

# 1

## Beginnings

This chapter begins with a brief discussion of the slight use of mathematics in early voyages to America. The coverage then jumps ahead to 1585, when the first world-class mathematician set foot on American soil. The instruction of mathematics in American schools is described next, first at Harvard (also referred to as “the College”) and later at William and Mary as well as Yale. The leading college, Harvard, produced the first American-born mathematician, Isaac Greenwood, and his more illustrious successor, John Winthrop. Yale produced Thomas Clap. Along the way, this chapter introduces the first American mathematics professor (Hugh Jones), authors of scientific almanacs, and the founding of other American colleges.

### Columbus

The story of how Columbus encountered America is of interest mathematically, and it provides a springboard for developments that took place before the American Revolutionary War. As a youngster **Christopher Columbus** (1451–1506) traveled from his native Genoa, Italy, to Lisbon, Portugal, so he could learn to speak both Portuguese and Castilian (the languages of seamen), learn to read Latin (for geography), and study mathematics and astronomy (for navigation). This enabled him to read a Latin translation of Strabo’s *Geographica* (1469), where the circumference of the earth was listed as roughly 18,000 statute miles. Columbus discovered an error (though not the right one) and deduced that the circumference was 16,500 statute miles. Columbus was not a very good mathematics student, but he was very lucky. Moreover, he found a patron to finance his voyage, departing from the Canary Islands on September 6, 1492. On October 7, the ships reached the desired mark with no land in sight. Expecting land nearby, Columbus changed his course to follow flocks of birds flying by. What serendipity! It has been said that Columbus didn’t know where he was going when he started out, didn’t know where he was when he got there, and didn’t know where he had been after he got back.

Where did he land? There seems to be no agreement on the exact island where Columbus first set foot but, as historian of mathematics Fred Rickey wrote, “Columbus did more than encounter America. He discovered a way to sail there—and back.”<sup>1</sup>

It seems that years congruent to  $76 \pmod{100}$  are witness to pivotal events in the political and mathematical histories of the United States. It is well known that the Revolutionary War began with the signing of the Declaration of Independence in 1776. It is not as well known that while the country was celebrating its centennial in Philadelphia in 1876, an equally important revolution in higher education was taking place in Baltimore. This latter development is described in Chapter 3. For now, let's go back to 1476, when the German mathematician **Johannes Müller** (1436–1476) died. Using the regal *nom de plume* Regiomontanus, he had published three classic works. One was the book *De Triangulis omnimodis*, the first textbook on trigonometry ever written. Another, *Epitoma*, became the most important astronomical text published in the fifteenth century. But of relevance here is Regiomontanus's *Canon Sinuum*, which provided the geometry of both plane and spherical triangle. It is known that Christopher Columbus carried the seven-place table of sines—which was printed as a supplement to *Canon Sinuum*—with him on his famous voyages of discovery.<sup>2</sup> So this, then, was the first mathematics book to reach America.

## First mathematician to visit the Colonies

Sir Walter Raleigh sent Thomas Harriot on one of his explorations to the New World. An Elizabethan scholar and scientist who contributed to almost all endeavors of his time, Harriot was arguably the most distinguished English mathematician before Isaac Newton. He was surely the first mathematician to land in the United States.

**Thomas Harriot** (1560–1621) was born in or near Oxford.<sup>3</sup> He entered Oxford University's Oriel College in 1576 and graduated four years later. Upon graduation, he moved to London, though it is unclear what a 20-year-old person with largely theoretical skills in mathematics could do. Yet he developed an interest in overseas explorations, for within a few years he became expert in a branch of applied mathematics—instrumental navigation—that brought him in contact with **Sir Walter Raleigh** (1554–1618; also spelled Raleigh). In addition Harriot had cultivated a reputation as a teacher of navigation and geography. By 1583 he had moved into Raleigh's household, where he tested navigational instruments the famed explorer had bought for him and instructed Raleigh's seamen in methods for using them.

By the time Raleigh's first reconnaissance voyage set out for America in 1584, Harriot had greatly refined the technique of using various instruments to take latitude sights from both the Sun and the Pole Star. Moreover, he revised existing tables based on his own astronomical observations, and, accordingly, he made physical modifications to his instruments. Within a short time, he determined theoretically how to construct the Mercator projection and thus provide true directional sailing. One problem eluded his grasp, however—the determination of longitude—a challenge that eluded the grasp of scientists for another 200 years. Nonetheless, Harriot exemplified problem-solving at its very best!

In 1585 Harriot became the first mathematician to land in America when he sailed on one of Sir Walter Raleigh's vessels in the official capacity of surveyor.<sup>4</sup> In preparation for that trip he acquired a working knowledge of several studies: botany, horticulture, geology, chemistry, metallurgy, and linguistics. He put his knowledge of linguistics to use by teaching English to, and learning Algonquin from, a Native American named Manteo who had been brought back to England from the earlier voyage. This enabled



Figure 1.1. Thomas Harriot


Harriot to communicate with the Native Americans when his boat, *Tiger*, arrived on the shores of modern North Carolina (called Virginia then).

A settlement of 108 men was established on Roanoke Island, which served as their home base for ten months until their precipitous departure in June 1586. The artist John White accompanied Harriot on all his investigations. While Harriot maintained a journal of what he saw and heard, White sketched the inhabitants, their villages, plants, and living creatures. During the winter the men charted the shores from what is now South Carolina to Chesapeake Bay. By April 1586 the two had finished the scaling down of survey sheets and created a map that White painted; this was the first surveyed map of any part of North America. It was so accurate that a satellite photo of the area taken in 1984 showed a remarkable similarity, if not congruence, of areas despite alterations to the shoreline in the intervening four centuries.

With Native American relations souring and colonists' unfulfilled expectations for gold leading to frustration, the settlement was abandoned and the crew returned to England in July 1586. Unfortunately, many of the papers, charts, and specimens prepared by Harriot and White were tragically tipped into the ocean while they were being moved onto the ship that transported them back to England. Consequently, their grand plan for a great encyclopedia, an illustrated work intended to provide the first detailed history of the colony, was thwarted. Nonetheless, two years later, in 1588, they published their findings in Thomas Harriot's book *A Briefe and True Report of the New-found Land of Virginia*, a thin, oversized source that is still available today and makes interesting reading for anyone interested in the Native Americans he encountered.<sup>5</sup> This became the only publication in his lifetime, although he left behind numerous mathematical manuscripts that were published posthumously.

Harriot holds interest for several reasons, even though he did not work on mathematics in the New World. For one thing, there was no such thing as a scientific periodical at the time, let alone a mathematics journal. The only medium for disseminating one's work to the public was the book, and that was a rare commodity. Today Harriot is regarded as one of the world's first scientists to adopt symbols in place of sets of words, a notational advance that deserves to be known as one of the most important in the history of mankind.

Harriot had hoped to return to America, especially to a tract of land that he had discovered near Chesapeake Bay, but Queen Elizabeth never gave him permission. Worse, his patron, the Duke of Northumberland, fell out of favor with the queen and was summarily executed. Nonetheless, he was granted an annual pension by Henry Percy, the Ninth Earl of Northumberland, that provided sufficient funds for securing the comfort and leisure which Harriot's scientific pursuits demanded. Unfortunately for Harriot, and especially regrettably for the earl, Percy was imprisoned in 1605 for the Gunpowder Plot. Harriot too was interrogated and briefly imprisoned, but soon released. Such major distractions, plus an increasingly painful cancerous growth on his nose, took a toll on his work in mathematics after that. Harriot died at age 61. The cause of his death might have been predicted beforehand—he died of cancer in the left nostril of his nose, a condition brought about by the habit of smoking he had acquired while visiting America.

The online file “Web01-Harriot” (see p. 1) provides a brief account of Harriot's mathematical accomplishments within the history of algebra and mathematical notation. Harriot's main contributions to mathematics were in the field of what we call algebra today, which was termed the “analytic art” at the time. The modern inequality symbols “ $<$ ” and “ $>$ ” first appeared in *Artis analyticae Praxis*, so Harriot is frequently given credit for introducing them into mathematics. They perhaps derive from the marking  on the shoulder of a Native American drawn by the artist John White who accompanied Harriot on his historic voyage (see Figure 1.2). From a mathematical viewpoint, “the significance of the inequality signs lies in the fact that this is the first time that such signs were used and accorded the same status as the equality sign.”<sup>6</sup>

The book *Artis analyticae Praxis* was put together from Harriot's manuscript papers and published in 1631, ten years after his death. Even if he had attempted to disseminate his mathematical knowledge in America, none of the early settlers had the leisure time to read him (and few had the requisite education to understand his works anyway).

Harriot contributed to scientific fields other than mathematics. His astronomical observations improved upon existing tables; he engaged in a notable correspondence with Kepler on this matter, and his sketches of the Moon predate Galileo's drawings. In addition, Harriot's study of the rainbow led him to state the sine law of refraction 20 years before Willebrord Snell did so in 1621. He also contributed to ballistics and optics. Oxford historian Robert Fox wrote that Harriot “was a towering figure in his day, and he remains for us a distinguished exemplar of . . . an Elizabethan man of science.”<sup>7</sup>

Harriot's journey to America in 1585 represents the only event of any mathematical consequence in the century after Columbus encountered the New World. But real progress occurred at the beginning of the next century.

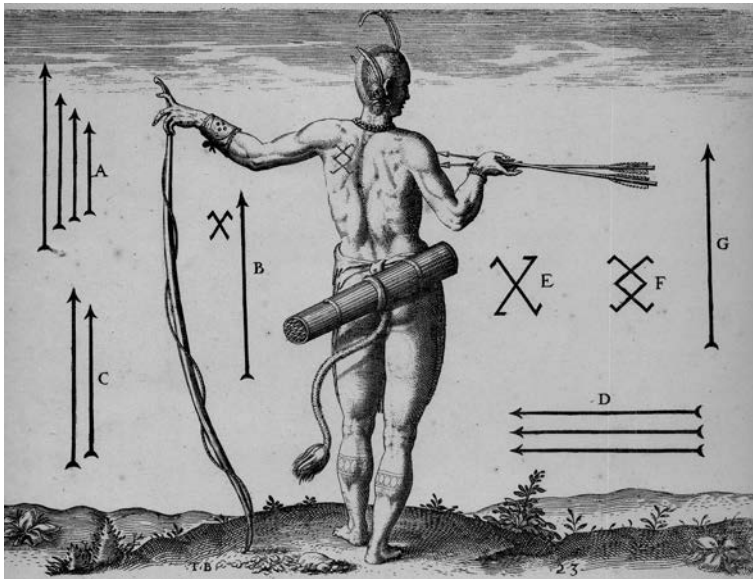


Figure 1.2. Source for inequality signs “<” and “>”

## Seventeenth century

It might appear that scant attention was paid to education in the US and Canada throughout most of the seventeenth century, so progress in mathematics, as measured by individual investigations and original contributions, was exceedingly slow. However, under the surface lurked impressive gains in education by a people whose main concern was with daily existence. Here I describe the teaching of mathematics in grammar schools and secondary schools in New England before turning our attention to the first college established in the US.

**Secondary schools.** During the early part of the seventeenth century, only densely populated settlements established schools, mainly those near Jamestown and Plymouth, the first two areas settled in 1607 and 1620, respectively. Some of those grammar schools did not offer instruction in mathematics, while those that did restricted their attention to counting and three of the four operations on integers (division was excluded). As late as 1750 a town in New Hampshire voted “to hire a school-master for six months in ye summer season to teach ye children to read and writing.”<sup>8</sup> As late as 1799 one school administrator bemoaned, “Until within a few years no studies have been permitted in the day school but spelling, reading, and writing.”<sup>9</sup> It seems that the “third R” was still missing from some curricula up to the beginning of the nineteenth century.

In general, grammar schools were established for the purpose of educating boys beginning at ages six to eight. Although the Puritans remained loyal to England, they were forbidden from enrolling in colleges there. However, there was a strongly felt need for all boys to know how to “cipher” for business purposes, that is, how to perform simple computations involving measures (pounds and ounces, inches and yards, etc.) and financial transactions (using various nondecimal currencies). Girls were never

taught the subject. Even in Philadelphia in the first half of the eighteenth century, two of the most celebrated schools in the colonies replaced instruction in arithmetic with sewing for girls, who were otherwise taught the same material as boys in reading and writing.

A few of the grammar schools evolved into secondary schools, some of which retain their names today. In the secondary schools, ciphering was taught by drilling students in the manipulation of integers because books were rare. Fractions were rarely taught. Slate boards were not introduced for school use until after the Revolutionary War, and blackboards not until the nineteenth century (and whiteboards at the end of the twentieth century). Paper too was costly in the Colonial Era, so birch bark was sometimes used in schools to teach children to write and calculate. Most instruction consisted of teachers dictating lessons, with students listening attentively, perhaps copying some notes, and then solving problems on birch bark. In such instances it was not unusual for up to a dozen students to be lined up at the teacher's desk awaiting evaluation of their solutions.

Who were the teachers? Most were drawn from the clergy, but the best were college students or college graduates using the position as a stepping stone to a better future. A shining example is former US President John Adams, who wrote of his experiences in 1755: "Sometimes paper, sometimes his penknife, now birch, now arithmetic, now a ferule, then ABC, then scolding, then flattering, then thwacking, calls for the pedagogue's attention."<sup>10</sup>

An outstanding teacher from these times was **Ezekiel Cheever** (1614–1708), called the "father of Connecticut School-masters, the Pioneer, and Patriarch of elementary classical culture in New England."<sup>11</sup> Cheever serves as an example of those who emigrated from England (he was born in London and emigrated in 1637) and whose lot in life rose beyond those of their ancestors in the old country—his grandfather was a yeoman and his father a skinner. Shortly after arriving in Boston, he moved to New Haven, where he was a schoolmaster 1638–1650; he was also deacon of the first church of New Haven during six of these years. Initially, Cheever was the head of the Free Schoole but soon it expanded to the Free Grammar School. Generally, colonial grammar schools provided instruction in Greek and Latin. They were endowed by either a grant of land or a bequest of money, and they were open to all white males, regardless of the family's economic standing. They later evolved into academies, not public schools.

Ezekiel Cheever moved to Ipswich, MA, in November 1650 to take charge of that town's grammar school which was supported by donations from publicly spirited individuals. Eleven years later he moved to Charlestown, MA, to become schoolmaster of that town's Free School. In 1670 Cheever returned to Boston to become headmaster of the Free School, which was renamed the Latin School in 1790. Boston Latin School can thus claim distinction as being the oldest public secondary school in the US. He remained at the school for the rest of his life, and under his guidance it became the principal classical school throughout the colonies.

