of them having their nodes situated not far from the orbits of the Planets."[71] If a massive comet passed near a planet, increased tidal fluxes might drown countrysides. Should a planet pass through a comet tail, the tail's aqueous vapors would inundate the globe. With reference to William Whiston's theory, Winthrop thought a comet could have caused the biblical Deluge. Moreover, if God saw fit to destroy the present frame of nature, he might direct a comet to crash into the earth. Winthrop concluded:

> Indeed, according to the laws of nature, particularly those of gravity, it is not possible but that the near approach of a Comet to a Planet, either in it's descent to the Sun or ascent from him, should draw after it a train of dangerous, if not fatal consequences.[72]

Nevertheless, Winthrop quickly advised his audience not to panic at the sight of every comet. While he did not want to explode every apprehension of comet catastrophes, he reminded his listeners that such disasters were rare.

The unlikelihood of danger from these vagrant bodies led Winthrop to underscore the moral purposes of comets. These exotic and irregular apparitions roused men from their complacent slumbers and instilled them with a reverent appreciation of God's skill in governing the world. Although comet orbits appeared haphazard, God had wisely contrived them to prevent collisions with the planets and would continue to regulate them so long as he chose to preserve this "machine of nature."[73]

It should be noted that these reflections on divine providence fulfilled Winthrop's duty as Hollis professor to "promote true piety & Godliness by his own Example and Incouragement." As the Harvard Corporation later reaffirmed this duty,

> the Professor [was to] be directed, while he is delivering his Philosophical and Astronomical Lectures, to make such incidental reflections upon the Being, Perfections and Providence of God, as may arise from the subjects, and may tend seriously to impress the minds of youth.[74]

This obligation, however, was ancillary to scientific instruction in the eighteenth century. By contrast, Increase Mather had seen comets as omens of divine wrath, and he had inspected Scripture and the sins of Boston society in order to ascertain the reasons for the monstrous signs.[75] Winthrop looked neither place; he consulted astronomical texts and made his own careful observations. Although like Mather, he still believed comets to be instruments of divine beneficence or justice, he looked beyond the paltry sins of Boston, and examined the natural role of comets in improving agriculture and health, deluging the globe, or ending the world.[76] His aim was not to urge Boston to awake and repent, but to admire God's handiwork. Natural causes had become emphasized over religious ends.

Intellectual changes mirrored social arrangements. In Increase Mather's day, people had turned to clergymen to learn the significance of comets. By the mid-eighteenth century they looked to a usually nonclerical Cambridge professor to serve as arbiter of scientific matters. A lively discussion of comets and their purposes cropped up amid the politically charged pages of the Boston newspapers, particularly during the appearance of bright comets in 1769 and 1770.[77] As an active contributor, Winthrop not only reported his observations, but served as scientific critic of other published accounts.[78] In providing an outlet for Winthrop's learned articles, the newspapers reinforced a social change that had occurred during the century and broadened the base for popular interest in scientific matters.

Development of Astronomical Curriculum

The Harvard curriculum also reflected the secularization and disciplinary development of astronomy. The early statutes dictated that students survey a range of topics including natural philosophy, astronomy, arithmetic, and geometry according to the time-honored system of lectures, recitations, and disputations. Although astronomy was a separately designated topic for seniors in the published programs of study since 1642, it was taught as a branch of natural philosophy. Under the provisions of the Hollis professorship, which introduced experimental philosophy, this practice did not much change. Throughout his tenure, John Winthrop delivered a general course of

ections on divine providence fulfilled
"promote true piety & Godliness by his
As the Harvard Corporation later

ile he is delivering his Philosophical and
incidental reflections upon the Being,
nay arise from the subjects, and may tend
74

lary to scientific instruction in the
e Mather had seen comets as omens of
pture and the sins of Boston society in
monstrous signs.[75] Winthrop looked
cal texts and made his own careful
still believed comets to be instruments
ked beyond the paltry sins of Boston,
s in improving agriculture and health,
.[76] His aim was not to urge Boston to
od's handiwork. Natural causes had
.

arrangements. In Increase Mather's
learn the significance of comets. By
to a usually nonclerical Cambridge
matters. A lively discussion of comets
the politically charged pages of the
the appearance of bright comets in
tor, Winthrop not only reported his
tic of other published accounts.[78] In
ed articles, the newspapers reinforced
the century and broadened the base
.

al Curriculum

d the secularization and disciplinary
atutes dictated that students survey a
sophy, astronomy, arithmetic, and
system of lectures, recitations, and
a separately designated topic for
tudy since 1642, it was taught as a
e provisions of the Hollis professor-
losophy, this practice did not much
nthrop delivered a general course of

thirty-three lectures on natural philosophy encompassing astronomy.[79] There is no evidence that he ever taught a full-length course on a more specialized topic, much less on his own research. Intensive, specialized courses—notably on astronomy and comets—were apparently introduced by the Reverend Samuel Williams (A.B. 1761), Winthrop's successor.

Professor Williams certainly saw the merits of a survey course, and surviving student lecture notes attest that he taught a twenty-lecture course similar to Winthrop's. Only the final lecture was devoted to astronomy. Here he illustrated the revolutions of planets and comets with Harvard's orrery, tellurian, and cometarium.[80] Not satisfied with a single astronomical lecture, Williams began in 1780 to deliver a twelve-lecture course on theoretical astronomy.[81] In 1785, he submitted a new prospectus for a complete course in practical and theoretical astronomy to the Harvard Corporation. This was to be a "hands-on" course for seniors, with emphasis on evening observations with scientific instruments. The Corporation approved Williams's novel proposal, voted him additional funds for his extra evening services, and put two telescopes at the disposal of the seniors. The course must have been successful, because in 1788 the Corporation made these senior lectures a statutory responsibility of the Hollis professor.[82] Thus, the teaching of astronomy became formally institutionalized.

Williams diversified the curriculum further and offered an advanced, seven-lecture course on the astronomy of comets. His reasons appear both religious and scientific. Williams possibly owed his fascination in astronomy to his clerical duties. He often declared how the wisdom and benevolence of God were evident in astronomical matters. "Every part of Astronomy seems to be well adapted to promote *moral* purposes and views," he told his students. "But there is no part of it better suited to enlarge our conceptions and extend our views of the Creation, than the doctrine of Comets."[83] This belief perhaps encouraged him to offer the comet course, in which he devoted a lecture to the use and divine purpose of comets. Williams also lectured on his own research into the heat of comets. Although he intended to publish this research and sent a slightly revised version of several lectures to the Royal Society in 1790,[84] he shared his original thoughts with Harvard students who perhaps helped him to refine his ideas.

With Williams's new courses and Harvard's superb collection of portable apparatus, Harvard students received a fine astronomical education. All the college lacked was a formal institution dedicated to research in astronomy—that is, an observatory with fixed instruments.

Establishment of Harvard's Observatory

For many years, Harvard scholars had to be content with the makeshift observatory equipped with eight- and twenty-four-foot telescopes acquired by

the college in 1712 and 1722, and set up on the rooftop of Massachusetts Hall by Thomas Robie (A.B. 1708, Harvard's library keeper, 1712, and tutor, 1713–23).[85] This situation remained largely unimproved when in 1780 the university attempted to establish a joint observatory-residence for Professor Williams. Harvard was short of funds and available houses. Therefore, after lectures on 13 April 1780, the president and fellows traveled to Boston to solicit the aid of the General Court of Massachusetts. Harvard's petition explained the problem:

> [Williams] has been endeavoring ever since his coming to Cambridge to procure a House into which he might remove his Family; but that the only House he can procure is one in which he shall not be able to make astronomical Observations of any sort; that he is extremely unwilling to be in a Situation incompatible with any part of the Duty incumbent upon him, & in Possession of the best astronomical Apparatus in America, of which, in such a Situation, he can make no Use—a Situation in which he must be obliged to disappoint the Expectations of the Public, & dishonor the University by Inactivity, & a Neglect of those Observations which will be expected from us in Europe.