Altogether, Ezekiel Cheever taught for seventy years, right up to the time of his death at age 94. He contributed little to the literature, but his *A Short Introduction to the Latin Tongue* was probably the earliest American school book. It was written when he was in New Haven, hence before 1650. The book was so popular that its twentieth edition appeared in 1790.

Most early settlers were too busy adapting to life in the New World to engage in higher education. Even those who came to America with a university education knew mathematics only up to the rule of three and *pons asinorum*. (The rule of three refers to problems that reduce to solving an equation of the form  $ab = cd$ , where all but one of the four variables is known. *Pons asinorum* refers to the inability to transcend Proposition I.5 in the first book of Euclid's *Elements*: in an isosceles triangle the base angles are equal.)

## Harvard College

The founding of a college so early in the history of the US is somewhat surprising given the challenging conditions the Pilgrims faced. Nonetheless, some of the college-educated leaders of the Massachusetts Bay Colony sought to afford their sons the same opportunity they had experienced at Cambridge, Oxford, or Edinburgh. To achieve that goal, in October 1636 the Great and General Court of the Colony “agreed to give 400£ towards a schoale or colledge.”<sup>12</sup> Classes at what would ultimately become Harvard University began in July 1638 with nine students and one master in a single-frame house. (Today a typical Harvard freshman class consists of 1600 students.)

When the Englishman and Puritan minister **John Harvard** (1607–1638) died at age 30, having emigrated from England only the year before, he bequeathed half his estate (780£) plus his entire library (260 books) to the fledgling institution. In appreciation, the school's name was changed from the “college at Newtowne” to Harvard College in 1639. Thus the first college in the US dates its founding to 1636, just 16 years after the first Pilgrims landed at Plymouth, a rather short period of time. Although the population of all of New England at the time was only 4000 and Boston consisted of no more than 30 houses, almost 100 men were graduates of Oxford, Cambridge, and Scottish universities. Nonetheless, Harvard remained a relatively small, provincial institution until the presidency of Charles W. Eliot, who by the turn of the twentieth century transformed it into the modern university of today. To put enrollment figures in perspective, only 465 students graduated in all of the seventeenth century.

Radcliffe College was established in 1894, during Eliot's presidency. The idea to found a women's college associated with the all-male Harvard had floated since 1878, and the following year saw the formation of the “Harvard Annex,” which was chartered in 1894. The school was named after Ann Radcliffe (Lady Mowson; 1576–1661), who had created Harvard's first scholarship fund in 1643. The year 1643 set a precedent for collegiate fundraising.

Even though classes at Harvard began in July 1638, the real founding of higher education in the colonies began with an unusual man, **Henry Dunster** (1609–1659), who became the first president of Harvard in 1640. Dunster studied oriental languages at Cambridge in England, where he earned a bachelor's degree in 1630 and a master's degree four years later. He then taught at Magdalene College, Cambridge, achieving a reputation as a Hebrew scholar, especially regarding biblical studies. He immigrated to Boston in 1640, one year after Nathaniel Eaton was dismissed as master of Harvard College. Dunster chose the title “president” in place of “master.” A Congregationalist minister, he modeled Harvard after Cambridge University, and ended up playing an important role in inaugurating mathematics instruction. There are no known images of Dunster.

Harvard College did not obtain its charter from the Massachusetts Bay Colony until 1650. The charter established the President and Fellows of the College, which thereby became the first corporation in the Western Hemisphere. Known today as the Harvard Corporation, this body still governs the university, a remarkable testament to Dunster's foresight; in fact, its membership was increased from the original seven to thirteen only in 2010.

Most colleges and universities in the US and Canada scramble for funds, and Harvard was no exception in the early Colonial Era. Although the Massachusetts Bay Colony's grant was generous, as was John Harvard's bequest, the need for additional funds was evident, so in 1643 the College launched an appeal called "New England's First Fruits." The pamphlet announcing the appeal reveals that Dunster read mathematics and astronomy to third-year students, with arithmetic and geometry taking up the first three quarters of the year. Later in Dunster's tenure he taught Harvard students plane surveying and a smattering of navigation.

The curriculum was entirely prescribed, and students followed a regular schedule. Each day was devoted to one or two subjects, so that in the final year of the program, for instance, mathematics and astronomy were read at 10 a.m. on Monday and Tuesday, Greek on Wednesday, Latin on Thursday, and rhetoric on Friday. Here "rhetoric" refers to public speaking, especially disputations carried out in Latin. However, to show the relative emphasis placed on mathematics, ten hours a week were devoted to philosophy, seven to Greek, six to rhetoric, four to Oriental languages, and just two to mathematics.

Initially, Harvard's degree program lasted three years, so Dunster was instructing third-year seniors. In 1655 the College switched to a four-year degree program, thus setting the stage for every college and university that followed. All Harvard students, called "scholars" at the time, took the same courses in six liberal arts (grammar, logic, rhetoric, arithmetic, geometry, and astronomy) and three philosophies (metaphysics, ethics, and natural science) as well as Greek, Hebrew, and ancient history. Final exams were given at the end of the four years when, over a six-day period, any graduate with a master's degree or any member of the Board of Overseers could quiz the students orally. All examinations were oral. This tradition continued until the 1870s; even then, most faculty members opposed the switch to written examinations.

At the end of a week of festive graduation ceremonies, the valedictorian delivered an oration in Greek, the salutatorian one in Latin, and the third-ranking student an address in Hebrew. Today a Harvard graduate, not necessarily the salutatorian, still delivers a commencement address in Latin.

Most Harvard students owned few if any mathematics textbooks; arithmetic and geometry books were a rarity in the colonies. Therefore, some teachers wrote manuscript textbooks based on original English sources. In the classroom they would mainly dictate the material from these works. For instance, in 1649 President Dunster based his geometry course on Euclid's *Elements* and from a book by Petrus Ramus. Moreover, he taught in English, even though Latin was the official language of the College, so in his copies of these texts he translated each proposition from Latin to English in the margin "with purpose to ripen it on fuller thought."<sup>13</sup> In 1652, Dunster managed to purchase a 1570 copy of Billingsley's *Elements of Geometrie*, the first edition of Euclid ever to appear in English. Students were expected to make their own copies of these



manuscripts, and in this way mathematics was handed down from one generation to the next.

Henry Dunster was succeeded as Harvard president by **Charles Chauncy** (1592–1672) in 1654. Chauncy was a Cambridge graduate who emigrated from England when he ran afoul of the Anglican Church. He landed in Plymouth 18 years after the original Pilgrims came ashore. In 1641 he settled in Scituate, MA, where he was a minister until he accepted the Harvard presidency. However, Chauncy did not share Dunster's vigor for mathematics, so instruction in the subject declined to the point that Thomas Brattle, who attended 1672–1676, never received instruction in geometry during his student days.

Only a few areas of human endeavor in the early colonial settlements had a need for mathematics. One was surveying. Even Thomas Harriot came to the country as a surveyor. The demand for skilled surveyors increased during 1625–1675, when the Colony of Virginia initiated a program of enticing middle-class Englishmen to settle there with an offer of 50 acres of ungranted land for each person the settler brought to the New World. The operative word here is *ungranted*. A surveyor had to lay out the new property to ensure that it was disjoint from all contiguous properties, and then to record the deed at the county court. (Since the clerk was “seated,” the court house became known as the county seat.) Surveying required knowledge of geometry and trigonometry beyond those simple computations needed for calculating measures and making financial transactions, resulting in the need for additional mathematics in the schools.

**Indian College.** Harvard's founding charter from 1650 dedicated the college to “the advancement and education of youth in all manners of good literature, arts, and sciences.” But it went even further in an attempt to obtain funding for the College. Part of that document read:

Whereas through the good hand of God many well devoted persons have beene and dayly are moved and stirred up to give and bestowe sundry guiftes legacies lands and Revennewes for the advancement of all good literature artes and Sciences at Harvard Colledge in Cambridge in the County of Middlesex and to the maintenance of the President and Fellowes and for all accommodacons of Buildings and all other necessary provisions that may conduce to the education of English & Indian youth of this country in knowledge and godliness.

Promoting the education of “Indian youth” carried with it a critical ulterior motive. Namely, it sought to raise funds from the Society for the Propagation of the Gospel in New England, which aimed to convert the Native American population to Christianity. By agreeing to support this purpose with donations to Harvard College in exchange for the free tuition, room, and board of Native American students, this London-based society expected its graduates to proselytize back in their home communities upon graduation.

Native American students had attended Harvard before 1650, although none completed requirements for a degree. But in 1655 Harvard established a formal Indian College to teach the English language and Protestantism to Native Americans. The next year, funding from the society enabled the College to construct a two-story brick building in what is now Harvard Yard. Because no Native American students attended

at first, the building was used for English students until the first Native Americans enrolled in 1661. This building also housed a printing press that two years later published the first Bible in any language printed in British North America. One of the “first fruits of the vine,” James Printer, did much of the translation and typesetting for John Eliot’s edition of the Bible. Written in the native Algonquin Indian language, it became known as the “Indian Bible.”

These Native American males had to satisfy the same entrance requirements as their colonial cohorts: recite and translate from Cicero and Virgil in Latin, and Isocrates, Xenophon, and the New Testament in Greek. They too would have already attended a grammar school, where they were expected to master Latin. (How many Harvard students today would have qualified for admission under these requirements?)

The entering class of eight included the first two Native Americans to enroll in the Indian College and live in the building. Neither was able to achieve what the Society for the Propagation of the Gospel envisioned. Tragically, Joel Iacoomes “was murdered by seafaring marauders on the way to Commencement,”<sup>14</sup> so he did not receive his degree. His classmate and fellow Wampanoag tribe member, Caleb Cheeshahteamuck, became the first Native American to graduate from college in 1665, but he died of pneumonia just a few months later and so was never able to carry out the society’s hope for proselytizing to the tribes on his native Martha’s Vineyard. He had been educated at Daniel Weld’s school in Roxbury and then Elijah Corlett’s elite grammar school in Cambridge before entering Harvard. Nothing is known about either of their performances in arithmetic and geometry, but a recent book, *Caleb’s Crossing*, paints a very engaging portrait of student life at Harvard in the seventeenth century.<sup>15</sup>

Harvard’s original outreach to Native American students essentially ended in 1675 with the onset of King Philip’s War with the Massachusetts Bay Colony. It seems that no Native American students enrolled after that, and the building was razed in 1693. Of related interest, when Tiffany Smalley received her Harvard BA in 2011, she became the first member of the Wampanoag nation from Martha’s Vineyard to graduate since Caleb Cheeshahteamuck earned his degree 346 years earlier; she resided in Dunster House.

## Almanacs

The Harvard curriculum indicates that mathematics was born as a handmaiden for astronomy. Apparently, Harriot’s advances had no influence on this side of the Atlantic at all, as algebra remained an unknown subject. Moreover, there was little change in the curriculum until the beginning of the eighteenth century, mainly because the course of study was designed for students seeking to enter the ministry through Cambridge or Oxford. Therefore, the subjects that monopolized the curriculum were philosophy, linguistics, and theology; mathematics was nearly excluded.

The main admission requirement was the ability to speak, read, and write Latin. There was no mathematics prerequisite, so by the time students became seniors, they had not studied mathematics for at least two years. Some excelled anyway, beginning with **Samuel Danforth** (1626–1674), certainly one of the “ripest fruits” in the class of 1643. Danforth came to the New World with his father when he was eight years old, his mother having died five years earlier, so he received his entire education in the colonies. By 1650, he had achieved local fame as an astronomer of distinction, probably

due to calculations he carried out for almanacs in 1646, 1647, and 1648. All three were printed in Cambridge, England. In 1651 a New England writer gushed, “[Danforth] hath not only studied divinity, but also astronomy; he put forth many almanacs.”<sup>16</sup>

The major mathematical activity in America during the seventeenth century was the writing of almanacs, which was regarded as proof of profound erudition. Four almanac authors were associated with Harvard and attained a fairly high degree of sophistication. Samuel Danforth has already been mentioned. Two others were **Urian Oakes** (1631–1681), who served as Harvard’s acting president 1675–1680 and was full president for the final year of his life, and **John Sherman** (1613–1685), who published *An Almanack of Coelestial Motions* in at least 1674, 1676, and 1677.<sup>17</sup> (The online file “Web01-Almanacs” provides additional material on Danforth, Oakes, and Sherman.)

The best of the seventeenth-century almanac authors, and an outstanding colonial scientist, was **Thomas Brattle** (1658–1713), whose work *An Almanack of Coelestial Motions of the Sun and Planets, with Their Principal Aspects, for the Year of the Christian æra 1678* was printed in Cambridge, MA. Unlike Oakes and Sherman, Brattle was born in Boston. He spent his entire life in the area, graduating from Harvard in 1676, and he later amassed a considerable fortune that enabled him to make several generous gifts to Harvard and to serve as treasurer 1693–1713. Brattle used a telescope (which had been given to Harvard in 1672) to observe a famous comet of 1680. He sent his observations to the first Astronomer Royal at Greenwich, who in turn forwarded them to Isaac Newton. That famous Englishman used the observations in his *Principia Mathematica* to prove that comets travel in paths determined by the law of gravity. Newton praised “the observer in New England”<sup>18</sup> amongst some European astronomers who also aided his investigations.

Thomas Brattle became the first American scientist to have scientific work published abroad, with articles from 1705 and 1707 appearing in the *Philosophical Transactions* of the Royal Society of London. The first work was done jointly with the astronomer James Hodgson in London, showing that collaboration was carried out effectively 300 years before the advent of electronic mail. In a letter that summarizes the plight up to 1876 of American scientists with an abiding interest in mathematics, Brattle wrote to a friend that he was working “here alone by myself, without a meet help in respect to my studies.”<sup>19</sup> A well-known street in Cambridge, MA, commemorates the Brattle family; it almost runs into Chauncy Street.

Clergymen played a prominent role at Harvard, and in general religion was another area with an expressed need for mathematics in the seventeenth century, though the level of mathematics needed by ministers and priests for establishing the dates of certain holidays and major saint days was considerably less than what astronomers and surveyors required. In conjunction with the needs in surveying and astronomy, this in turn led to the founding of several grammar schools, especially by the Jesuits. This order played a pivotal role in higher education in Canada when French Jesuits opened the Collège de Québec in 1635, one year before the founding of Harvard. Thirty years later the French-born Martin Boutet was appointed “professor matheseos,” thereby becoming the first mathematics professor in America. The course of study at the Collège de Québec lasted five years and was in the hands of two priests, with help from six brothers. Mathematics was taught in the last two years in the curriculum as an aid for navigation, surveying, and cartography during this time, but it was doubtless limited

to elementary and commercial arithmetic. Nonetheless, a book on the history of Jesuit education reports “a pitiful contrast between the intellectual culture in the newly acquired Canada and the uncultured backwardness of the older English colonies.”<sup>20</sup>

## Royal College of William and Mary

The first permanent settlement in the US was established in 1607 at Jamestown by the Virginia Company of London. Another successful settlement took place in 1620 when a group of Anglicans and Separatists landed at Plymouth, MA; they later became known as Pilgrims. Therefore it seems appropriate that the first two American colleges would be founded near these sites. Harvard College was established only 16 years after the initial landing at Plymouth Harbor. Its early founding might suggest that the US prized higher education right from the start, but the College was far inferior to Oxford, Cambridge, and Edinburgh, even though these prestigious universities recognized degrees from the American version at once. Harvard enjoyed a 57-year head start on the competition, as the second US institution of higher learning, the Royal College of William and Mary, was not founded until 1693 and the third, Yale, in 1701. Incidentally, the first college in all of North America was Real y Pontifica Universidad de México, which was founded in 1551 and opened two years later.

Why did it take so much longer for a southern colony to establish an institution of higher learning? Were Jamestown’s inhabitants more involved with mere survival? Was education undervalued there?

The answers to all three questions emanate from the main difference between the two groups of settlers. New Englanders were mainly farmers, with a small percentage having earned a college degree, yet many had a burning desire for their sons to enjoy a better life through education. Those afforded the time and expense of being able to prepare their sons for Harvard, either in public schools or by private tutors, benefited from the College’s founding in 1636.

Many of the settlers in the Colony of Virginia, on the other hand, were plantation owners and successful merchants. A very high percentage of inhabitants in the colony were Englishmen, “and as men from the English and Scotch universities were continually arriving, the need of a home institution was not as acutely felt during the [seventeenth] century.”<sup>21</sup> Instead, these wealthy colonists sent their sons abroad to study at Cambridge, Oxford, or Edinburgh “to an extent never dreamed of in the northern colonies. The ocean was, in fact, a connecting bridge to the shipping people and merchants who really settled Virginia.”<sup>22</sup> A sense of adventure and commercial enterprise minimized perceived risks associated with trans-Atlantic travel for these men, who often made multiple crossings in order to obtain additional land grants. Extended families supported young students too. For instance, a will from 1671 provided funds so that a magistrate’s two nephews “should be sent to school in London and afterwards returned to Virginia.”<sup>23</sup>

The desire for a college education caused a concomitant need for preparatory education. Essentially the Colony of Virginia initiated a system of compulsory education in 1646 when a legislative act empowered the eight counties to provide schooling even for children of “such parents whose poverty extends not to give them good breeding.”<sup>24</sup> The colony consisted of twenty parishes, each with a minister who provided instruction in the school along with ministerial duties. Income was derived from taxes assessed for

this purpose. At this early date lessons were provided only in reading and writing; there is no evidence of any formal instruction in arithmetic.

It is noteworthy that the act provided instruction without regard to gender or race, often with the pupils being indentured as apprentices. As an example, in 1690 a girl named Rebecca was apprenticed until age 21 to a married couple who were required to provide “a Compleat yeares schooling ... to bee taught ... within the aforesaid term of ... Apprenticeship.”<sup>25</sup> Here a complete year included summertime, so this provision amounted to three years of instruction. By contrast, in the seventeenth century generally schools in New England were open only for two months in the summer and two months in the winter.

The clause stating that education should be provided regardless of race did not always apply to slaves. It did, however, extend to children with one white parent and one black parent. For instance, in 1716 George Petsworth, “a molattoe boy of the age of 2 years,” was apprenticed to Ralph Bevis, who was required to provide “3 years’ schooling, and carefully to Instruct him afterwards that he may read well in any part of the Bible, also to Instruct and Learn him y<sup>e</sup> s<sup>d</sup> molattoe boy such Lawful way or ways that he may be able after his Indenture time expired to gitt his own Liveing.”<sup>26</sup>

One particularly successful free school was established in the 1634 will of the childless planter Benjamin Syms (b. 1590) for children in two adjoining parishes. Syms bequeathed 200 acres of land in Elizabeth County and eight cows whose milk and ultimate sale provided funds for a school building that was erected by 1647. The same year Syms wrote his will, another successful Virginian, Thomas Eaton, bequeathed 250 acres for a nearby school called the Eaton Charity School. Sixty years later, in 1695, a county register recorded that “a negroe Joan belonging to Eaton’s free school ... be free from paying Levyes.”<sup>27</sup> After roughly 125 years of successes, both the Syms and Eaton free schools experienced financial difficulties during and after the Revolutionary War. However, the depths to which they fell by 1800 were bemoaned by the inhabitants of coastal Virginia, leading the new state’s general assembly to incorporate them as the Hampton Academy in 1805. State funding became more critical over the next 46 years, resulting in the former academy evolving into the public Hampton High School. Noted historian and William and Mary president, Lyon G. Tyler, concluded, “Hampton, the oldest existing English town in the United States, has the oldest free school.”<sup>28</sup>

Various smaller schools dotted the Colony of Virginia landscape up to the Revolutionary War, some being unrelated to public parish schools. Two were established for teaching Native American children. A fashionable boarding school for girls was established in Williamsburg about 1760.

Wealthy Virginia colonists, who did not send children to England or Scotland for their education, sent them to private schools or provided tutors at home. There was a fine line between these two means for providing preparatory education because private tutors generally taught other children in addition to those residing in the house. Young ministers often came over from abroad to serve as tutors or as teachers. Some educated but poor colonists were also employed as teachers by indenture.

Advertisements placed in the *Virginia Gazette* indicate ways in which individuals or schools sought teachers or tutors. For instance, Theophilus Field advertised for “Any single man capable of teaching Greek, Latin, and the Mathematicks, who can be well recommended.”<sup>29</sup> An unnamed person required “A tutor for a private family, who among other things thoroughly understands mathematics.”<sup>30</sup> The Norborne Parish

was looking to hire “A school-master well qualified to teach writing and Arithmetic”<sup>31</sup> to a class of 15 to 20 students. On a higher level, a “publick School” at Cabin Point, VA, sought to hire “a Master properly qualified to teach English, writing and Arithmetick. This school will consist of nearly Thirty scholars.”<sup>32</sup>

**Third college in America.** There were plans to found a college in present day Williamsburg even before the Pilgrims landed at Plymouth. As early as 1617 King James decreed that funds should be collected for a college to be located in Henrico, near Richmond, VA. At about the same time, money was raised to start “a collegiate or free school”<sup>33</sup> to be situated inland at City Point, VA, and named the East India School in honor of its benefactors from the East India Company. Two years later the First Colonial Assembly at Jamestown discussed the possibility of establishing a college. Over the next few years those ideas began to gain credence when appropriately skilled individuals were sent to the colony—a manager for the lands as well as a rector, master, and usher for the college. However, a massacre by Native Americans in 1622 killed 350 settlers and thus scuttled any idea about starting a college.

The idea of founding an institution of higher learning gained traction a generation later when, in 1660, the Colonial General Assembly passed an act founding “a college and free schoole.”<sup>34</sup> However, a different kind of uprising conspired to douse this second set of flames when Virginia settlers became so upset with the actions of the colony’s governor, William Berkeley, a proponent of the college, that popular rebellions broke out in several parishes. The best known, Bacon’s Rebellion, was the first uprising among discontented colonists against a king’s appointed official in the colonies. These rebellions became so violent that the settlement at Jamestown, which served as the capital of the colony 1607–1698, was burned to the ground, including the state house.

In 1690, thirty years after the Virginia legislature passed an act to found a college, the General Assembly again proposed the idea. This time the legislature instructed Dr. James Blair to “endeav<sup>r</sup> to procure from their Ma<sup>tys</sup> an ample charter for a *Free Schoole and colledge*, wherein shall be taught the Latin, Greek; and Hebrew tongues, together w<sup>th</sup> Philosophy, Mathematicks, and Divinity.”<sup>35</sup> James Blair was a Scottish clergyman brought to Virginia to marshal resources for the proposed college. To do so, he first gained the support of the new governor’s council and a Convention of Clergy. Both groups accepted his proposals and, moreover, recommended them to the General Assembly, which approved them in 1691. That assembly appointed Blair as an agent in England, where he sailed with the intent of securing a charter from King William and Queen Mary. This time Blair gained the support of influential merchants, the Bishop of London, and Archbishop of Canterbury before appealing to the rulers. Once again his approach was successful, and on February 2, 1693, King William issued a charter for Their Majesties’ Royal College of William and Mary.

Initially the Royal College of William and Mary was to consist of three divisions. The lowest was the Grammar School, which was essentially a “free,” meaning “public,” secondary school. Above that would be the Philosophical School, offering a four-year program, and the Divinity School, providing another three years of biblical training. William and Mary was founded as an Anglican school, so all students, including Native Americans, had to be members of the Church of England and all professors had to declare adherence to the Thirty-Nine Articles of the Anglican faith. The first building, later named for English mathematician Christopher Wren, was completed in 1695.

The charter for William and Mary provided for five professorships—two in divinity and one each in mathematics, Greek and Latin, and moral philosophy. By contrast, Harvard still had no mathematics professor at the time. But this was only in theory. In practice, only the Grammar School was operational until about 1712. Classes were taught by the first president, James Blair, as well as a grammar master, a writing master, and an usher.

The first professor—of mathematics and natural philosophy—was appointed in 1712, which marked the real beginning of the institution as a college. This professor taught “physicks, metaphysics, and mathematics.”<sup>36</sup> A second professor, of moral philosophy, was soon added to teach rhetoric, logic, and ethics. Their salaries consisted of a fixed amount plus an added amount for each student except those on scholarship. Professors were also entitled to apartments in the college building. Curiously, the president was allowed to be married, but the professors were not, though this requirement was not always enforced.

At the end of four years each student took an oral examination in front of the president, professors, and any ministers proficient in Latin and Greek. If the student’s performance was satisfactory, he was awarded a Bachelor of Arts degree and, three years later, a Master of Arts degree. (I used the masculine pronoun deliberately because William and Mary did not admit women until 1918.) Passing the examination also enabled the student to proceed to the Divinity School, which prepared these young men to become ministers in the Church of England.

By 1729 the foundation for the college was complete. There were six professors, all graduates of Edinburgh, Oxford, or Cambridge. In 1779 the Grammar School and Divinity School were abolished and replaced by three schools: modern languages, constitutional and court law, and medicine. Enrollment increased from 29 in 1704 to 60 in 1737 and then to 115 in 1754. Records show that 75 of the 115 students boarded at the college—52 paying students, 15 on scholarship, and eight Native Americans; the other 40 lived in town.

A second college in the US can trace its roots to the Colony of Virginia. In 1749 the Edinburgh graduate Robert Alexander founded the Augusta Academy that was run by the Princeton graduate John Brown for the next 20 years. It was renamed the Liberty Hall Academy in 1776 in a burst of revolutionary pride, but it did not become a college until awarding its first bachelor’s degree nine years later. Its name was changed to Washington Academy when George Washington donated a substantial amount of money in 1796, and it was chartered as Washington College 17 years after that. Another famous general, Robert E. Lee, took over the presidency of the college after the Civil War and, upon his death in 1870, the name was changed to its present Washington and Lee University.

Some of America’s first professors of mathematics were very colorful figures—if not rogues. Three of these scallawags will be introduced shortly, two at Harvard and the other one at William and Mary.

**First mathematics professor.** Harvard’s instruction in mathematics was carried out by tutors after Henry Dunster was removed as president in 1654, so it was the second college in the US that appointed the country’s first professor of mathematics and philosophy. That particular individual turned out to be a scoundrel, with misbehavior curtailing his tenure in less than a year.

The distinction of being the first professor of mathematics in the US rests with the **Reverend Tanaquil Lefevre** (dates unknown). Toward the early part of the eighteenth century, authorities at William and Mary sought to appoint someone versed in mathematics. They kept in close touch with the college chancellor, the Lord Bishop of London, who carried out his duties from abroad. Upon his recommendation, Tanaquil Lefevre was appointed professor of mathematics and philosophy on April 25, 1711, with a salary of £80 a year. Lefevre was probably chosen for his excellent background and education. In fact, he published a work on algebra in 1714 with his father, who spelled his name Tanaguy Lefebvre.

Many settlers of French descent arrived in Jamestown about 1700. Lefèvre is one of the most common French surnames, meaning “metal worker,” and it was spelled variously as Lefebvre, Lefebvre, Lefebvre, Lefevre, and Fèvre. This produced some confusion; several internet sites state that Isaac Lefevre was the first professor of mathematics and physics at William and Mary. The authors of such assertions were apparently not acquainted with an article in the *American Mathematical Monthly* that settled the matter almost 70 years ago in favor of *Tanaquil Lefevre*.<sup>37</sup>

William and Mary extended the offer to Lefevre with the hope that he would bring scholarship and honor to the college. Instead, he brought shame. In a letter addressed to the Lord Bishop of London the following May, an authority wrote:<sup>38</sup>

I gave your lordship an account of Mr. Lefevre’s admission into the college upon your lordship’s recommendation and aim to acquaint you now that after a tryal of three quarters of a year he appeared so negligent in all of the posts of duty and guilty of some other very great irregularities, that the governors of the college could no longer bear with him, and were obliged to remove him from office.

What were these “irregularities,” and what might have caused them?<sup>39</sup>

I am apt to believe that most of his irregularities were owing to an idle hussy he brought over with him, because since she left him (I got her a passage back to England last February) he has left off that scandalous custom of drinking and appears quite another man, being now settled at a gentleman’s house for teaching his son, and has a competent salary enough to keep him from being any more burdensome to your lordship or his other friends.

Consequently, Lefevre achieved no fame in mathematics—and professorships in our field got off to a rocky start. Similar misconduct occurred with the first mathematics professors at Harvard and at West Point, but for now we remain with William and Mary.