Harvard reminded the legislature of the "Advantages & Credit resulting to the Community from the Knowledge of the Arts and Sciences, & Literature in general," and asked the Court to appropriate a sequestered estate for college use.[86]

Whereas eighteenth-century Harvard could successfully call upon state government to furnish a simple observational facility, the university's material needs for astronomical research dramatically outstripped its former resources in the nineteenth century. To make precision observations, an observatory with expensive, fixed instruments like those at Greenwich or Paris was required. But as costs escalated, state funding dried up. Harvard lost its annual state subsidy of $10,000 in 1824, and the university was forced to solicit the patronage of wealthy Bostonians.[87]

A succession of Harvard faculty members attempted to revive interest in an observatory from time to time. In 1805, the Hollis professor, Samuel Webber, procured instructions on observatory buildings and instruments from Paris, but no official action was taken. Ten years later, the Corporation appointed a committee to consider an observatory, and the committee chairman, Professor John Farrar commissioned William Cranch Bond, a Dorchester clockmaker and astronomer then bound for Europe, to study the observatories and equipment in Britain. From Bond's report and those received from Continental institutions, it became evident that the expense of building and maintaining a first-class observatory far exceeded the initial estimates. An unsuccessful appeal to wealthy friends postponed the project until 1822 when it was briefly revived. In 1823 John Quincy Adams, U.S. secretary of state, urged the Corporation to open a subscription for the project, and as proof of his earnestness offered $1,000 anonymously if the requisite sum could be raised in two years. When this attempt failed, Adams renewed his offer for

another two years. In 1825, he wrote to a Corporation member that the establishment of an observatory "was brought again to my mind by several interesting incidents, among which was the appearance of the Comet which at this very time is lighting our starry nights *unobserved*, for want of such an institution." Alas, the fund-raising campaign still proved inadequate. Meanwhile, President John Kirkland's appeals to the overseers to establish an astronomy professorship also met with indifference.[88]

Harvard was not the only institution whose early nineteenth-century plans to establish an observatory stalled for want of financial backing. The American Philosophical Society and the administrations of Presidents James Monroe and John Quincy Adams also unsuccessfully strived to build permanent astronomical institutions. Prior to 1830, nothing worthy to be called an observatory existed in the United States, and George Airy chagrined Americans by declaring the fact in an address on the progress of astronomy presented in 1832 to the British Association for the Advancement of Science. The tide turned in the 1830s and 1840s when twenty observatories were rapidly founded by colleges, communities, private individuals, and the federal government.[89] Patriotic ambitions, practical needs, and, most important, public interest in physical astronomy (sparked by meteoric displays in 1833 and the widely announced return of Halley's comet in 1835) jointly promoted the construction trend.[90]

In this "observatory movement," Harvard unquestionably lagged behind. One reason may be that Harvard had set ambitious goals for itself and was initially unwilling to settle for a lesser structure. But in 1839, Harvard dusted off its observatory plans once again. The university now appropriated the Dana House for an observatory and invited Bond to transport his apparatus to Cambridge and become Astronomical Observer. From the start, this arrangement was provisional. The Dana House was ill situated and ill equipped. Bond himself received no salary and relied on a volunteer team of undergraduate observers.[91]

An astounding comet came to the rescue in 1843.[92] It first dazzled the public in broad daylight and then sported the longest tail ever recorded (200 million miles). A high level of popular and professional interest is evident in contemporary newspaper accounts.[93] "Electrifying the nervous—puzzling and ever quizzing the scientific—frightning the timid, and confirming the fanatics," the comet commanded the attention of thousands of stargazers.[94] While citizens crowded onto the Boston Common to view the comet, scientists in Cambridge busied themselves with orbital computations.[95] The press gathered information from astronomers around the globe and reported technical details concerning the comet's position, orbit, size, and nature.[96] The latest scientific issues were aired. Did the comet graze the sun? Was it so insubstantial that its vast tail could be compressed into a common snuff box? These and other marvels of nature were presented as majestic curiosities before the public.

In Boston and elsewhere, some spectators viewed the cometary apparition

with apprehension that William Miller's apocalyptic prophesy might be fulfilled. Through biblical calculations, Miller had concluded that Jesus would return in 1843, separate the wicked from the righteous, purify the world by fire, create a new heaven and earth, and introduce the millennium.[97] Since 1831, he had preached this adventist message and had attracted considerable following, thanks in part to a fantastic meteor shower in 1833, which reminded many of the wreck of worlds described in Revelation.[98] Although the Millerite press dissociated itself from astronomical portents, the popular movement examined heavenly signs with fear and wonder. Meteors, parhelia, solar halos, peculiar lights around Venus and Jupiter, auroras, a cross on the moon, and the letters G-O-D in the sky were viewed as tokens of an imminent Second Coming.[99] As the critical year dawned, Miller told his anxious followers that the world would end sometime between 21 March 1843 and 21 March 1844.[100] When the comet appeared on 28 February, frenzied and exultant Millerites believed it to be the "judgment car." They redistributed personal property and prepared to meet the Lord.[101] Even some skeptics began to reconsider Miller's prophecy in light of the comet.[102]

The secular Boston press portrayed the Millerites as deluded and irrationally frightened by the comet.[103] One Boston paper mocked them along with outmoded, eighteenth-century scientific theory by publishing a horror story in which mathematicians, quibbling about the exact time of a comet's collision with the earth, were swallowed up when the comet destroyed the world by fire and flood. The editor intended to give his readers a pleasurable frisson, and hoped that "neither the appearance of a comet of unusual dimensions, nor the delusions of Millerism, which have occupied so many minds, will lead any of our readers to the absurdity of apprehending any such termination of the world as is here imagined."[104] Boston newspapers printed scholarly pronouncements by foreign and domestic authorities such as Laplace, Arago, Herschel, Peirce, and Olmsted on the harmless nature of comets. In the improbable event of a comet approaching the earth, its insensible mass posed no danger.[105] By 1843, cometary calamities were rejected since scientists no longer believed comets massive, and the press soberly reminded readers that cometary observations were useful to study Newtonian celestial mechanics.[106]

Partially enlightened by the press, people enthusiastically appealed to the Cambridge observatory for more information, but the observatory lacked the proper instruments for accurately delineating comet orbits. In fact, this deficiency had been noticed earlier by critics at home and abroad. In 1840, for example, the Boston correspondent for the London *Athenaeum* had chastised the university for not following the leads of Williams College, the Western Reserve College in Hudson, Ohio, and others that had erected observatories with fixed instruments.[107] Now the 1843 comet brought Harvard's inadequacies into sharper focus. The Boston press commended William Bond's efforts to observe the comet, but added:

apocalyptic prophesy might be
ler had concluded that Jesus would
the righteous, purify the world by
introduce the millennium.[97] Since
ge and had attracted considerable
or shower in 1833, which reminded
d in Revelation.[98] Although the
ronomical portents, the popular
ar and wonder. Meteors, parhelia,
nd Jupiter, auroras, a cross on the
e viewed as tokens of an imminent
dawned, Miller told his anxious
ne between 21 March 1843 and 21
d on 28 February, frenzied and
udgment car." They redistributed
the Lord.[101] Even some skeptics
ght of the comet.[102]
illerites as deluded and irrationally
paper mocked them along with
ory by publishing a horror story in
exact time of a comet's collision
comet destroyed the world by fire
readers a pleasurable frisson, and
net of unusual dimensions, nor the
d so many minds, will lead any of
ling any such termination of the
newspapers printed scholarly
uthorities such as Laplace, Arago,
rmless nature of comets. In the
ne earth, its insensible mass posed
s were rejected since scientists no
ess soberly reminded readers that
Newtonian celestial mechanics.[106]
e enthusiastically appealed to the
on, but the observatory lacked the
ting comet orbits. In fact, this
at home and abroad. In 1840, for
London *Athenaeum* had chastised
of Williams College, the Western
ers that had erected observatories
comet brought Harvard's inade-
ess commended William Bond's

> It will not be his fault if the two additional observations, necessary to calculate its orbit, are not obtained. The nucleus is sensibly diminishing in distinctness, and it is feared that the small telescope which he is obliged to employ will not be of sufficient power. Being unprovided with micrometers, he is obliged to refer the comet to distant stars; the uncertainty of the refraction, which is very great when a body is so near the horizon, will, therefore, affect his results, and materially diminish their value. It must not, therefore, be expected that with all his skill and labor, his observations will rival those which can easily be made with a proper equatorial telescope.[108]

In a long published letter on the comet, Sears Cook Walker of the Philadelphia High School Observatory commented:

> As far as I am informed, and I mention it with much regret, the only astronomical establishment in the United States capable of furnishing observations of any value by the side of the European, are the High School observatory, ... and the Hudson observatory, under professor Loomis in Ohio. The first instalments for instruments superior to ours in capacity have been forwarded to Munich for a national establishment at Washington, and a subscription observatory at Cincinnati. The corporation of Harvard have for many years been talking on the subject.[109]

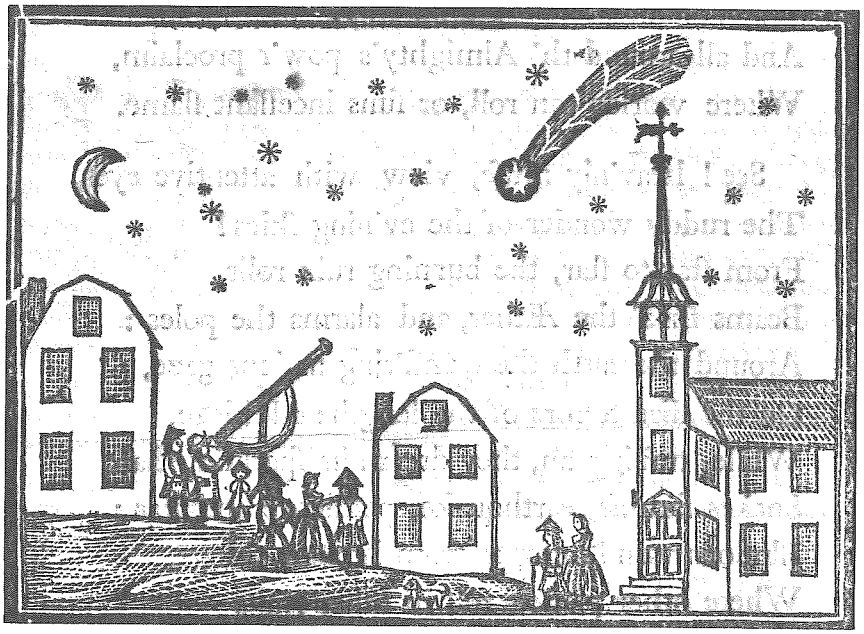
Indeed, Harvard's Corporation had engaged in more talk than action, and Walker could not resist rubbing it in.

Rather than cover up this embarrassing situation, President Josiah Quincy and Professor Benjamin Peirce took advantage of this opportunity to impress the community with the inadequacies of the Harvard observatory and the importance of procuring a first-class, equatorially mounted telescope. In a public lecture on the comet, Peirce shrewdly noted that Yale was well provided, a Philadelphia high school possessed the best equatorial telescope in the nation, and an Ohio river-town's citizens had generously contributed $10,000 to procure a better telescope still. "Massachusetts is not wont to lag behind, and I trust it is only necessary that the public should know the want to relieve it."[110] A week later, Peirce repeated his remarks at a public meeting sanctioned by the American Academy of Arts and Sciences. It was resolved that the "reputation of a great commercial city, and the interests of commerce and science" equally required a first-class telescope.[111] In six short weeks a subscription campaign netted $25,000 in gifts from a combination of public-spirited, commercially motivated, and astronomically enthusiastic merchants, manufacturers, marine insurance underwriters, commercial institutions, and learned societies of Boston, Salem, New Bedford, and Nantucket. With this endowment, Harvard ordered a fifteen-inch "Great Refractor," rivaled only by that at the Imperial Russian Observatory at Pulkovo. Soon after, the university broke ground on a hilly site to erect new observatory buildings, appointed Bond director, and began to pay him a salary.[112]

Religion, Teaching, and Research in New Balance

From the founding of the college, there was a demonstrated interest in astronomy at Harvard. Why then did it take two hundred years to establish an observatory?

The delay cannot be blamed on a lack of promotion or popular support. Since the seventeenth century, Harvard scholars had not isolated themselves but had cultivated popular audiences by preparing almanacs and newspaper articles, delivering sermons and public lectures. Fellowship in the Boston Philosophical Society and later the American Academy of Arts and Sciences also promoted scientific enterprises outside of Harvard Yard. Promotional campaigns do not always meet with receptive audiences, but in this case Harvard scholars retailed astronomical ideas to a public that was eager to consume. In Boston, a telescope was set up near the old South Meeting House for public viewings of celestial phenomena such as the comet of 1744.[113] Foreign astronomers, seeking transatlantic collaborators, acknowledged this public interest and looked to America as a land of eager observers. For example, in anticipation of a comet return predicted by Halley for 1789, Nevil



Colonial Bostonians observing the 1744 comet as depicted in Mather Byles, *The Comet* (Boston 1744). *Courtesy of the Rare Books and Manuscripts Division, The New York Public Library, Astor, Lenox and Tilden Foundations.*

rch in New Balance

e was a demonstrated interest in
ke two hundred years to establish

f promotion or popular support.
olars had not isolated themselves
eparing almanacs and newspaper
tures. Fellowship in the Boston
n Academy of Arts and Sciences
of Harvard Yard. Promotional
otive audiences, but in this case
as to a public that was eager to
ear the old South Meeting House
a such as the comet of 1744.[113]
collaborators, acknowledged this
a land of eager observers. For
redicted by Halley for 1789, Nevil

depicted in Mather Byles, *The Comet*
Manuscripts Division, The New York
lations.

Maskelyne, the Astronomer Royal in Greenwich, sent Harvard president Joseph Willard a notice to be circulated in local newspapers and magazines.[114] American periodicals contained more papers on astronomy than on any other scientific subject. Moreover, readers could be induced to dig into their pockets in order to patronize astronomy on the grounds that it lent prestige to the community. Colonial observations of the transits of Venus (1761 and 1769), which garnered praise abroad, were received enthusiastically at home. The usefulness of astronomy in surveying and navigation fostered public support and legislative financing of astronomical expeditions of presumed, if not real, utilitarian merit. Overall, Benjamin Franklin was so optimistic about the future of American astronomy that he boasted to William Herschel, discoverer of Uranus, that clearer American skies allowed nearly a third more days for observation than the misty English air. He teased Herschel, "Had Fortune plac'd you in this part of America, your Progress in these Discoveries might have been still more rapid."[115]

If interest in and philanthropic support for astronomy was necessary but apparently not sufficient to establish an observatory at Harvard before 1843, then the reasons for the delay must lie in the dynamic relationship of religion, teaching, and research at the university.