**Hugh Jones.** William and Mary authorities were in no hurry to name a successor to Lefevre, taking five years—yes, five *years*—before appointing the **Reverend Hugh Jones** (1692–1760) in 1717. Yet it was another ten years after that when Harvard appointed its first mathematics professor. Reverend Jones was a university graduate, but it is unclear whether he attended Cambridge or Oxford.<sup>40</sup> He was regarded by William and Mary leaders as possessing outstanding culture and scholarship as well as virtuosity. He seems to have emigrated from England in 1716 shortly after receiving his MA degree. An aristocratic, loyal Hanoverian and zealous churchman, Jones wrote the first English grammar in America. He is also known for his book published in



Table 1.1. Professors of mathematics at William and Mary, 1711–1805

<b>Name</b>	<b>Appointment</b>	<b>Name</b>	<b>Appointment</b>
Tanaquil Lefevre	1711	William Small	1758
Hugh Jones	1717	Richard Graham	1763
Alexander Irvine	1728	John Carom	1766
Joshua Fry	1732	Thomas Gwatkin	1769
John Graeme	1737	James Madison	1773
Richard Graham	1749	Robert Andrews	1784

1724, *Present State of Virginia*, which served as “an invaluable source of material for subsequent historians.”<sup>41</sup> This was the first historical work in America written by a professor in a college.

Jones attained some recognition in mathematics for a work arguing that the base-8 number system is superior to our decimal system for arithmetical computations. The 47-page manuscript, titled “The Reasons, Rules, and Uses of Octave Computation or Natural Arithmetic,” is shelved in the British Museum. The purpose, Jones wrote, was to devise this system because even common arithmetic had become “mysterious to Women and Youths and often troublesome to the best Artists.”<sup>42</sup> Written about 1745, it espouses that the octonary system was the most practical numerical system for dealing with coins, measures, and weights. Besides applications to arithmetic, geometry, and natural philosophy, the manuscript also presents utilitarian uses in land surveying, grain storage, and ship displacement. Nonetheless, the author was doubtful that his proposal would be adopted, for “there seems no Probability that this will be soon, if ever, complied with.”<sup>43</sup>

Hugh Jones may also have published the book *Accidence to the Mathematicks*, but no printed copy is extant. Because his experience with colonists had taught him that they are “for the most part only desirous of learning what is absolutely necessary in the shortest and best method,”<sup>44</sup> he composed manuscripts on algebra, geometry, surveying of land, and navigation, but none of these were printed in book form. Overall, then, it seems that Hugh Jones was educated in basic mathematics and attempted to convey the subject to his young students, but the low level of the material is what we typically associate today with the Colonial Era.

Reverend Jones held the professorship until 1722, when he was only 30 years old. For unknown reasons, he left the post and returned to England. Although he sailed back to the colonies in 1724, he became a minister in churches in Virginia and Maryland for his remaining time. However, he was appointed the chief mathematician for the determination of the boundaries delineating Maryland, Pennsylvania, Delaware, and present-day West Virginia (then part of the Colony of Virginia), an historic project later known as the Mason–Dixon Line.

Table 1.1 lists the initial year of appointment of the eleven professors who held the mathematics and philosophy chair at William and Mary up 1784.<sup>45</sup> Note that Richard Graham served two different terms. I provide brief sketches of most of these William and Mary mathematics professors; the online file “Web01-W&M” supplies more details.

It is advisable to notice the varying degrees of loyalty among these first mathematics professors toward the English monarchy, which was an important issue at this royal college. Little is known about **Alexander Irvine** (d. 1732) except that he was educated in Edinburgh, sailed to Philadelphia in 1727, and was appointed professor of mathematics and surveying the next year. Apparently, he was the surveyor who determined the boundary between the colonies of Virginia and North Carolina. **John Graeme** tested George Washington as a surveyor. **Joshua Fry** (1699–1754) graduated from Oxford in 1718 and came to William and Mary as professor of natural philosophy and mathematics upon the death of Irvine in 1732. Fry served on the commission with Irvine to determine the Virginia–North Carolina border. In 1752 he collaborated with Thomas Jefferson’s father on an influential map of Virginia.

**Richard Graham** (b. 1720) entered Queen’s College at Oxford in 1737, received his bachelor of arts degree in 1742 and then a master of arts in 1746. This qualified him to be appointed professor of natural philosophy and mathematics at William and Mary in 1749. For unknown reasons he was removed from his position in 1758, yet three years later he returned to William and Mary as chair of moral philosophy. Graham resumed his professorship of natural philosophy and mathematics in early 1764 but sailed back to England to become a fellow at Oxford two years later.

**William Small** (1734–1775) served between Graham’s two terms. Born in Scotland, Small received a master’s degree in 1755 from Aberdeen College. Three years later he was appointed professor of natural philosophy and mathematics at William and Mary. It is believed that he was the first professor in America to adopt the lecture method of teaching in place of the custom of reading from a manuscript that had been favored up to that time. Small’s most famous student from 1760 to 1762 was Thomas Jefferson, who penned an endearing tribute to his teacher.<sup>46</sup> Sadly, Small passed away at age 40 from malaria he had contracted during his stay in Virginia.

**Thomas Gwatkin** (1741–1800) matriculated at Jesus College, Oxford, in 1763 and was ordained four years later by the Chancellor of the Royal College of William and Mary. Gwatkin set sail for Virginia in 1770, a year after being nominated at age 28 for the chair of natural philosophy and mathematics at William and Mary. In early June 1775, he was asked by Richard Henry Lee and Thomas Jefferson to support the proceedings of the Congress of the Colonies. A devout Loyalist, however, he was disgusted “with rebellious colonists and disorderly collegians,”<sup>47</sup> so he refused. From that day forward “he was subjected to a variety of cruel treatment, by which his life was put into imminent danger and which was the cause of his subsequent permanent ill-health.”<sup>48</sup> He sought protection from the Governor of Virginia but instead was removed from his professorship. He sailed back to England later in June.

**Bishop James Madison** (1747–1812) was a William and Mary graduate (1771) who was appointed professor of natural philosophy and mathematics at his *alma mater* in 1773 and was associated with the college during the turbulent revolutionary period. He traveled to England in 1775 to be ordained a priest of the Church of England, but he returned to the Colony of Virginia as instructor at William and Mary shortly before independence was declared. He organized a student militia in 1777 when he assumed the presidency of the college. Two years later he abolished the college’s grammar and divinity schools.

About 1770, some prospective students wanted to study only a particular subject, but the time was not yet ripe for colleges to satisfy such interests. In May of that

year the six professors wrote, “The president and masters or professors beg leave to represent that the college is not designed to be the sole place of resort for education in the colony.”<sup>49</sup> That made it clear that the main purpose of a William and Mary education was to pursue, in descending order, 1) classical studies, 2) natural and moral philosophy, and 3) the sciences. The document added that this three-sided mission for education “cannot be departed from or occasionally altered even for the sake of extraordinary geniuses ... who aim at no more than a skill in Vulgare Arithmetic and some practical branch of mathematics to qualify them for an inferior office in life.”<sup>50</sup> Although such specialization did not arise in America for another century, a slight change took place at William and Mary in 1779, when Madison adopted a kind of elective system. Madison allowed “irregular” students (called “part-time” today) to study only those subjects they wanted to. Regarding this change, Thomas Jefferson wrote, “At William and Mary students are allowed to attend the schools of their choice, and those branches of science only which will be useful to them in the line of life they propose.”<sup>51</sup>

**Robert Andrews** (c. 1750–1804) is noteworthy for two reasons. First, he was born in America (Pennsylvania), a first at William and Mary, but others preceded him at Harvard and Yale in this regard. Andrews graduated from the University of Pennsylvania (then the College of Philadelphia). Upon graduation, he was a tutor for several years before traveling to London to be ordained in the Church of England. He was appointed professor of moral philosophy during the Revolutionary War (1779). However a historic event occurred in 1784, when President Madison (of William and Mary) was relieved of the duty of teaching mathematics and was made professor of moral philosophy and natural philosophy. The outspoken patriot Robert Andrews was then transferred to the mathematics chair, making him probably the first person in America to teach mathematics only, which he did from 1784 to at least 1789, becoming the second reason why I list Andrews in this chapter.

## First Harvard mathematics professor

Harvard created its first professorship of mathematics in 1727, five years after Hugh Jones had departed from William and Mary. I regard that person, Isaac Greenwood (see pp. 31), as the closest thing to a mathematician in America based on the works he produced and the material he taught. Greenwood is not well known, perhaps due to misbehavior that puts him in league with Lefevre, but an examination of his writings shows that he was current with mathematical advances taking place in England, particularly with the writings of Isaac Newton. Moreover, he presented some of this material to his Harvard students and included it in at least one book.

To place Greenwood’s contributions in context, I first view texts that were available for instruction in the Colonial Era. Then I introduce Thomas Hollis, the Harvard benefactor who established the first endowed professorship of mathematics in America. (As of March 12, 2018, the Hollis Professor of Mathematics and Natural Philosophy was the physicist Bertrand Halperin. The mathematician **Andrew Gleason** (1921–2008) held the chair from 1969 to 1992, when Halperin succeeded him.)

**Textbooks.** During the first part of the eighteenth century, printing presses in the colonies churned out numerous books, but few dealt with mathematics, and those that did principally covered arithmetic. Initially even these works were reprints of English

versions. For instance, the twenty-fifth edition of an arithmetic book written by James Hodder in London in 1661, but revised by Henry Mose after his death, was published in Boston in 1719 by Benjamin Franklin's uncle, James Franklin. Called merely *Hodder's Arithmetic*, the American edition contained nothing relating directly to the colonies. Franklin's autobiography informs us that he learned his arithmetic in 1722 not from his uncle's book but from a similar work of that time, *Cocker's Arithmetic*. This work first appeared in 1678 and "attained a record of approximately one hundred English editions in something over one hundred years."<sup>52</sup> Another European book known to have an American edition was an English translation from the Dutch of an arithmetic written by Pieter Venema. Published in New York in 1730, this book is notable because it contained material on algebra as well as arithmetic.

A textbook imported from England for instruction at both Harvard and Yale was the third edition of the work *The Young Mathematician's Guide*. Written by John Ward, "formerly the chief surveyor and now Professor of Mathematics in the City of Chester," it was published in London in 1707 and was apparently used at Harvard and Yale soon thereafter. This 400-page text consists of five parts: arithmetic (pp. 1–142), algebra (pp. 143–276), the elements of Euclid's geometry (pp. 277–354), conic sections (pp. 355–390), and "the arithmetic of infinities" (pp. 391–426). A modern reader is advised to refrain from drawing pre-Cantorian conclusions from the title of the fifth part; it is concerned with finding solutions, mainly to problems from finance, by progressions and series. This material does not adumbrate a calculus of infinite quantities.

More than a hundred English books on arithmetic were published in Great Britain in the early 1700s; I single out one author because of his role in America. The Scotsman **Alexander Malcolm** published two hefty treatises on arithmetic in London in 1726 and 1730. It is known that Malcolm came to New York City about 1740 and set up a school, yet, for unknown reasons, no American publisher printed either of his works.

One other arithmetic book of smaller interest, published in New Haven in 1747, carried a title that indicates a kind of applied usage that differed from other works on arithmetic both in its coverage and its intended audience: *Small Tract of Arithmetick, for the Use of Farmers and Country-People*. I do not know anything about its author, Jonathan Burnham.

The authoritative source on textbooks in the Colonial Era remains *Bibliography of Mathematical Works Printed in America through 1850*<sup>53</sup> by the historian of mathematics **Louis Charles Karpinski** (1878–1956), who spent the bulk of his professional career at the University of Michigan. The interested reader is advised to consult this tome for additional information on mathematics books published in America up to 1850.

**Hollis Professorship.** The first textbook on mathematics written by an American contained important advances in the teaching of the subject in the colonies, but it also has a curious history. The scandalous behavior of the author is equally fascinating. To set the scene when he appeared on stage, we go back to London in 1721, when the aristocratic **Thomas Hollis** (1659–1731) became deeply interested in Harvard and established a professorship of divinity. A successful merchant in London, Hollis had been a trustee for an uncle's will that bequeathed a donation to Harvard and this seems to have attracted his attention to the college. Inspired to do likewise, he established an endowed chair in divinity in 1721 and, moreover, stipulated that a Baptist could not be forbidden from holding the professorship even though that religion was not favored by

the Church of England. Hollis planned to establish a second endowed chair at Harvard himself in his will, a professorship in mathematics and natural philosophy.

Two years later, in 1723, Isaac Greenwood delivered a parcel of items from Harvard to Hollis. The two men must have kept in contact because in May 1725, Hollis reported that Greenwood had dined with him and had made a lasting impression. He wrote<sup>54</sup> that Greenwood

... was much admired as a Divine [Minister] ... & had several advantageous offers made him [*sic*] of spending the remainder of his life [in London]: but either thro' too great a Fondness for his native Country and Friends, or a much more prevalent Passion to Philosophy, he chose rather to postpone his Interest for that Time. His Genius leading him chiefly to the Mathematics and Philosophy, he applied himself mostly to these.

Hollis added that Greenwood had “made such strange and surprizing Advances” in science that his English tutor, the Copley Medalist John Theophilus Desaguliers, was duly impressed.

Isaac Newton was equally captivated. Hollis wrote that Greenwood had been invited to attend meetings of the Royal Society by Desaguliers and another English scientist, William Derham. According to Hollis, Greenwood “had the Honour of answering several Questions to their Satisfaction propos'd to him by [the Royal Society's] President, the great Sir Isaac Newton.”<sup>55</sup>

Six months later, in December 1725, Hollis proposed endowing a chair in mathematics and natural philosophy at Harvard. The two Hollis professorships, combined with the Hancock Professor of Religion established in 1765, were the only other named chairs in America before 1800. Today the Harvard Online Library Information System is named HOLLIS in honor of this early benefactor, who left the university a generous donation, apparatus for scientific investigations, a substantial number of books, and sets of Hebrew and Greek types for printing. (The types were treasured gifts in the days before desktop publishing.)

**Isaac Greenwood.** The person who induced Thomas Hollis to endow the professorship in mathematics and natural philosophy at Harvard was the scalawag **Isaac Greenwood** (1702–1745). The case can be made that he was America's first true mathematician. I base this assertion on three of his activities: 1) he taught advanced mathematics, 2) he published works on mathematics, and 3) he mentored advanced students in the field. Greenwood was assuredly the first “true fruit” to grow on the mathematics vine at Harvard, using terminology from the 1643 appeal for funding, but ultimately we consider him a “practitioner” (see pp. 55, 118). Born in Boston, where his father was a carpenter skilled in ship construction and repair, he did not do well in school initially; his obituary in the *Boston Gazette* read that “he was Old before he could read letters.”<sup>56</sup> That account quickly added, however, that due to “the Advantage of an uncommon Memory, he soon made so prodigious a Progress in his Studies as is scarce credible. At 15 he was thought fit for an Admission into College.”<sup>57</sup>

Thus in 1717 Isaac Greenwood enrolled at Harvard, where an older brother had graduated in 1709 and an uncle in 1685. He did not live there, nor did he seem to engage in student activities, but he studied under an excellent tutor, Thomas Robie. (The online file “Web01-Robie” provides further details about Robie.) For now, it is

pertinent to note that Robie's emphasis on science and knowledge of Isaac Newton's writings would help to mold Greenwood during his formative years.