Although Harvard was not founded as a seminary, its primary function—to prevent the formation of an ignorant clergy by educating future candidates for the ministry—was essentially a religious one. Early astronomical studies were motivated by interest in discerning providence in operation. Cotton Mather, for instance, urged candidates for the ministry to study Newtonian natural philosophy and especially astronomy in order to appreciate God's handiwork in the world.[116] In a setting in which telescopic observations were acts of religious devotion, there was little need for a fancy observatory. To read divine messages in the heavens, one required little apparatus.

In the eighteenth century, astronomical work became increasingly secularized. Intellectually, the content of lectures subtly shifted in emphasis. Although Winthrop and Williams promoted piety by lecturing on the being, perfections, and providence of God as revealed in the subject of astronomy, their role as religious guides was secondary to their duties as scientific instructors. Institutionally, the secularization trend was manifest in the expansion of the scientific curriculum and the decreasing tendency of the school to draw professors and tutors from the ranks of the clergy.

With greater weight being placed on astronomical studies for academic rather than religious ends, interest in setting up an observatory increased during the eighteenth century. Harvard, however, channeled its resources into teaching and collected much scientific apparatus for lectures in experimental philosophy. Although its faculty conducted some independent investigation, research was not the distinguishing feature of seventeenth- or eighteenth-century Harvard, or of any other contemporary university. To this end, investment in expensive, fixed, observatory equipment was not warranted. Hence, eighteenth-century observing stations were makeshift arrangements set

up on the rooftops of Harvard buildings, and they functioned primarily as teaching facilities.

Before the nineteenth century, astronomical research facilities were not to be found at universities, but in state-sponsored institutions like the observatories at Greenwich and Paris. These were the models that the Harvard Corporation members had in mind when they began in the early nineteenth century to consider plans for a first-class observatory dedicated to research. The emergence of such research facilities at centers of teaching was a nineteenth-century phenomena whose general characteristics are beyond the scope of this paper to explore. The timing of Harvard's efforts to build an observatory may in part be explained by the same underlying factors that promoted the integration of research and teaching at other American universities during that century. Whether these factors be an emphasis on the utility of scientific research, which promoted schools for technical education in the mid-century, or the German ideal of research for its own sake, which characterized the rise of graduate education in the 1870s, historians of education have primarily focused their attention on the late nineteenth century and ignored the early decades.[117] Although many questions remain to be answered with respect to why the early nineteenth century was ripe for the building of research observatories on college campuses, it is clear why the seventeenth and eighteenth centuries were not ripe at Harvard.

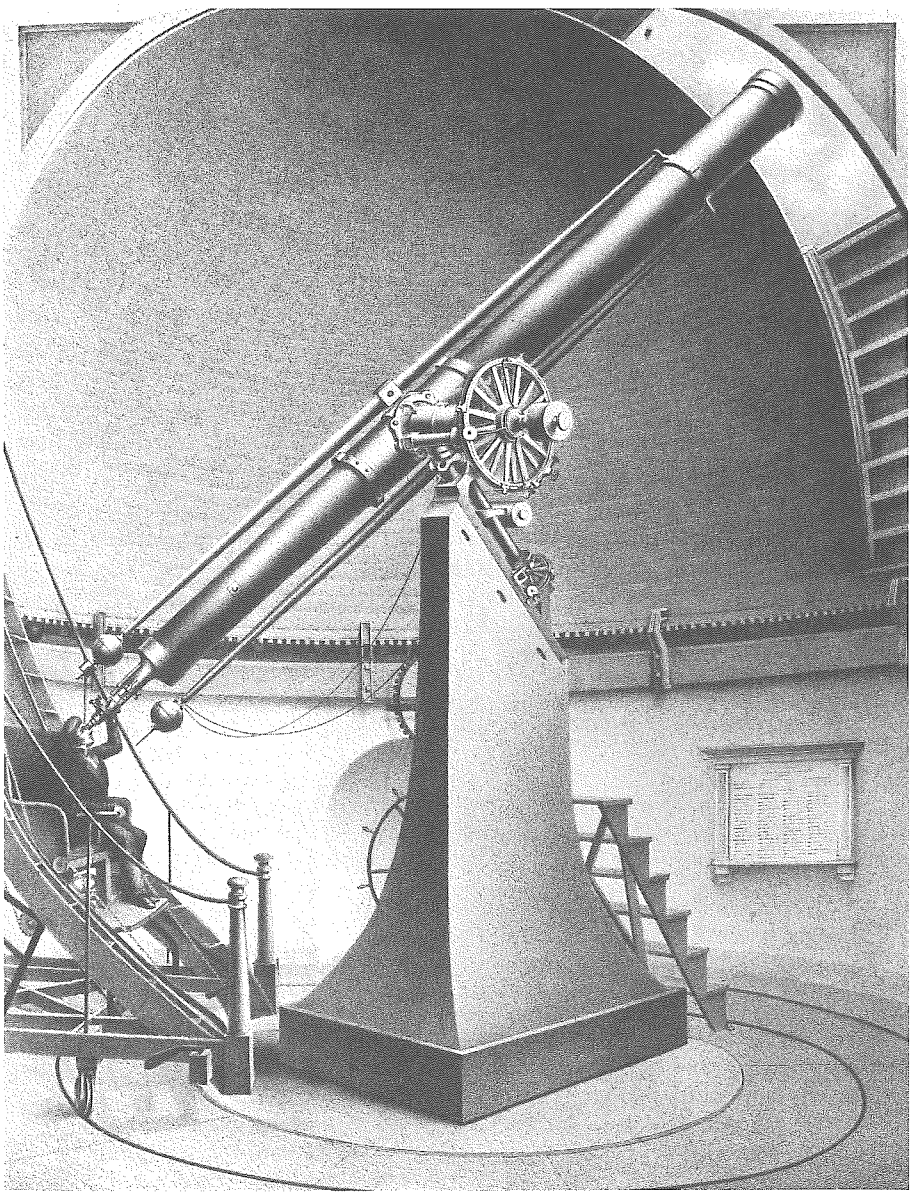
Once mentally prepared to establish a research facility at the university, the Corporation members needed to marshall the requisite economic resources. At this stage, the Corporation was dependent on the ebb and flow of public interest in astronomical matters and needed to convince the public of an observatory's value to the community. The comet of 1843 focused attention on religious enthusiasm, and on a countering need for sober calculations and astronomical education. In this light, Professor Peirce, in his public lecture, rejected Cotton Mather's assertion that comets were scythes to cut down the wicked, and dismissed Millerite claims that the 1843 comet heralded world dissolution, but opined hopefully that it might portend an observatory telescope.[118] This "prophecy" was fulfilled.

By the time the observatory was endowed, astronomers had ceased to fear comets as serious agents of world destruction and could cheerfully use the old prognosticary discourse for promotional or didactic ends. In the mid-nineteenth century, Professor Joseph Lovering traveled the lyceum circuit with a famous lecture on the end of the world. In the first half, he detailed with gory precision the collision of some astronomical body such as a comet with the earth. In the second half, he affirmed that the statistical probabilities of this event were slight, and thereby gratified audiences with a spine-chilling, scientific thriller. At Plymouth, the lyceum could afford only half of Lovering's hundred dollar fee. Lovering delivered the first part of his lecture and sat down. The rapt audience was held in suspense. When the terrified

nd they functioned primarily as

ical research facilities were not
-sponsored institutions like the
were the models that the Harvard
ey began in the early nineteenth
bservatory dedicated to research.
at centers of teaching was a
al characteristics are beyond the
of Harvard's efforts to build an
he same underlying factors that
d teaching at other American
se factors be an emphasis on the
d schools for technical education
research for its own sake, which
on in the 1870s, historians of
ion on the late nineteenth century
h many questions remain to be
eteenth century was ripe for the
ge campuses, it is clear why the
ot ripe at Harvard.
arch facility at the university, the
requisite economic resources. At
on the ebb and flow of public
d to convince the public of an
comet of 1843 focused attention
g need for sober calculations and
ssor Peirce, in his public lecture,
ets were scythes to cut down the
the 1843 comet heralded world
might portend an observatory

, astronomers had ceased to fear
and could cheerfully use the old
or didactic ends. In the mid-
g traveled the lyceum circuit with
he first half, he detailed with gory
l body such as a comet with the
he statistical probabilities of this
audiences with a spine-chilling,
um could afford only half of
ivered the first part of his lecture
in suspense. When the terrified



The "Great Refractor" financed by cometary enthusiasts in 1843. *Courtesy of the Adler Planetarium.*

chairman asked if Lovering could offer no comfort, he staunchly replied, "Not for fifty dollars!"[19]

Thus in two hundred years of eschatological discussions, comets were transformed from earnest agents of divine wrath to the butt of intellectual jokes. As the religious urgency of the early cometary studies had given way to secular concerns, the eighteenth-century professor of natural philosophy had supplanted the Puritan clergyman-tutor as the arbiter of astronomical matters. Comets no longer were the proper fare of sermons; they became the grist of lectures. As astronomy ceased to be ancillary to theology, there was a concomitant expansion of the scientific curriculum. Astronomy and comets were the topics of Harvard's first two specialized courses. Thus, intellectual shifts paralleled institutional and professional changes at Harvard. The new balance between religion, teaching, and research achieved by the early nineteenth century set the stage for the establishment of Harvard's observatory. Beyond Harvard Yard, scholars cultivated the interests of both academic and popular audiences through almanacs and lectures, newspaper articles and learned societies. These audiences in turn were induced to patronize astronomy at Harvard and support the observatory.

Notes

1. Winthrop S. Hudson, "The Morison Myth Concerning the Founding of Harvard College," *Church History* 8 (1939): 148–59. Cf. Samuel Eliot Morison, *The Intellectual Life of Colonial New England*, 2d ed. (New York: New York University Press, 1956), 31–33, 42–43.

2. Theodore Hornberger, *Scientific Thought in the American Colleges, 1638–1800* (Austin: University of Texas Press, 1945), 22–24, 37.

3. Josiah Quincy, *The History of Harvard University*, 2 vols. (Cambridge, Mass.: John Owen, 1840), 1:517.

4. Samuel Eliot Morison, *The Founding of Harvard College* (Cambridge: Harvard University Press, 1935), 438–40; idem, *Harvard College in the Seventeenth Century* (Cambridge: Harvard University Press, 1936), 580–638.

5. For more on this press, see Morison, *Intellectual Life*, chap. 5.

6. Samuel E. Morison, "The Harvard School of Astronomy in the Seventeenth Century," *New England Quarterly* 7 (1934): 3–24; Perry Miller and Thomas H. Johnson, eds., *The Puritans: A Sourcebook of Their Writings*, rev. ed., 2 vols. (New York: Harper Torchbook, 1963), 2:802–3; Donald Fleming, "The Judgment upon Copernicus in Puritan New England," *Mélanges Alexandre Koyré*, 2 vols. (Paris: Hermann, 1964), 2:160–75.

7. This has been overlooked by Morison, "Harvard School of Astronomy"; Fleming, "Judgment upon Copernicus"; Michael G. Hall, "Renaissance Science in Puritan New England," in *Aspects of the Renaissance*, ed. Archibald R. Lewis (Austin: University of Texas Press, 1967), 123–36; Rose Lockwood, "The Scientific Revolution in Seventeenth-Century New England," *New England Quarterly* 53 (1980): 76–95.

8. Alexander Nowell, "The Suns Prerogative Vindicated," in *An Almanack of*

no comfort, he staunchly replied,

ological discussions, comets were
e wrath to the butt of intellectual
cometary studies had given way to
rofessor of natural philosophy had
he arbiter of astronomical matters.
sermons; they became the grist of
icillary to theology, there was a
urriculum. Astronomy and comets
cialized courses. Thus, intellectual
onal changes at Harvard. The new
research achieved by the early
the establishment of Harvard's
ars cultivated the interests of both
almanacs and lectures, newspaper
diences in turn were induced to
ort the observatory.

Myth Concerning the Founding of
8–59. Cf. Samuel Eliot Morison, *The*
ed. (New York: New York University

ought in the American Colleges,
1945), 22–24, 37.
University, 2 vols. (Cambridge, Mass.:

g of Harvard College (Cambridge:
, *Harvard College in the Seventeenth*
, 1936), 580–638.
ntellectual Life, chap. 5.
ool of Astronomy in the Seventeenth
3–24; Perry Miller and Thomas H.
Their Writings, rev. ed., 2 vols. (New
nald Fleming, "The Judgment upon
ges Alexandre Koyré, 2 vols. (Paris:

, "Harvard School of Astronomy";
ael G. Hall, "Renaissance Science in
sance, ed. Archibald R. Lewis (Austin:
Rose Lockwood, "The Scientific
d," *New England Quarterly* 53 (1980):

ive Vindicated," in *An Almanack of*

Coelestial Motions for ... 1665 (Cambridge: Samuel Green, 1665); reprinted in John Langdon Sibley with Clifford K. Shipton, *Biographical Sketches of Graduates of Harvard University*, 17 vols. (Cambridge: C. W. Sever, 1873–85; Boston: Massachusetts Historical Society, 1933-75), 2:149–151 (hereafter cited as *Sibley's Harvard Graduates*).

9. William Williams, *Ephemeris* (Cambridge: Samuel Green, 1685); reprinted in Miller and Johnson, *Puritans*, 2:744–747.

10. Henry Newman, *Harvard's Ephemeris* (Cambridge: Samuel Green, 1690), postscript.

11. Miller and Johnson, *Puritans*, 2:732, 778.

12. *Sibley's Harvard Graduates*, 1:88–92.

13. Joseph Lovering, "Boston and Science," *The Memorial History of Boston*, 4 vols., ed. Justin Winsor (Boston: James R. Osgood and Company, 1881), 4:489–526, esp. 490–91.

14. S[amuel] D[anforth], *An Astronomical Description of the Late Comet or Blazing Star, as it appeared in New-England in ... 1664. Together with a brief Theological Application thereof* (Cambridge: Samuel Green, 1665), 16–17.

15. Ibid., 18–21.

16. Oldenburg to Winthrop, 26 March 1664, *The Correspondence of Henry Oldenburg*, 11 vols., ed. A. R. Hall and M. B. Hall (Madison: University of Wisconsin Press, 1965–73; London: Mansell, 1975–77), 2:149–50; Raymond Phineas Stearns, *Science in the British Colonies of America* (Urbana: University of Illinois Press, 1970), 130–31, 134, 691–94.