A particularly virulent smallpox epidemic struck Boston in 1721, Greenwood's senior year at Harvard. A controversial way of combating the disease then was by inoculation, whereby a person was infected with a strain of it (from a patient who had a mild case of smallpox) through a cut in the skin. Greenwood was inoculated, developed a light case with a few pocks, and soon fully recovered. Convinced of the efficacy of the method, he then wrote a small pamphlet defending a major proponent of this predecessor of vaccination, the prominent Puritan minister Cotton Mather.

It is unknown what Isaac Greenwood did with his time between graduation and his voyage to England in 1723. He arrived in London armed with two important items. One was the packet of documents delivered to Thomas Hollis, thanking him also for the 24-foot telescope he had donated to Harvard the year before. The other was a letter from his pastor Cotton Mather to James Jurin (1684–1750), the English scientist and physician who was conducting research on smallpox vaccines. In mathematics, Jurin is known as an early and outspoken advocate of Newton's approach to calculus over Leibniz's.

Greenwood made a distinct impression on Hollis in the two years between the time he arrived in London in 1723 and when Hollis wrote to Harvard about him two years later. This indicates that, in the interim, Greenwood studied mathematics beyond what Robie had taught at Harvard. In the middle of this period Greenwood was awarded an AM degree from Harvard (1724). The College's graduates could obtain a master's degree three years beyond the bachelor's by paying a nominal fee. Most did.

In June 1725 Hollis informed Harvard authorities that Greenwood would be returning in time for the start of the fall semester armed with apparatus for teaching mathematics. He wrote, "I hope he will prove an usefull instructor in your college ... [he] appears to me sober, and dilligent to acquire knowledge."<sup>58</sup> Now, the word "sober" can mean a person of earnestly thoughtful character. I am unsure what Hollis meant, but correspondence from a year later suggests he intended the word to mean "not drunk."

In any event, Greenwood did not return to the colonies in 1725 as Hollis had expected. That December the two met, and Hollis informed Greenwood of his plan to endow a professorship in science at Harvard and to recommend him for the position. The aspiring mathematician then helped his benefactor draw up a set of guidelines for the endowed chair. However, Greenwood was still in London the next July, 1726, when Hollis received word that Greenwood had suddenly fled for Lisbon on his way back to Boston. It appears that Greenwood's nonmathematical character caused some concern, because even before he sailed back to the colonies, Hollis warned Harvard, "Mr. Greenwood has left us on a sudden without paying his debts or taking leave of Dr. Desaguliers, his Landlord or Tutor."<sup>59</sup> Not to mention that Hollis himself had not been informed of the colonist's departure.

Greenwood arrived in Boston in late October, preached a few times over the next couple of months, and in January 1727 offered the first public lecture course on science in the New World. The newspaper advertisement for the course declared that it would make subscribers "better acquainted with the Principles of Nature, and the wonderful Discoveries of the incomparable Sir Isaac Newton, than by a Years Application to Books."<sup>60</sup> The lectures were assembled and published as a pamphlet.<sup>61</sup>

That spring Hollis considered the appointment of Greenwood that was being proposed by Harvard authorities—curiously based on Hollis’s initial recommendation—for the chair he had endowed that was to begin with the fall 1727 semester. Hollis informed the College that “concerning Mr Greenwood . . . [and] wishing his future carriage may be sober, Religious, dilligent, and becoming his Profession . . . I think I shall accept him as my Professor.”<sup>62</sup> Note once again the use of the word “sober.” The Harvard Board immediately appointed Greenwood as “Professor of Mathematicks & Natural & Experimental Philosophy,” thus creating the first position in America where a person could make a living by mathematics. It should be kept in mind, however, that “The Hollis chair . . . was expected to lecture, not engage in research.”<sup>63</sup> It would be another 150 years before the idea that professors should engage in original investigations would gain a foothold in American universities.

The inaugural ceremony celebrating this new position was held in February 1728. Greenwood’s teaching load was light (this was similar to how leading universities woo top-notch researchers today)—he was required only to lecture on Wednesday afternoons at 2 p.m. Moreover, he was able to restrict attendance to those upperclassmen who first obtained his approval and whose parents paid a fee beforehand. What a wonderful precedent!

Isaac Greenwood was an especially effective teacher whose remarkably lucid lectures inspired several of his students to pursue science as a career. His most successful charge in this regard was John Winthrop, who entered Harvard in 1728 as a 14-year-old prodigy and succeeded Greenwood as Hollis Professor ten years later. Mostly, Greenwood lectured on work by Isaac Newton, some of which his tutor, Thomas Robie, had introduced to him, but most of which he had learned while in England. In fact, his personal copy of *Principia Mathematica* was one of only three in the colonies. Moreover Greenwood actively engaged his students in cutting-edge research by having them participate with him in using the telescope that Hollis had donated to Harvard to make observations that were subsequently transmitted to the Royal Society through James Jurin. As a result of this joint effort, Greenwood published the paper “An account of an aurora borealis on the 22d of October, 1730” in the Royal Society’s *Philosophical Transactions*.<sup>64</sup> He had published two other papers in the journal before then.<sup>65</sup>

In addition, Greenwood offered to organize private classes outside the College. In 1727 he advertised private instruction on two different but related topics. One was called “The modern discoveries in astronomy and philosophy.” The other was “Sir Isaac Newton’s incomparable method of fluxions, or the differential calculus, together with any of the universal methods of investigation used by the moderns; the *Elements* of Euclid and Appollonius [*sic*].” The latter class is intriguing because it indicates that Greenwood was aware of the Leibniz approach to calculus as well as the fluxions of Newton.

At the start of his Harvard tenure, Greenwood’s appointment was propitious, as he became the first American to write a mathematics textbook, which he titled *Arithmetic, Vulgar and Decimal*. Curiously, this book was published anonymously in 1729. It took a sleuth, the twentieth-century historian of mathematics Lao G. Simons, to identify the author when she found conclusive evidence in an advertisement for the book in a Boston newspaper from 1729.<sup>66</sup> (A brief biography of Simons is given in the online file “Web01-LaoSimons.”) The preface to Greenwood’s book states:<sup>67</sup>

There are many things in the following Treatise of greater Curiosity, than Necessity in the Practice of Numbers. Such are the Methods . . . of contracting Decimal Multiplication and Division, the Rules concerning Circulating Figures, Sir Isaac Newton's Contraction in the Evolution of the Square Root, &c.

Although Greenwood lectured on this material at Harvard, it appears that it was unknown elsewhere; there is no evidence of a reference to it at either of the two other existing colleges or any founded between 1746 and 1776. Indeed, no second edition was ever written, and by 1890 only three copies of it were known to exist.

Although this first mathematics book written by someone born in the US was restricted to arithmetic properties and their applications, Isaac Greenwood lectured on higher topics to his advanced students at Harvard. Two manuscript notebooks from students toward the beginning and end of his tenure as Hollis Professor indicate his breadth of knowledge and show what he had learned from reading the *Treatise on Algebra* by John Wallis (1616–1703), one of the leading English mathematicians before Isaac Newton. This was the first time that topics beyond mere arithmetic were available in the colonies—methods for solving “adlected Quadratic Equations,” “the Method of Converging Series,” and “Dr. Halley's Theorems for Solving Equations of all Sorts.” Along the way he cited works by two English mathematicians (William Oughtred and Joseph Raphson), in addition to Halley, that provide evidence of his wide scholarship.

Notebooks from two illustrious Harvard students show that Greenwood lectured on algebra throughout his tenure at Harvard. One of the manuscripts was written by James Diman, a 1730 Harvard graduate who served as college librarian 1735–1737. The first page of the 129-page notebook contains the inscription “James Diman's Book 1730/31,” indicating that the notes were taken toward the beginning of Greenwood's professorship. The second manuscript was written by Samuel Langdon, a 1740 Harvard graduate who served as president of the college during the revolutionary period 1774–1780. The inscription on the front cover of this 93-page manuscript reads, “Samuel Langdon's Book, July 25, 1739,” indicating that Greenwood lectured on this material right on up to his dismissal. This conclusion is confirmed by the titles of the two notebooks, Diman's reading, “Algebra or Universal Mathematics reviewed 1738 with Notes and Additions,” and Langdon's reading, “Algebra by Isaac Greenwood, MA Began July 25, 1739.” The two manuscripts resemble each other so closely that their contents must have been derived from the same source.

As the titles show, the topics were in algebra, a subject so lacking in the colonies that Greenwood was the only colonist capable of teaching it at that time. Elsewhere, arithmetic was the mainstay up to 1800. What did the term “algebra” mean for Greenwood? Basically, it meant material that is taught in a two-year high-school algebra sequence today. For instance, he introduced the notation for powers of a variable  $x$  as  $x^2$ ,  $x^3$ ,  $x^4$ , signifying the “Square, Cube & Biquadratick of  $x$ : so  $x^{\frac{1}{2}}$ ,  $x^{\frac{1}{3}}$ ,  $x^{\frac{1}{4}}$  will signifie  $y^e$  Square, Cube & Biquadratick Root of  $x$ .” From there Greenwood discussed the meaning of the notation

$$\sqrt[3]{7 + \sqrt{2}},$$

which he expressed as

$$\sqrt{:}^3 \overline{7 + \sqrt{:} 2}.$$



Greenwood also treated higher order equations, providing three distinct methods for solving cubic equations. The third, called the “Method of converging series,” is a version of the Newton–Raphson method of successive approximations. This discussion led naturally into “M<sup>r</sup>. Raphson’s Theorems for Simple Powers,” which was used to calculate  $\sqrt[4]{90}$ . He extended this method to solve equations such as

$$a^4 \pm pa^3 = N$$

and

$$\frac{N - g^4 \mp pg^3}{4g^3 \pm 3pg^2} = x.$$

I state here a passage (in the original old English) that offers the interested reader an opportunity to interpret a result covered in most high schools and which is well known to professional mathematicians. This is the kind of example showing how the history of mathematics can be used in high-school or university courses. The challenge is to understand the original wording in order to determine what rule is being described, and then to express the rule in modern terms.

To find  $y^e$  Coefficients in Binomial Powers. Rule: Multiply  $y^e$  Coefficient into  $y^e$  Index of  $y^e$  Power and Divide that Product by  $y^e$  Number of terms, counting from  $y^e$  left hand, and  $y^e$  Quotient will be  $y^e$  Coefficient or Numerical Figure of  $y^e$  next successive Quantity.

The online file “Web01-Binomial” gives the solution.

Greenwood solved geometric problems by reducing them to linear and quadratic equations. One such quadratic in the 1740 manuscript of Langdon has complex roots, indicating not only Greenwood’s sophistication but also the accomplishments of his very advanced students. As another indication that Greenwood was a product of a time when using algebra to solve geometric problems was in vogue as well as using techniques articulated by René Descartes a century earlier, he presented these algebraic topics amongst methods for solving a series of 24 problems from geometry. Results are taken from Euclid’s *Elements* throughout the solutions of these problems, indicating that Greenwood’s students had already completed a very good course in geometry.

Greenwood’s appointment was propitious initially, both for him and for Harvard. However, it was known that he had fled London and was on the lam from debts incurred from trusting, influential, supportive figures. But it appears that money matters were only the tip of the iceberg. Lurking below was an expansive problem that floated financial affairs above the seemingly calm waters on all sides of Isaac Greenwood. He had a very serious drinking problem, one that, curiously, does not seem to have morphed into a thinking problem for almost a decade. After all, the manuscripts and public lectures cited above attest to his command of advanced topics and recent developments over his first ten years at Harvard.

But ultimately the “demon rum,” as the Puritans called it (a term later adopted by twentieth-century prohibitionists), caused a precipitous fall from Greenwood’s perch as the top mathematician in America to a sorry, solitary figure. In April 1737, almost ten years after his appointment, Greenwood was called before the board and admonished for dereliction of duties and repeated confrontations with the few other professors at the time. The board reported “he confessed the Charge of intemperance . . . and cast himself on the Lenity of the Overseers & professed his resolution of reformation.”<sup>68</sup>

Like a duck on a lake, Greenwood appeared calm on the surface while paddling furiously below. In his case the paddling amounted to irresponsible behavior in regards to his professional and familial obligations—he had a wife and five children.

By that November the governing corporation had had enough. Greenwood was accused of disregarding repeated warnings, ordered to exhibit “an humble confession” in the public hall, and warned that if he did not remain sober he would be removed from office within five months. How did he react? He got drunk again. To add insult to injury, when summoned before the board, he refused to appear. Yet the overseers continued to coddle their prize professor in spite of a vote on December 7, 1737, to remove him from office. The board then accepted his humble confession and vow to reform. This time, however, a set of members was charged with overseeing the astronomy apparatus on a daily basis and charged with locking the door to the building if he appeared in a drunken state.

Greenwood was able to win his battle against the demon rum for the next four months, for which he was rewarded with a pay raise and renewed control of the Hollis telescope. He promptly celebrated with a bout of uncontrollable intemperance. When dragged before the corporation once again, he was too sick and befuddled to even offer yet another humble confession. This was the final straw. Isaac Greenwood was removed as Hollis Professor in July 1738. He was replaced by John Winthrop, who had benefited enormously from Greenwood as a mentor in the classroom and astronomical observatory. Winthrop, in fact, had carried out observations under Greenwood’s guidance. Winthrop would prove to be a sober successor—in both senses of the word.

What happened to Greenwood after his firing?

In the fall of 1738 he established a school of experimental philosophy to teach from Newton’s *Principia Mathematica*, modeled along the lines of the one he had witnessed under Desaguliers in London. This position seemed to agree with Greenwood, who exhibited the elusive talent of reaching students of heterogeneous ability. The *Boston Gazette* reported, “He had a happy Talent ... of representing the most obscure and difficult Things in such a plain and easy Light, as it could not fail to satisfy the most ignorant, at the same Time that it would please the most learned.”<sup>69</sup> Yet the school faltered within two years. Like Benjamin Franklin before him, Greenwood set out from Boston to seek greater opportunity in Philadelphia. Once again he advertised a course of lectures on scientific experimentation. Franklin himself arranged for Greenwood to use astronomical equipment owned by the nascent American Philosophical Society. But the duck’s frantic paddling beneath the surface was unable to keep him afloat even amongst an emerging community of scientists in the largest colonial city.