17. Danforth, *Astronomical Description*, 8; Nowell, "Suns Prerogative."

18. John Winthrop to Waitstill Winthrop, April 1672; Morison, "Harvard School of Astronomy," 17–19.

19. Morison, "Harvard School of Astronomy," 17–18. On Harvard's apparatus, see I. Bernard Cohen, *Some Early Tools of American Science* (New York: Russell & Russell, 1967); David P. Wheatland, *The Apparatus of Science at Harvard, 1765–1800* (Cambridge: Harvard University Press, 1968); Sara J. Schechner, "John Prince and Early American Scientific Instrument Making," *Publications of the Colonial Society of Massachusetts* 59 (1982): 431–503.

20. [Thomas Brattle], "Observations of a Comet seen this last Winter 1680. and how it appeared at Boston," appended to John Foster (A.B. 1667), *An Almanack of Coelestial Motions for ... 1681* (Boston: John Foster, 1681); Morison, "Harvard School of Astronomy," 16, 21. On the Newton-Flamsteed debate, see R. S. Westfall, *Never at Rest* (Cambridge: Cambridge University Press, 1980), 391–95.

21. Brattle to Flamsteed, 4 June 1681; cited in Morison, "Harvard School of Astronomy," 21. Observations were communicated to the Royal Society earlier on 13 April 1681. See Thomas Birch, *The History of the Royal Society of London*, 4 vols. (London: A. Millar, 1757), 4:80. Cf. Donald K. Yeomans, "The Origin of North American Astronomy—Seventeenth Century," *Isis* 68 (1977): 414–25.

22. Isaac Newton, *Philosophiae naturalis principia mathematica* (London: Royal Society, 1687), book III, prop. 41, problem 21.

23. Brattle to Flamsteed, 8 February 1704–5; quoted in Morison, "Harvard School of Astronomy," 20–21.

24. Kenneth Silverman, *The Life and Times of Cotton Mather* (New York: Columbia University Press, 1985), 40; Stearns, *Science in the British Colonies*, 154; Morison, "Harvard School of Astronomy," 21–22.

25. Sewall also viewed comets in 1695 and 1702. *The Diary of Samuel Sewall, 1674–1729*, 2 vols., ed. M. Halsey Thomas (New York: Farrar, Straus and Giroux, 1973), 1:53, 340, 462.

26. "The Autobiography of Increase Mather," ed. Michael G. Hall, *Proceedings of the American Antiquarian Society* 71 (1961): 271–360, esp. 307.

27. Cotton Mather, *Parentator* (Boston: B. Green, 1724), 86.

28. Otho T. Beall, Jr., "Cotton Mather's Early 'Curiosa Americana' and the Boston Philosophical Society of 1683," *William and Mary Quarterly*, 3d ser., 18 (1961): 360–72; Kenneth B. Murdock, *Increase Mather: The Foremost American Puritan* (Cambridge: Harvard University Press, 1925), 167–76.

29. Stearns, *Science in the British Colonies*, 155–59.

30. Perry Miller, *The New England Mind: The Seventeenth Century* (Cambridge: Harvard University Press, 1954), chap. 8. See also Lockwood, "Scientific Revolution"; Fleming, "Judgment upon Copernicus."

31. John Cotton, *Gods Mercie Mixed with His Justice* (London: G.M. for E. Brewster and H. Hood, 1641), 134.

32. Ibid., 118; Theodore Hornberger, "Puritanism and Science: The Relationship Revealed in the Writings of John Cotton," *New England Quarterly* 10 (1937): 503–15.

33. Nathaniel Hawthorne, *The Scarlet Letter* (Boston: Ticknor, Reed, and Fields, 1850), chap. 12.

34. Stearns, *Science in the British Colonies*, 160–61.

35. "Autobiography of Increase Mather"; Murdock, *Increase Mather*, 179, 342; Silverman, *Cotton Mather*, 40.

36. Murdock, *Increase Mather*, 343–45.

37. Frederick C. Kilgour, "The First Century of Scientific Books in the Harvard College Library," *Harvard Library Notes* 3, no. 29 (1939): 217–25.

38. Increase Mather, *Heaven's Alarm to the World*, 2d ed. (Boston: Samuel Sewall, 1682), quotations from p. 37. See Perry Miller, *The New England Mind: From Colony to Province* (Cambridge: Harvard University Press, 1953), chap. 2.

39. Increase Mather, *The Latter Sign Discoursed of* (Boston: Samuel Sewall, 1682).

40. For letters to colleagues, see *Collections of the Massachusetts Historical Society*, 4th ser., 8 (1868). For Mather's astronomical sources, see Michael G. Hall, "The Introduction of Modern Science into 17th-Century New England: Increase Mather," in *Proceedings of the Tenth International Congress of the History of Science*, Ithaca, 26 August 1962–2 September 1962 (Paris: Hermann, 1964), 261–64.

41. Increase Mather, *ΚΟΜΗΤΟΓΡΑΦΙΑ. or a Discourse Concerning Comets* (Boston: Samuel Green for Samuel Sewall 1683), 1–21, quotation from p. 18.

42. Ibid., 21–22, 132–34.

43. Mather, *Heaven's Alarm*, 31.

44. *Kometographia*, 24–142, quotation from p. 130. Increase Mather to Joseph Dudley, 10 November 1684, *Collections of the Massachusetts Historical Society*, 4th ser., 8 (1868): 101–2.

45. [Cotton Mather], *An Essay on Comets, their Nature, the Laws of their Motions, the Cause and Magnitude of their Atmosphere, and Tails; with a Conjecture of their Use and Design* (Boston: Rogers & Fowle, 1744), 2–3; enlarged edition of text first printed in Cotton Mather, *The Christian Philosopher* (London: E. Matthews, 1721), 41–45.

46. [Cotton Mather], *A Voice from Heaven. An Account of a Late Uncommon Appearance in the Heavens* (Boston, 1719), 7.

47. Ibid., 13–16.

48. Mather, *Essay on Comets*, 2–7; Mather, *Voice from Heaven*, 11.

49. Mather, *Voice from Heaven*, 8–10.

50. Ibid., 10–12.

51. Charles Morton, *Compendium physicae*, Publications of the Colonial Society of Massachusetts, Collections, no. 33 (Boston: The Colonial Society of Massachusetts,

,'' ed. Michael G. Hall, *Proceedings*
271–360, esp. 307.
Green, 1724), 86.
Early 'Curiosa Americana' and the
m and Mary Quarterly, 3d ser., 18
e Mather: The Foremost American
1925), 167–76.
155–59.
he Seventeenth Century (Cambridge:
Lockwood, ''Scientific Revolution'';

His Justice (London: G.M. for E.

anism and Science: The Relationship
New England Quarterly 10 (1937):

(Boston: Ticknor, Reed, and Fields,

160–61.
Murdock, *Increase Mather*, 179, 342;

y of Scientific Books in the Harvard
29 (1939): 217–25.
World, 2d ed. (Boston: Samuel Sewall,
he New England Mind: From Colony
ess, 1953), chap. 2.
sed of (Boston: Samuel Sewall, 1682).
ns of the Massachusetts Historical
omical sources, see Michael G. Hall,
7th-Century New England: Increase
al Congress of the History of Science,
s: Hermann, 1964), 261–64.
or a Discourse Concerning Comets
, 1–21, quotation from p. 18.

p. 130. Increase Mather to Joseph
Massachusetts Historical Society, 4th

s, their Nature, the Laws of their
osphere, and Tails; with a Conjecture
wle, 1744), 2–3; enlarged edition of
Philosopher (London: E. Matthews,

An Account of a Late Uncommon

Voice from Heaven, 11.

Publications of the Colonial Society
ne Colonial Society of Massachusetts,

1940), xxxi, 4, 27–30, 35, 101–3. I. Bernard Cohen, ''The *Compendium Physicae* of Charles Morton (1627–1698),'' *Isis* 33 (1942): 657–71.