Greenwood returned to Boston by July 1742, when he accepted a position as instructor aboard a Royal Navy man-of-war that sailed to England. His whereabouts for the next three years remain unknown, but after a cruise on a similar ship, he landed in South Carolina, where he died a pitiful, solitary man in October 1745. No autopsy report is available but if it were, it would probably list his death due to cirrhosis of the liver.

Isaac Greenwood was surely America’s first mathematician. He was the most learned person in mathematics in the colonies up to 1738, standing head and shoulders above his contemporaries until being surpassed by his very best student, John Winthrop. His public lectures on the work of Isaac Newton were very popular, yet he never became a productive scientist because he was dogged by alcohol. In spite of

the demon rum, or perhaps because of it, Greenwood exerted a profound influence on some of his students. Overall, although he was not the first mathematics professor in the US, he was the country's first important one and the most accomplished up to that time.

When were mathematics books first written in the New World? Greenwood's *Arithmetic, Vulgar and Decimal* was the first book on mathematics penned by an American, but it was not the first in North America. That honor goes to Brother Juan Diez, who arrived in Mexico with the conquistador Hernando Cortés in 1519 and wrote *Sumario Compendioso (Comprehensive Summary)*, the first nonreligious book (and the twenty-fifth overall) to be published in the New World.<sup>70</sup> Its publication date of 1556 is remarkable because it precedes the settlements at Jamestown (1607), Quebec (1608), and Plymouth (1620) by over 50 years. Greenwood's 1729 book was not the first in English either, as several appeared in the first quarter of the eighteenth century before his *Arithmetic*.

Advertisements posted in various cities in the eighteenth century indicate that qualified individuals (and perhaps some charlatans) offered private instruction in mathematics. The earliest extant example is a 1709 advertisement by Owen Harris in Boston offering instruction in surveying, dialing (related to sun dials), navigation, and astronomy. As noted above, an advertisement from 1729 showed Isaac Greenwood's desire to teach calculus via Newton's fluxions. In 1743 Nathan Prince, who had been a tutor at Harvard, advertised the opening of a school offering instruction in the application of mathematics to areas typical for that time, like surveying and navigation, and emerging areas, like gunnery.<sup>71</sup>

## Sober successor

The Royal College of William and Mary hired Hugh Jones to succeed Tanaquil Lefevre, and Jones proved to be a counterweight to his predecessor's reprehensible behavior. Harvard did the same after firing Isaac Greenwood for shameful conduct. Whereas it took William and Mary five years to find a suitable replacement, Harvard acted with dispatch. And with prudence.

The natural person for Harvard College to consider was the tutor for mathematics and natural philosophy, **Nathan Prince** (1698–1748), who had held the position since 1723. However, his life bore too many resemblances to Greenwood to make him an appropriate candidate. Like Greenwood, Prince was born in the Massachusetts Bay Colony and educated at Harvard, receiving his BA in 1718. This means his time there overlapped with Greenwood, though I do not know if they knew each other. Both had an older brother who had graduated from the College. Upon graduation Prince taught school for two years, returned to Harvard, received an MA degree in 1721, and preached a year in Rhode Island and Nantucket before returning to Harvard once again. In April 1723 Harvard's president John Leverett appointed him tutor to succeed Thomas Robie.

Even though Prince published only one scientific article (in astronomy), he was known as a remarkable scholar. However, he was also widely known to be hot tempered and unreliable, two traits that might explain why the Harvard Corporation bypassed him as a candidate for the Hollis Professorship in 1738. Obviously, he was disappointed when not offered the post, and the rest of his years at Harvard were marked by myriad complaints from faculty and students as well as accusations of intoxication.

Finally, in February 1742 the Board of Overseers dismissed him after bringing him up on multiple charges:

- (1) intemperance;
- (2) disturbing the peace;
- (3) contemptuous speech toward the president and fellows;
- (4) ridiculing his peers;
- (5) stirring up strife;
- (6) numerous other misdeeds.

The historian of mathematics Florian Cajori described Prince's personal habits as "notoriously irregular."<sup>72</sup> In light of the problems Harvard had with Greenwood, it is not surprising that the College looked elsewhere for a replacement.

Prince seemed to follow Greenwood's example after his removal. First he set up a school in Boston that was equally unsuccessful. Next he taught school in the Colony of Connecticut for several years before accepting a position as schoolmaster on a man-of-war bound for Lisbon. While there in the summer of 1746, he learned that the Society for the Propagation of the Gospel wanted him to be a missionary to Native Americans on the Island of Roatán near Honduras. Prince accepted, and sailed there to assume his duties in June 1748. However, he died just one month later.

What is it with these colonial mathematicians? Lefevre womanized, Greenwood boozed, and Prince was personally disagreeable. What kind of examples did they set? Fortunately, the next mathematics professor served as a much better role model.

**John Winthrop IV.** Today, **John Winthrop IV** (1714–1779) is known primarily as an astronomer, mainly for discovering a moon of Jupiter. Here I provide a brief account of his career. (The online file "Web01-Winthrop" adds further details.) He was one of the few American scientists from the Colonial Era to make contributions to astronomy using precise spherical trigonometry. A child prodigy who entered Harvard in 1728 at age 13 (just when Greenwood began lecturing at the College), Winthrop received his AB four years later, finishing as class valedictorian. He returned to Cambridge in the fall to continue his studies, which culminated with a master's degree in 1735 based on his disputation that it is not permissible for magistrates to impose hardships on anyone who maintained his own religious views. This was the first public sign of a protest against then-prevailing Puritanical beliefs.

Three years later, in 1738, Harvard sought a notable scientist to succeed Isaac Greenwood as "Hollisian Professor of the Mathematicks and of natural and Experimental Philosophy." The Corporation rejected longtime tutor Nathan Prince because his vices extended even beyond Greenwood's faults. Instead, that August the Corporation elected the 23-year-old John Winthrop, although he still had to pass muster before two committees. Only one person publicly opposed Winthrop's election—the disappointed Nathan Prince. Unlike Greenwood, he held the position a long time, 41 years altogether.

In fact, John Winthrop took the responsibilities of this chair very seriously. In addition to teaching such topics as plane and spherical trigonometry, mensuration of solids, and conic sections, he set about mastering Newton's *Principia Mathematica*, thereby becoming one of the very few Americans able to understand calculus. Harvard records indicate that he lectured on the method of fluxions as early as 1756, thus adopting the terminology of Newton instead of Leibniz. In a document from 1764 Winthrop defined

the mathematical areas that the Hollis Professor should teach: geometry, algebra, conic sections, and plane and spherical trigonometry. Although calculus is not included in this list, his inventory contained areas of remarkable scope, including hydrostatics, mechanics, statics, optics, astronomy, geography, navigation, and surveying.

The main mission of a Harvard professor at the time was teaching, so Winthrop had to carve out time for his scientific endeavors from these duties as well as personal responsibilities. In 1746 he married Elizabeth Townsend, a member of the Chauncy family. This couple thus represented a generation of colonists that was inching farther and farther away from Great Britain.

Winthrop also mentored students in the laboratory located on the second floor of Old Harvard, where he “established for the first time America’s independence in scientific development, and also gave to Harvard College her early prominence in scientific investigations.”<sup>73</sup> The modern laboratory, as we know it today, did not exist then, so students were reduced to observing experiments without actively engaging in them. Equipment was just not generally available, even to the professor of natural philosophy. Yet in 1746 Winthrop gave the first practical demonstration of electricity and magnetism in America, using instruments that were obtained for him from London by none other than Benjamin Franklin. This emerging breed of American scientist felt no need to travel abroad for education or for research.

Socially, Winthrop was a product of his era in another way. Although a slave owner, he was aghast at the spectacle of a slave woman burning at the stake for murdering her master. A historian from 50 years ago reported, “When his own slave boy, George, died of the measles, he was mourned as one of the family, not as an unfortunate investment. His successor, Scipio, was watched over like the white children of the family.”<sup>74</sup>

Winthrop’s wife died suddenly in 1753. To overcome loneliness, he began to visit other colonial scientists with whom he had only corresponded with beforehand. One year later, for instance, he traveled to Yale to meet William Johnson, to Princeton to visit President Burr, and to Philadelphia to meet with Benjamin Franklin and his compatriots in the American Philosophical Society.

Back in Cambridge, in 1756, Winthrop married the widow Hannah Fayerweather Tolman, who was “a geyser of patriotism,”<sup>75</sup> even though her new husband initially supported strong ties to Great Britain. Winthrop opposed a movement to form an American “philosophic society” beyond the one foundering in Philadelphia because “our Country has hardly arrived yet to a state of maturity”<sup>76</sup> like the Royal Society in London. However, during the war scare of 1759, he agreed to the Massachusetts Bay Colony governor’s request to update the Admiralty chart of Boston harbor that had been made in 1705. Winthrop also became indignant at the subsequent Stamp Act and Massacre, which compelled him to add his name to the list of candidates for Province Council in 1773. His reply to Benjamin Franklin’s congratulatory letter, upon his successful election, evinced an ability in matters political as well as scientific: “If the Ministry are determin’d to inforce these Measures, I dread the Consequences: I verily fear they will turn America into a field of blood.”<sup>77</sup> By this time John Winthrop’s patriotism matched his wife Hannah’s, and his bold public pronouncements on redressing perceived injustices made him a popular figure. In April 1776 Winthrop wrote to John Adams in Philadelphia, where utterances of independence still remained whispered, “Our people are impatiently waiting for the Congress to declare off from Great Britain.

If they should not do it pretty soon, I am not sure but this colony will do it for themselves. Pray, how would such a step be relished by the Congress.”<sup>78</sup> Congress declared Independence three months later.

By late 1778 John Winthrop’s physical condition worsened and he died the next May, deprived of seeing the colonies’ ultimate victory and participating in the critical Constitutional Convention. Forty years earlier, just a year after assuming the Hollis Professorship, he had observed sun spots that led to his first known scientific investigation. The notes he recorded on that occasion were transcribed by the prominent Harvard librarian Frederick G. Kilgour.<sup>79</sup> Winthrop began (the italics are due to Winthrop):<sup>80</sup>

1739 April 19th at Boston. Walking on the Common a little before sunset, the air being so hazy that I was able to look on the sun, I plainly saw *with my naked eye* a very large and remarkable spot. Its shape was oblong and the length of it was perpendicular to the horizon. I observed it several minutes till the sun was actually set. . . . The next day, Friday, coming back to Cambridge, I looked at the sun with an 8 foot telescope from 6 A.M. till sunset and discovered not only the same spot which I saw before but several others in his disk.

Winthrop’s notes afford the modern reader an appreciation of how long such observations took. From our vantage point, the observations themselves are not the essence—rather it is the drawing of a conclusion from the evidence and then the establishment of a proof for its theoretical underpinning.

John Winthrop began his astronomy investigations in 1739 with a telescope that Thomas Hollis himself had obtained from the famous astronomer Edmund Halley. That instrument enabled Winthrop to observe a solar eclipse and to become the first American to view the transit of Mercury. His findings were published in the *Philosophical Transactions* of the Royal Society. Because this scientific periodical became such an important outlet for Winthrop’s research, it is discussed before his published scientific work is described.

**Royal Society of London.** During the 1640s, a group of English scientists, then called natural philosophers, began meeting to discuss the idea of promoting knowledge of the natural world through observation and experiment. A dozen of them, who had assembled in 1660 to hear a lecture by mathematician Christopher Wren, decided to formalize their association by constituting what they called a “Colledge for the Promoting of Physico-Mathematicall Experimentall Learning.” (Recall that the first building at William and Mary College was named in honor of Wren.) The group agreed to meet weekly to observe experiments and discuss advances in the field. Three years later the Royal Charter of King Charles II established this group as “The Royal Society of London for Improving Natural Knowledge.” The last four words in the title were ultimately dropped.

The Royal Society became the leading scientific organization in the British Empire during the eighteenth century. The original 12 organizers became charter members. John Winthrop’s namesake and great-granduncle was one of the original members, who were called Fellows. From that time onward, Fellows had to be elected, the third of whom was John Winthrop. Initially, criteria for membership were not well defined,

but in 1731 a rule established that each candidate had to be proposed in writing and the certificate signed by those who supported election.

By 1665, Royal Society members felt the need for an outlet to publish their findings, resulting in the first issue of the *Philosophical Transactions*. This leading scientific journal celebrated its 350th anniversary in 2015, making it the oldest scientific periodical in the world still in continuous publication. One of the early articles in the journal, published in 1670 by John Winthrop, the “Governour of Connecticut in New England,” described some features of trees in the New World, “matrices” (a kind of shellfish the Native Americans used for bartering), and some “very strange and very curiously contrived fish” existing in that area.<sup>81</sup> This article was typical of most colonial contributions to the *Philosophical Transactions* in that it described natural phenomena or living creatures in New England and Nova Scotia. Nonetheless, some articles were published by a few of these early Americans containing theoretical material, namely Thomas Brattle (two articles), Thomas Robie (two), and Isaac Greenwood (three).

Initially, scientists who did not live in London could get an article published by mailing it to any member of the Royal Society, who decided whether to read the submission at a weekly meeting. The Secretary of the Society then alone determined which readings qualified for publication in the *Philosophical Transactions*. Volumes of the journal appeared about once every two years. In 1750, however, the Royal Society reorganized its publication procedure by adding other competent peers to work with the Secretary in deciding which submissions to accept for publication, thus establishing the idea of what has become the norm today of (sometimes blind) refereeing.

A paper from 30 years ago from the *Notes and Records of the Royal Society of London* analyzed the 23 colonial authors of papers deemed worthy of publication in the *Philosophical Transactions* during 1753–1775 and provided brief snippets of their careers.<sup>82</sup> The work of four of these scientists in this chapter is mentioned—Cadwallader Colden, Benjamin Franklin, David Rittenhouse, and John Winthrop. Colden and Rittenhouse published one paper each (altogether, 14 of the 23 colonial authors produced one article) while Winthrop led the way with twelve and Franklin followed with nine. We turn now to the leading American scientist before the Revolutionary War.

**Winthrop’s publications.** One biographer wrote, “Winthrop is undoubtedly the most important American pioneer in mathematics and astronomy.”<sup>83</sup> Yet only one of Winthrop’s published articles evinced mathematics explicitly. As a result, I tend to agree with the Harvard mathematician and historian Julian Coolidge, who wrote, “I can not find that [Winthrop’s] interest in pure mathematics was outstanding.”<sup>84</sup> Nevertheless, Winthrop used mathematics in novel ways in other articles to carry out calculations allowing him to aim his telescope at the proper position in the sky.

To illustrate this hidden use of mathematics, I examine his first article on the transit of Mercury and eclipse of the moon he observed in 1740. The results of these first authentic astronomy observations in America were included in a letter he sent to the Royal Society on December 30, 1740. The letter was read in November 1743, almost three years later, by secretary C. Mortimer and published in the 1742–1743 issue of the *Philosophical Transactions*. Knowing he was a 26-year-old unknown, Winthrop opened in a very modest way that tied him to two predecessors known to Royal Society Fellows:<sup>85</sup>

Though I have not the honor to be known to you, I flatter myself you will excuse the freedom of this letter, since the design of it is to lay before you an observation which, I hope, may be of some use in astronomy. In confidence of this, I take the liberty to inform you, that, on the 21st of April 1740, I had an opportunity to observe Mercury ... transiting the sun's disk. Being advertised by the calculations of that excellent astronomer, Dr. Halley, that the former part of this transit would be visible in our horizon, I was resolved to observe it in the best manner I could, with those few instruments I was furnished with; which were only those I had received from my predecessor Mr. Isaac Greenwood, and are the same that are mentioned by the late Mr. Thomas Robie in *Philosophical Transactions* N<sup>o</sup> 382.

Winthrop revealed his novel approach to the transit of Mercury by writing, "I chose rather to deduce Mercury's right ascensions and declinations by calculation from hence, than to observe them immediately in the common way of placing one of the cross hairs parallel to the equator."<sup>86</sup> He listed the results in tabular form:<sup>87</sup>

	h.	'.	".
The sun at the horizontal	5.	37.	59.
The sun at the vertical		39.	1.
Mercury at the vertical		39.	16.
Mercury at the horizontal		40.	1.

This table demonstrates the precision—accurate to the second—with which Winthrop's calculations allowed him to compute in an era that was without clocks or chronographs. Although Winthrop's computations differ very little from what is known today, the transit of Mercury was not of great astronomical importance overall, yet by ascertaining the planet's position, knowledge of its orbit was considerably improved.

An eclipse of the moon holds even less importance, so Winthrop devoted little attention to it in his first published article. In the concluding few paragraphs he wrote, "I was in hopes to have made a good observation of the lunar eclipse, which happened last week. But the Sky ... became overcast, which hindered me from making above One or Two Observations that I could depend upon."<sup>88</sup> He concluded the article by presenting his observations again in tabular form.

Transits of Mercury continued to fascinate Winthrop over the course of his career, as attested by two short notes he published in the *Philosophical Transactions* regarding transits from 1743, the year his first article appeared in that journal, and 1769, by which time he was recognized as a leading scientist and had been elected a Fellow of the Royal Society. For unknown reasons he demurred 20 years from the time of the October 1743 transit to the time when he reported on it in June 1763 by a letter to Nathaniel Bliss, the Astronomer Royal of the United Kingdom. The objective of the note was to establish that Winthrop's observations "determine the longitude of Cambridge, New England, with more exactness than any of the observations that have been used for that purpose."<sup>89</sup> Perhaps the reason for publishing his observations at this later time was that Winthrop found himself among leading European scholars. He wrote, "The comparison of this observation with those made in Europe will, I presume, determine the difference of meridians within a few seconds of time."<sup>90</sup>



Winthrop's observations of the 1769 transit of Mercury were limited by the fact that sunset occurred before the planet had crossed over the sun. Nonetheless, he reported on his calculations from Mercury's entry across the sun in a letter sent that December to Benjamin Franklin in London. Results traveled slowly 250 years ago—Franklin forwarded the letter the following February, it was read at the Royal Society meeting in January 1771, and finally published in the *Philosophical Transactions* later that year. Winthrop stated that the reason for publishing the note was because, "This transit completes three periods of 46 years, since the first observation of [Peter] Gaffendi at Paris, in 1631."<sup>91</sup>

Back in 1742, shortly after Winthrop's first observations of Mercury, he became involved in an application of mathematics that is still current today—weather forecasts. Boston was then a small city of about 25,000 inhabitants surrounded by a fairly prosperous farming community, yet there was no need for systematic weather prognostication. Nonetheless, that year Winthrop began keeping daily records of weather observations. However, lack of proper instruments prevented accurate measurements of even such seemingly innocuous facts as maximal and minimal temperatures during a day. Thus, his daily meteorological observations were generally inaccurate up to 1759, when he obtained a Fahrenheit thermometer. He continued recording temperatures for the next several years but did not posit a theory for predicting weather.

In 1755 a different act of Mother Nature compelled Winthrop to study seismology, an area where he did reach a conclusion. His observations and analysis of an earthquake were published in the very first article in the volume of the *Philosophical Transactions* that appeared in 1758. The opening paragraph in the letter submitted to Royal Society secretary Thomas Birch set the stage for what was to follow:<sup>92</sup>

I beg leave to lay before you the best account I am able to give of the great earthquake, which shook New England, and the neighboring parts of America, on Tuesday the eighteenth day of November 1755, about a quarter after four in the morning. I deferred writing till this time, in order to obtain the most distinct information of the several particulars relating to it, both here and in the other places where it was felt; especially the extent of it.

After describing his own observations of the movement of a pendulum caused by the rather severe earthquake, Winthrop questioned neighbors for corroboration of the effects of a series of four separate shocks. His introductory statement shows that he sought information from people as far away as New York, Philadelphia, and the Chesapeake Bay in one direction, Halifax, Nova Scotia, in another, the British Fort of Oswego and Lake George, New York, in a third, and even St. Martin's in what was then known as the West Indies.

Winthrop did not advance his theory in this publication; rather he announced it in two public lectures delivered at Harvard. A later analysis concluded, "that the disturbances of the earth-crust were in the form of waves, and transmitted a pendulum-like motion to buildings and objects on the surface." He was the first to apply computation to the phenomena, consequently discovering the analogy between seismic motion and musical vibrations; he also discovered the principle that "the quicker the motion the shorter the wave length of the disturbance."<sup>93</sup>

Winthrop's public pronouncements served another purpose as well. His theological views were consonant with the times, so he made sure to emphasize that his findings were aimed at describing the acts of God. In this way he hoped to combat the idea that earthquakes were a direct expression of the wrath of God. Overall, Winthrop's study of the earthquake thrust him into becoming America's first seismologist.

A particularly notable worldwide scientific event took place in 1761 with the transit of Venus, the first time such a passage had been observed since 1639. Winthrop sensed the value of this episode beforehand and diligently prepared for what would become America's first astronomy expedition. By a special act of the Massachusetts Bay Colony, he arranged for the use of a sloop to transport him, two of his students as assistants, and instruments loaned from Harvard to St. John's, Newfoundland, where conditions for observing the passage of the planet across the sun were maximal. Winthrop and his assistants recorded various aspects of the transit methodically, providing him with invaluable data for analysis once he returned to Cambridge. Gathering all available evidence, he calculated the sun's parallax at its mean distance from the Earth to be  $8''$ .<sup>68</sup> The computation of a parallax in general involves the principle of triangulation for long, narrow triangles, which was considered advanced mathematics at the time. Today, use of spacecraft telemetry puts the accepted value of solar parallax at  $8''.794$  143.

Once again Winthrop presented his observations in tabular form in the *Philosophical Transactions*.<sup>94</sup> He ended the article with a statement that he was hoping to find more celestial bodies during his time in Newfoundland: "I viewed the Sun with great attention . . . in hopes to find a satellite of Venus; but in vain. There were several spots then on the Sun; but none that I saw could be a satellite."<sup>95</sup>

The next transit of Venus occurred eight years later, in 1769. (Occurring in pairs, the ensuing two, with Simon Newcomb the main American observer, took place in 1874 and 1882. The next pair occurred in our time—2004 and 2012.) The British Astronomer Royal, Nevil Maskelyne, urged Winthrop to lead an expedition to the Lake Superior region, which afforded views of the beginning and end of the transit, but ill health forced him to carry out his observations at Cambridge, where only the planet's entry was visible. His findings were published as part of a large report on worldwide observations in the initial volume of the *Transactions of the American Physical Society*.<sup>96</sup> Again Winthrop made a detailed study of his observations but was unable to improve upon his earlier computation of the sun's parallax. An analysis of his conclusions of these transits based on public lectures he delivered was published a century ago.<sup>97</sup>

The results of Winthrop's study of comets bears special mention because of its mathematical structure. Inspired by the first predicted return of Halley's Comet from 1682, he delivered two public lectures on the nature of comets in general that found light of day in a *Philosophical Transactions* paper from 1767. Curiously, this long article was communicated to the Royal Society and was written in Latin.<sup>98</sup> He posed five problems whose solutions were presented in terms of lemmas, corollaries, scholia, and mathematical demonstrations. Overall, Winthrop determined the limits of attraction between a comet and the sun, as well as the laws of motion and direction governing the vapor trail following the head of a comet. In this paper he also explained the curved appearance of the tail of a comet.

The Royal Society was so impressed with Winthrop's work that it elected him a Fellow in 1765, one year after his article on the 1761 transit of Venus appeared. He

garnered other honors as well. In 1768 he was awarded the honorary degree of LLD (Doctor of Laws) by the University of Edinburgh, thus becoming the first American to be awarded that degree; Harvard also bestowed it upon him five years later.

Overall, it is difficult to classify Winthrop as a mathematician because, although versed in the subject, it was never his major focus. His reputation as the leading colonial astronomer of the time, on the other hand, is well deserved, with many of his contributions partly due to his skills in mathematics. Like Isaac Greenwood and Nathan Prince before him, he was born and educated in the colonies, reflecting a difference between the settlements in New England and Virginia, where the two initial professors at William and Mary were both born and educated in England.

John Winthrop IV died in 1779 at age 64. The Hollis Professorship had gotten off to a promising start with Isaac Greenwood—in mathematics, if not in citizenship—and had attained even greater heights with John Winthrop, but went into decline with the subsequent appointments of Samuel Williams and Samuel Webber.<sup>99</sup>

## Yale

Let us turn our attention now from Harvard to Yale. Like William and Mary, Yale traces its roots back to the 1640s, when colonial clergymen led an effort to establish a college in the New Haven Colony, which had been established in 1638. However, this vision remained unfulfilled until 1701, when the Collegiate School was founded in nearby Killingworth. The third college in the colonies maintained a nomadic existence during its first 15 years at several locations in the cultural wilderness of colonial Connecticut before finally settling in New Haven in 1716, when that town outbid all other communities in both land and money to support the college.

Although mathematics and natural philosophy were included in the curriculum from the beginning, the conservative-minded trustees adhered to the medieval tradition of emphasizing moral philosophy, divinity, and classical languages, particularly Latin. As a result, surveying was taught but without the rudiments of geometry and trigonometry, a practice that reflects the colonies' practical tendencies at the time. Yet some scientifically interested students benefited from their training anyway, especially after a collection of books was donated to Yale in 1715 to form the first holdings of a library.

The person responsible for securing the books was **Jeremiah Dummer** (1681–1739). Dummer was born in Boston; his father was an accomplished portrait artist, silversmith, and engraver. Jeremiah Dummer graduated from Harvard in 1699 and remained there for two more years before sailing to Holland to pursue further studies in theology. First he enrolled at the University of Leiden, earning a degree in 1703. Just ten days later he was examined in Universal Philosophy at the University of Utrecht, where he defended two theses and performed well in two disputations. As a result, Dummer was awarded a doctorate, which was then the highest degree available, so when he sailed back to the colonies, he became “the first Harvard man to return from the Continent with a PhD.”<sup>100</sup>

Lacking a community of scholars with similar interests, Dummer sailed to London in 1708. He remained in England for the rest of his life, engaging in controversial politics in his adopted land while concurrently serving as the agent for the colonies of Massachusetts and Connecticut. His biographer, Harvard librarian John Langdon

Sibley, wrote, “Dummer was the greatest colonial agent before Franklin.”<sup>101</sup> In 1715 Dummer wrote an essay titled “The defense of the New England charters” that was published as a pamphlet six years later and became instrumental in defeating a proposal to abolish those charters.

For our purposes, Jeremiah Dummer’s most important contribution to American mathematics was the collection of some 700–800 books he arranged to be donated to Yale. It is unclear why Dummer acted on behalf of Yale instead of his *alma mater*, Harvard, but he was unrelenting in his zeal to obtain donations for a library. He had appealed to the leading citizens in Old England, and his biggest conquest was undoubtedly **Elihu Yale** (1649–1721), the governor of the British East India Company, who never set foot in the New World yet was convinced to make a gift of nine bales of goods that included 417 books and a portrait and arms of King George I. This generosity induced the Collegiate School’s trustees to rename it Yale College in 1718. Dummer also induced important works from two notable scientific figures. He wrote, “Sir Isaac Newton gives the second edition of his *Principia* (which appeared in 1713) . . . Doctor Halley sends his edition of *Apollonius*.”<sup>102</sup>

One Yale student who benefited from this largess at once was **Samuel Johnson** (1696–1772). Born in Guilford, CT, to parents who traced their American lineage back to 1637, Johnson attended Yale 1712–1716. Upon graduation, he moved with the college to the new location in New Haven, where he was appointed tutor for three years. Thus the Collegiate School underwent a name change while Johnson was a student there. During those three years Johnson initiated curricular changes that marked the first important advances in mathematics and science offerings at his *alma mater*. To prepare himself for the upper-level material he sought to teach, he underwent an intensive self-study of “Euclid, Algebra and Conic Sections”<sup>103</sup> during his first year in this position.

When Samuel Johnson was two years into his tutorship (in 1718), he was able to make extensive use of the library of books donated by Elihu Yale. However, in 1720 Johnson left Yale to become a minister at the Congregational Church in West Haven, and two years after that, influenced by extensive readings of Locke and Newton available in the library, he along with six other Yale graduates publicly expressed doubts about the legitimacy of Congregational ordination. Therefore, they sailed to England to be ordained by a Bishop of the Church of England. When they returned to Connecticut the next year, they established the colony’s first Anglican Church in Stratford. Over the next three decades Johnson became identified as a vigorous advocate for Anglican causes.

## Columbia

We digress here briefly to link Samuel Johnson with another new college established in the colonies. Several American colleges were founded during the late 1740s, including Princeton and the University of Pennsylvania. A third was Columbia University. Then called King’s College, it was envisioned initially as an “Episcopal Colledge” in New York City. Samuel Johnson was elected the first president in November 1753, and classes opened the next July in an unused room in a schoolhouse adjacent to Trinity Church.