52. This view had been espoused by Tycho Brahe and Girolamo Cardano, among others. In New England, it was held by Danforth, *Astronomical Description*.

53. Morton, *Compendium physicae*, 88–93.

54. [Cotton Mather], *The Boston Ephemeris. An Almanack for ... MDCLXXXIII* (Boston: Samuel Green for Samuel Sewall, 1683).

55. Cf. Herbert Leventhal, *In the Shadow of the Enlightenment: Occultism and Renaissance Science in Eighteenth-Century America* (New York: New York University Press, 1976).

56. Stearns, *Science in the British Colonies*, 446–55. The Hollis professorship was established in 1727 and its first incumbent was Isaac Greenwood.

57. John Winthrop, Commonplace Book (1728–), pp. 84–85, Harvard University Archives, HUC 8728.394.

58. John Winthrop, ''Cogitata de cometis,'' *Philosophical Transactions* 57 (1767): 132–54. For its reception, see Stearns, *Science in the British Colonies*, 633, 651; [John Davis, ed.], *Two Lectures on Comets, by Professor Winthrop, also, An Essay on Comets, by A. Oliver, Jun. With sketches of the lives of Professor Winthrop and Mr. Oliver. Likewise, a supplement, relative to the present comet of 1811* (Boston: W. Wells, 1811), x–xii.

59. E.g., Samuel Langdon to John Winthrop, 15 September 1769, College Papers, 2:17, Harvard University Archives, UAI.5.131. See also Winthrop's correspondence with Ezra Stiles, Stiles MSS, Yale University; of which a microfilm is deposited in the Harvard University Archives, HUG 1879.203.

60. John Winthrop, Diaries and Notes (1730–79), 22 January 1744, Harvard University Archives, HUG 1879.205.

61. *Sibley's Harvard Graduates*, 9:252.

62. Holyoke and family observed comets in 1742, 1743–44, 1748, 1811. *The Holyoke Diaries, 1709–1856* (Salem: Essex Institute, 1911), 31, 36, 45, 155.

63. Clap's paper concerned ''terrestrial comets.'' See *Sibley's Harvard Graduates*, 9:252; Stearns, *Science in the British Colonies*, 652–53; Brooke Hindle, *The Pursuit of Science in Revolutionary America 1735–1789* (Chapel Hill: University of North Carolina Press, 1956), 97.

64. Mather Byles, *The Comet: A Poem* (Boston: B. Green and Company for B. Green and for D. Gookin, 1744); *Sibley's Harvard Graduates*, 7:464.

65. 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).

66. John Winthrop, ''The Summary of a Course of Experimental Philosophical Lectures'' (1746–47), lecture 12; and student notes, Timothy Foster, ''The Summary of a Course of experimental Lectures in natural Philosophy, by Dr. Jno. Winthrop'' (1772–73), lecture 10, Harvard University Archives, HUC 8745.294 and HUC 8772.358 respectively. Cohen, *Some Early Tools*, 41–44, gives an outline of the lectures.

67. Winthrop to Stiles, 17 April 1756, 3 October 1757, 10 July 1758, Stiles MSS, Yale University; microfilm of correspondence, Harvard University Archives, HUG 1879.203. Nathaniel Ames, *An Astronomical Diary or, an Almanack for ... 1759* (Boston: John Draper, 1759).

68. Winthrop Diary; *Boston News-Letter*, 12 April and 3 May 1759.

69. John Winthrop, *Two Lectures on Comets* (Boston: Green & Russell, 1759).

70. Winthrop, *Two Lectures*, 38. Cf. Winthrop letter in *Boston News-Letter*, 9 August 1770.

71. Winthrop, *Two Lectures*, 39–42, quotation from p. 42.
72. Ibid., 42–43.
73. Ibid., 38–39, 43–44.
74. College Book 6 (Hollis Book), 6–8; and Corporation Records, 3:326–27, Harvard University Archives.
75. This view was expressed as late as 1760, but no longer held in high esteem. See *Boston News-Letter*, 3 May 1759; *Blazing Stars, messengers of God's Wrath; in a few serious and solemn meditations upon the late wonderful Comet: . . . Together with a Solemn Call to Sinners, and Consel to Saints; how to behave themselves when God is in this wise speaking to them from Heaven* [Boston: R. Draper, 1760].
76. Winthrop is Newtonian. See Sara Schechner Genuth, "Comets, Teleology, and the Relationship of Chemistry to Cosmology in Newton's Thought," *Annali dell'Istituto e Museo di Storia della Scienza di Firenze* 10, fasc. 2 (1985): 31–65.
77. *Boston Evening Post*, 4, 18 September, 9, 16, 23 October, 6, 13 November 1769; *Boston News-Letter*, 2 November 1769, 5, 12 July 1770; *Boston Gazette*, 11 September 1769; Benjamin West, *The New-England Almanack, or Lady's and Gentleman's Diary for the year . . . 1770* (Providence: John Carter, [1769]). Hindle, *Pursuit of Science*, 172, notes other colonial newspapers.
78. *Boston Gazette*, 2 October 1769; *Boston News-Letter*, 28 June and 20 September 1770. Unsigned reports, but likely Winthrop's work, include the *Boston News-Letter*, 28 September and 26 October 1769; *Boston Evening Post*, 2 October 1769.
79. College Book 6 (Hollis Book), 6–8; Morison, *Harvard College in the Seventeenth Century*, 139–49; Cohen, *Some Early Tools*, 33, 41–44.
80. Thomas Crafts, "An Epitome of Mr Williams's experimental Lectures" (1782), Harvard University Archives, HUC 8781.370.
81. Samuel Williams, "Astronomical Lectures" (1780–81), Harvard University Archives, HUC 8780.305.
82. College Book 8, pp. 190, 192–94, 270–72; College Papers, 2:76, Harvard University Archives, UAI.5.15 and UAI.5.131. The 1785 prospectus is reprinted in Cohen, *Some Early Tools*, 54–55. For curriculum ca. 1800, see Samuel Miller, *A Brief Retrospect of the Eighteenth Century*, 2 vols. (New York: 1803), 2:493–94.
83. Samuel Williams, "The Astronomy of Comets" (1785), fol. 11r after p. 70, Harvard University Archives, HUC 8785.306. Cf. idem, *Essex Gazette*, 7–14 November 1769.
84. Samuel Williams, lecture notebooks entitled "The Astronomy of Comets" (1785) and "Philosophical and Astronomical Lectures" [late 1780s], Harvard University Archives, HUC 8785.306 and HUC 8787.370. Idem, "Observations and Conjectures on the state, motion, and phenomena of Heat in Comets" (1790), MS sent to Royal Society; Williams to Sir Joseph Banks, 16 September 1789, drafts at University of Vermont, Burlington, and British Museum, Add. MS 8097.358. I am indebted to Robert Rothschild for sharing copies of Williams's Royal Society papers.
85. Miller, *New England Mind: From Colony to Province*, 443–44; Stearns, *Science in the British Colonies*, 426, 431–35; *Sibley's Harvard Graduates*, 5:450–55; Samuel Eliot Morison, *Three Centuries of Harvard, 1636–1936* (Cambridge: Belknap Press, 1936), 58; Frederick G. Kilgour, "Thomas Robie (1689–1729), Colonial Scientist and Physician," *Isis* 30 (1939): 473–90.
86. College Book 8, pp. 49–50; College Papers, 2:62, Harvard University Archives.
87. Morison, *Three Centuries*, 218–20.
88. William Cranch Bond, "History and Description of the Astronomical Observatory of Harvard College," *Annals of the Astronomical Observatory of*

Harvard College 1, part 1 (1856): ii–v; Bessie Z. Jones and Lyle G. Boyd, *The Harvard College Observatory: The First Four Directorships, 1839–1919* (Cambridge: Harvard University Press, 1971), 27–35, Adams quotation from p. 35. Solon I. Bailey, *The History of the Harvard Observatory, 1839–1927* (New York: McGraw-Hill, 1931), 11–14.