At first Johnson was the only faculty member for the eight students. During part of his eight-year tenure, he shared teaching responsibilities with a tutor, his younger son, William Samuel Johnson, in 1755 and then with Leonard Cutting (1756–1762) and Columbia's first professor, **Daniel Treadwell** (1757–1760). The death of Johnson's wife in 1759, the death of Treadwell the next year, plus ongoing political and denominational haggling within Columbia, impelled Johnson to leave his post in 1762. He was replaced by the 26-year-old, Oxford-trained Anglican minister **Myles Cooper** (1737–1781). Johnson's older son, the attorney Samuel William Johnson, became its third president in 1787, holding the post until 1800. Our Samuel Johnson did not live to see this succession, having died in 1772.

**Thomas Clap.** The courses Samuel Johnson instituted at Yale were continued by the tutors Daniel Brown and Jonathan Edwards up to 1728. However, Elisha Williams, the college's rector (1726–1739), held little interest in mathematics and science (called natural philosophy), so those subjects were marginalized and taught in a desultory manner.

That situation was reversed dramatically within three years of the appointment of a new rector, **Thomas Stephen Clap** (1703–1767), whose 26-year presidency (1740–1766) has been called “the golden age of mathematics and science in Yale's colonial history.”<sup>104</sup> Thomas Clap was born and educated in Scituate, MA. His father was a descendant of a family that had immigrated to New England in 1630 and settled in Scituate ten years later. Clap graduated in 1722 from Harvard. His tutor there was **Thomas Robie** (1689–1729). Described by one exuberant biographer as “the most famous New Englander in science in his day,”<sup>105</sup> Robie was a mentor of Clap's contemporary Isaac Greenwood. (As noted earlier, details about Robie are available online at “Web01-Robie.”) Robie immersed Clap in a doctrine of natural philosophy that presented the natural causation of Isaac Newton as mutually compatible with the natural causation of Puritan beliefs. One of Clap's essays contained a tribute to Newton that expressed his own views on the role of science and mathematics *vis-à-vis* religion:<sup>106</sup>

There are many important Truths in natural Philosophy and Mathematics, which, when they come to be fairly proposed, were never doubted of; such as the general Laws of Attraction, the Weight of the Atmosphere, Rules of Fluxions, etc.

Clap carried on a vigorous correspondence with Benjamin Franklin and Cadwalader Colden on the matters described in this quotation.

Thomas Clap made significant changes in the curriculum shortly after assuming the Yale presidency in 1740. He adhered to a philosophy in which “Languages and Mathematics (which are themselves indeed a kind of Language) for these are both of them a necessary Furniture in order to the attainment of any considerable Perfection in the other parts of the Learning.”<sup>107</sup> In 1742 Clap instituted a new curriculum described as follows: “In the first year to study principally the tongues, arithmetic, and algebra; the second, logic, rhetoric, and geometry; the third, mathematics, and natural philosophy; and the fourth, ethics and divinity.”<sup>108</sup> It is noteworthy that mathematics preceded natural philosophy, the reverse of the Harvard curriculum in which Clap had been educated.

In 1745, to ensure that entering students would be able to handle the new curriculum, Yale instituted a policy that would eventually revolutionize admission policies at

institutions of higher learning throughout the country by establishing a mathematical requirement of proficiency in arithmetic. Beyond that, mathematics continued to play a prominent role under President Clap, whose second curricular change, instituted in 1766, his last year in office, offered a course “Mathematics” for freshmen, algebra and trigonometry for sophomores, and “most branches of the mathematics”<sup>109</sup> for juniors. In this curriculum, applications in the senior year included surveying and navigation, the latter based on conic sections and fluxions. This was the earliest mention of conic sections and calculus as part of college courses in the country. The emphasis on navigation reflects the rising importance of the East India Company and its role in England’s colonial expansion throughout the world. Beginning in 1770, Yale also established a second professorship, in mathematics, its first since the one in sacred theology had been established 25 years earlier. This one, like those at some other colleges of the time, was combined with philosophy and natural philosophy.

However, by the end of his Yale days, Clap was not so revered by students. He resigned the presidency in 1766 due to a rebellious bunch that almost reduced the college’s buildings to rubble because of his imposition of old-style religious values on this younger generation. This is especially surprising in light of his earlier effort to teach Newtonianism within the confines of Puritan beliefs.

Competition between Harvard and Yale heated up over the first half of the eighteenth century—and has continued unabated ever since. In general, the advantage went to Harvard, which gained a slight edge with its curricular offerings. For instance, higher plane curves entered Harvard under Isaac Greenwood in 1735 but not at Yale until four years later, while fluxions were offered at Harvard in 1751 under John Winthrop but not for another seven years at Yale.

In this regard, bachelors’ theses provide evidence of these subjects being known before they resided officially in courses. At that time a thesis was a statement the degree candidate was prepared to defend or a question he could answer. (I purposely use the male form here because female students were not accepted at Yale until 1969 and Harvard in 1977.) Undergraduate theses first appeared in Harvard’s commencement programs in 1653 but none was in mathematics for another 40 years, yet that one only reflects the low state of affairs at the time because the student answered “Yes” to the question, “Is the quadrature of a circle possible?” (Perhaps the student did not restrict constructions to straightedge and compass.) However, beginning with a 1711 statement on conic sections, three theses from the period 1711–1721 suggest that some students were exposed to algebra, conics, and calculus. In 1719 one Harvard thesis read, “A fluxion is the velocity of an increasing or decreasing flowing quantity,” while another from 1721 stated, “Algebra is the art of reasoning with unknown quantities in order to define their relation to known quantities.” Moreover, reflecting the influence of Samuel Johnson, a Yale thesis from 1720 deals with a topic related to Fermat’s last theorem, showing that there are no nontrivial solutions to the equation  $x^4 + y^4 = z^2$ . Theses during Clap’s presidency ran the gamut of mathematics from simple algebra to complex integral calculus, the latter appearing as fluxions for the first time in 1758.

Samuel Johnson had stayed at Yale as a tutor for three years after graduation. Such positions were generally held by recent graduates of the college who served terms of two or three years before moving on to other professions; tutoring was conceived as an interim career. During his long tenure as Yale president, Thomas Clap appointed 28 tutors, and many of them exhibited proficiency in mathematics and natural philosophy;

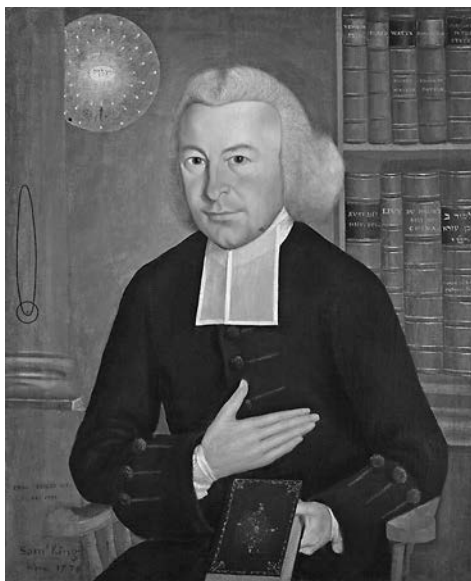


Figure 1.3. Ezra Stiles

he was acutely aware that students required such specialized instruction in technical areas. These tutors underwent a special, more intensive course of preparation, including two such notable mathematical figures introduced here briefly because of subsequent accomplishments in the young country. The online file “Web01-YaleTutors” adds more information.

**Ezra Stiles** (1727–1795) was born in North Haven, CT, into a family that had emigrated from England in 1635. Ezra’s father was a 1722 graduate of Yale who was then ordained a pastor in North Haven, then part of New Haven. Ezra Stiles studied theology at Yale and received his bachelor’s degree in 1746. Three years later he was singled out by Thomas Clap to be a tutor, but he held this position for only one year. That was an important time in his life because Benjamin Franklin had donated an electric apparatus to Yale that Stiles used to conduct the first experiments in electricity in New England. In 1755 Stiles delivered an oration in honor of Benjamin Franklin even though he was no longer officially connected to Yale. The two colonial scientists had formed a friendship that lasted a lifetime. The next year Stiles moved to Newport, RI, where he remained until 1777, when his congregation had to disperse due to a British attack on the town. His pastoral duties ended when he accepted the presidency of Yale in June 1778, a post he held until his death 17 years later.

**Nehemiah Strong** (c. 1729–1807) was born in Northampton, MA. He received his AB in 1755 and his AM three years later, both from Yale. Strong was chosen by Thomas Clap to be a tutor 1757–1760. Once ordained, he became pastor of a church, but he ended up losing that post in 1767 due to a very embarrassing incident. During this time he married a woman whose first husband was believed to have perished at sea, but he appeared unexpectedly and claimed his wife, who left Strong for her first husband. He was dismissed from the pastorate due to entanglements involved in the resulting marriage annulment.

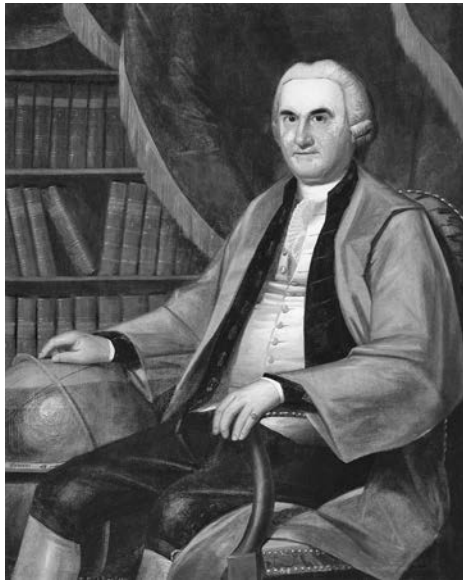


Figure 1.4. Nehemiah Strong

Fortunately, Strong's reputation in mathematics earned him an appointment as the first professor of mathematics and natural philosophy at Yale in December of 1770. He held the position throughout the Revolutionary War, though his salary was reduced, not just due to uncertain economics but friction with the governing corporation over his Tory views. Strong was gradually "squeezed out when the Corporation first reduced his salary, then forbade him to lecture, and finally required him to take an oath of allegiance as though he were a closet loyalist."<sup>10</sup> As a result, he resigned his professorship in 1781. He became known for his 1784 book *Astronomy Improved*.

## Dartmouth College

The third accomplished mathematician who served as a tutor at Yale under Thomas Clap was Bezaleel Woodward, who shortly thereafter moved to Dartmouth College in remote New Hampshire. The founding of Dartmouth College is described below, followed by a brief overview of Woodward's career.

Dartmouth's first president, the Puritan minister **Eleazar Wheelock** (1711–1779), was a 1733 graduate of Yale. One year later he was installed as the pastor of a Congregational church in Lebanon, CT, where he remained another 34 years until moving to Hanover, NH, to establish a college. During his ministering, Wheelock became so impressed with the learning ability of one of his Native American students, Samson Occom, who himself went on to become an ordained minister, that in 1755 he established Moor's Indian Charity School to train other Native Americans as missionaries. Occom and another minister sailed to England 11 years later to raise funds to establish a trust for the school. The head of that trust was William Legge, the 2nd Earl of Dartmouth. Although funding was sufficient to support the Charity School, Wheelock was unable to attract enough Native American students to attend it. In fact, Wheelock had a bigger



plan in mind—to establish a college for the benefit of the sons of colonists. When the Royal Governor of New Hampshire offered him land to build the college and sufficient resources to support it, Wheeler moved his operations from Connecticut to Hanover, NH. Moreover, Governor John Wentworth issued a charter in the name of King George III in December for a college “for the education and instruction of Youth of the Indian Tribes in this Land ... and also of English Youth and any others.”<sup>111</sup> Cleverly, the inclusion of wording about educating Native Americans enabled the new college to use the Charity School’s unspent trust money. The college was named after the 2nd Earl of Dartmouth even though he not only opposed the institution but never donated anything to it—books, laboratory equipment, nor money.

Dartmouth thus became the ninth college in the US and the last one established under colonial rule. Success happened quickly, with four students graduating in 1771, one of whom was Wheelock’s son John, who succeeded him as president upon his father’s death at age 68. However, those early gains were soon negated by the Revolutionary War, which exacted such a heavy toll on Dartmouth that it took another 125 years before the college attained national renown under the presidency of William Jewell Tucker from 1893 to 1909.

Dartmouth president Eleazar Wheelock had the good fortune to recruit a very able mathematics professor to his outpost in Hanover, NH. **Bezaleel Woodward** (1745–1804) was born in Lebanon, CT, where Wheelock was a minister, into a family that traced its roots back to Dorchester, MA, in 1638 on one side of the family and to Northampton in 1639 on the other. Woodward graduated from Yale in 1764 at age 19 and then became a tutor under Thomas Clap. He then spent a few years in the ministry before being contacted by Eleazar Wheelock, who appointed him tutor at Dartmouth in October 1770. Woodward played an important role at Dartmouth in those early, challenging days:<sup>112</sup>

[Wheelock’s] first associate in instruction, who acted in the capacity of tutor, was Mr. Bezaleel Woodward. ... The fact that Mr. Woodward was subsequently, for many years, a highly esteemed professor of Mathematics in the college indicates that he was a worthy pupil of his distinguished teacher [Clap].

In 1771 the trustees of the college donated an acre of land to Woodward for a home.

The Yale curriculum doubtlessly served as the model for Dartmouth, with Woodward as professor of mathematics and philosophy. Bezaleel Woodward was married to Wheelock’s daughter and served the college in many ways over the years, including being its librarian, acting president on two occasions, and treasurer. His salary was small, even when he was promoted to professor of mathematics and natural science in 1782.

Overall, Bezaleel Woodward had a long and illustrious career until his death in August 1804. Yet there is no evidence of any contributions to science, let alone mathematics. So why was he called a mathematician? Similarly, Thomas Clap wrote about his Yale graduates:<sup>113</sup>

Many of them well understand Surveying, Navigation and the Calculation of the Eclipses; and some of them are considerable Proficients in Conic Sections and Fluxions.

This statement encompasses the reason that Thomas Clap was regarded by his contemporaries as an accomplished mathematician. He taught applications of mathematics to fields that were critical at the time—surveying, navigation, and astronomy. Nonetheless, he too did not produce any original works in mathematics. By today's standards neither Wheelock nor Clap would be regarded as mathematicians. Chapter 2 begins with a discussion of this issue.