89. David F. Musto, "A Survey of the American Observatory Movement, 1800–1850," *Vistas in Astronomy* 9 (1967): 87–92; W. C. Rufus, "Astronomical Observatories in the United States Prior to 1848," *Scientific Monthly* 19 (1924): 120–39; Nathan Reingold, ed., *Science in Nineteenth-Century America* (Chicago: University of Chicago Press, 1985), 134–39. Howard S. Miller, *Dollars for Research: Science and Its Patrons in Nineteenth-Century America* (Seattle: University of Washington Press, 1970), chap. 2.

90. Deborah Jean Warner, "Astronomy in Antebellum America," in *The Sciences in the American Context: New Perspectives*, ed. Nathan Reingold (Washington: Smithsonian Institution Press, 1979), 55–75; David F. Musto, "The Development of American Astronomy During the Early 19th Century," in *Proceedings of the Tenth International Congress of the History of Science*, Ithaca, 26 August 1962–2 September 1962 (Paris: Hermann, 1964), 733–36.

91. Bond, "Astronomical Observatory," v–xiv; Jones and Boyd, *Harvard College Observatory*, 40–45; Bailey, *Harvard Observatory*, 14–23.

92. Benjamin Peirce, "The Great Comet of 1843," in *The American Almanac and Repository of Useful Knowledge for the Year 1844* (Boston: Gray and Bowen, 1843), 94–100; *American Journal of Science and Arts* 44 (1843): 412–17, and 45 (1843): 188–208, 229–30; Agnes M. Clerke, *A Popular History of Astronomy during the Nineteenth Century*, 3d ed. (London: Adam & Charles Black, 1893), 128–30.

93. Donald Zochert, "Science and the Common Man in Ante-Bellum America," in *Science in America since 1820*, ed. Nathan Reingold (New York: Science History Publications, 1976), 7–32; cf. John C. Greene, "Science and the Public in the Age of Jefferson," in *Early American Science*, ed. Brooke Hindle (New York: Science History Publications, 1976), 201–13.

94. *Niles' National Register*, 8 April 1843.

95. *Boston Evening Transcript*, 10 March 1843.

96. *Boston Evening Transcript*, 2, 9–15, 17, 21–22 March 1843; *Boston Semi-Weekly Advertiser*, 4, 11, 18, 25 March 1843; *Niles' National Register*, 4, 18 March, 1, 8 April, 13, 27 May, and 3 June 1843. Often nineteenth-century newspapers reprinted articles previously published by other papers across the United States, and I have used *Niles' National Register* as an example of an out-of-town paper printing reports by and about Harvard astronomers.

97. William Miller, *Evidence from Scripture and History of the Second Coming of Christ, about the Year 1843* (Troy, N.Y.: E. Gates, 1838); Sylvester Bliss, *Memoirs of William Miller* (Boston: J. V. Himes, 1853); David L. Rowe, *Thunder and Trumpets: Millerites and Dissenting Religion in Upstate New York, 1800–1850* (Chico, Calif.: Scholars Press, 1985).

98. Rev. 6:13.

99. Clara Endicott Sears, *Days of Delusion* (Boston: Houghton Mifflin, 1924), chaps. 3, 5; Rowe, *Thunder and Trumpets*, 21, 58–61.

100. Bliss, *William Miller*, 170–72; *Niles' National Register*, 16 February 1843.

101. *Boston Evening Transcript*, 15 March 1843.

102. Rowe, *Thunder and Trumpets*, 60–61.

103. *Boston Evening Transcript*, 15, 17 March 1843; *Niles' National Register*, 18 March and 8 April 1843. See also Ira V. Brown, "The Millerites and the Boston Press," *New England Quarterly* 16 (1943): 592–614.

104. *Boston Semi-Weekly Advertiser*, 15 March 1843. The story was "The Comet," by S. Austin, Jr. (1839).

105. *Boston Evening Transcript*, 11–14, 22 March 1843; *Boston Semi-Weekly Advertiser*, 22, 25 March 1843.

106. E.g., *Niles' National Register*, 1 April 1843.

107. London *Athenaeum* (11 July 1840): 555–56.

108. *Boston Semi-Weekly Advertiser*, 18 March 1843.

109. *Niles' National Register*, 1 April 1843.

110. A transcript and report of Peirce's lecture at the Odeon on 22 March 1843 can be found in the *Boston Semi-Weekly Advertiser* and *Boston Evening Transcript*, both 25 March 1843.

111. *Boston Semi-Weekly Advertiser*, 29 March and 1 April 1843.

112. *American Journal of Science and Arts* 45 (1843): 224–25, and 62 (1851): 295–300; Bond, "Astronomical Observatory," xiv–xvi; Lovering, "Boston and Science," 507–8; Jones and Boyd, *Harvard College Observatory*, 48–56; Bailey, *Harvard Observatory*, 23–25; Miller, *Dollars for Research*, 36–37.

113. Byles, *Comet*, frontispiece. This was the first comet depicted in America. See Roberta Olson, *Fire and Ice: A History of Comets in Art* (New York: Walker and Company, 1985), 66, 68.

114. Richard Price to Joseph Willard, 22 January 1787, *Proceedings of the Massachusetts Historical Society* 43 (1909–10): 625; Hindle, *Pursuit of Science*, 334. Incidentally, this comet never did reappear. Samuel Williams was among those who awaited it. See Samuel Williams, "The Return of the Comet of 1532 and 1661 in the year 1789" [ca. 1780s], Harvard University Archives, HUG 1877.75. Bartholomew Burges, *A short account of the solar system, and of comets in general: together with a particular account of the comet that will appear in 1789* (Boston: B. Edes & Son, 1789); *Boston Gazette*, 8 December 1788, 7 September 1789.

115. Franklin to Herschel, 18 May 1787; quoted in Hindle, *Pursuit of Science*, 334, see also pp. 140, 146–69, 333–38; Miller, *Brief Retrospect*, 2:372–73; John C. Greene, "Some Aspects of American Astronomy, 1750–1815," in *Early American Science*, ed. Brooke Hindle (New York: Science History Publications, 1976), 181–200; Cohen, *Some Early Tools*, 37–39.

116. Cotton Mather, *Manuductio ad ministerium* (Boston: Thomas Hancock, 1726).

117. E.g., Edward Shils, "The Order of Learning in the United States: The Ascendancy of the University," and Hugh Hawkins, "University Identity: The Teaching and Research Functions," in *The Organization of Knowledge in Modern America, 1860–1920*, ed. Alexandra Oleson and John Voss (Baltimore: Johns Hopkins University Press, 1979), 19–47, 285–312. For a study of the early and mid-nineteenth century, see Stanley M. Guralnick, "The American Scientist in Higher Education, 1820–1910," in Reingold, *Sciences in the American Context*, 99–141.

118. *Boston Semi-Weekly Advertiser* and *Boston Evening Transcript*, both 25 March 1843.

119. As recounted by Professor I. Bernard Cohen; and Perry Miller, *Errand into the Wilderness* (Cambridge: Belknap Press, 1956), 237–38.