

Science for Ladies, Classics for Gentlemen: A Comparative Analysis of Scientific Subjects in the Curricula of Boys' and Girls' Secondary Schools in the United States, 1794–1850

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In 1864, the British government established the Taunton Commission to conduct an inquiry into the education of middle-class boys. Concerned about the status of the arts and sciences in the schools, the Commission directed its appointed inspectors to pay particular attention to scientific subjects. Almost as an afterthought, the Commission decided to investigate the conditions in girls' schools as well. From 1864 to 1868, inspectors traveled throughout Great Britain, observing classes, interviewing headmasters and headmistresses, and examining students in private, proprietary, and endowed schools. To their surprise, members of the Taunton Commission discovered that while the sciences maintained at best a marginal toehold in boys' schools, they were quite popular in girls' schools. While a boy's education centered around Latin and Greek, a girl's education included ample doses of botany, chemistry, natural philosophy, natural history, and physiology.¹

Did comparable conditions exist in the United States? Based on data compiled from newspaper advertisements, published accounts of school examinations, and state superintendents' reports, this study demonstrates that similar conditions indeed existed in America during the first half of

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¹*Schools Inquiry Commission: General Reports of the Assistant Commissioners, Southern Counties*, VII (1867–68), [3966–VI] XXVIII, mf. 74.275–81, 71, 206–7; Patricia Phillips, *The Scientific Lady: A Social History of Women's Scientific Interests, 1520–1918* (London, 1990), 236. According to Phillips, the commission defined members of the middle classes as those occupying houses assessed at an annual value of twenty pounds or more. There were estimated to be between 974,000 children between the ages of five and twenty in this social class in approximately ten thousand educational institutions, most of which catered to boys.

the nineteenth century. The data support the thesis that by 1840, the subjects of natural philosophy, chemistry, and astronomy had become more prevalent in American schools for middle- and upper-class girls than in comparable institutions for boys.²

The inclusion of scientific subjects in the courses of study of American female seminaries and academies in the early nineteenth century has been noted by historians of women's education. When Thomas Woody published his classic history of women's education in 1929, he included an appendix listing the subjects offered in 162 female seminaries between 1742 and 1871. Natural philosophy, astronomy, chemistry, and botany were among the ten subjects most frequently listed by the seminaries in Woody's sample. More recent studies have described in some detail the many opportunities afforded girls to study scientific subjects in their academies and seminaries. Until now, however, there has been insufficient data upon which to base a comparison of the relative emphasis placed on the sciences in boys' and girls' schools.³

It has been a long-standing paradigm in histories of science education to date the rapid infusion of the sciences into the secondary school curriculum from the publication dates of such writers as Thomas Huxley and Herbert Spencer in the 1850s and 1860s.⁴ This study suggests that this paradigm has misled us in fundamental ways. While the writings of such men as Huxley and Spencer were undoubtedly pivotal in efforts to increase the science curriculum, first at the college, and then at the secondary level, this increase represented a marked change for only half of the American student population. While the decades after the 1860s saw an increase in the sciences in male colleges, boys' academies, and coeducational secondary schools, the data revealed here indicate that the sciences had already long formed a visible part of the schooling of American girls.

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During the last decades of the eighteenth century, American reformers developed several rationales for the education of females, often basing

²The term *middle class* is used loosely here to denote those members of society able to afford the tuition rates of private secondary schools during the early nineteenth century.

³See Thomas Woody, *A History of Women's Education in the United States* (New York, 1980; 1929), 1: 563–65. Although Woody did not specify the institutions represented in his collection of school catalogs, a perusal of his bibliography reveals catalogs from twenty states. See Deborah Jean Warner, "Science Education for Women in Antebellum America," *Isis* 69 (Mar. 1978): 58–67; Christie Farnham, *The Education of the Southern Belle: Higher Education and Student Socialization in the Antebellum South* (New York, 1994). Farnham argues that the science courses offered in southern women's colleges compared favorably with those offered in men's colleges. Her conclusion must be interpreted with caution, however, since it appears to be based on a small sample of primary sources and does not include an analytical comparison of the actual textbooks used in these institutions.

⁴This view is promoted most recently by George E. DeBoer in *A History of Ideas in Science Education: Implications for Practice* (New York, 1991).

their arguments on women's social roles as mothers, wives, and teachers. The education of women was crucial to the welfare of the state because the primary duties of motherhood included "the education for time and eternity of the next generation of immortal beings." As a wife, a woman "must be able to comprehend [her husband's] plans; she must sympathize in his feelings, or else she cannot be his helpmate." The demand for teachers created a need that could be admirably filled by educated females, because "Women [were] the very best teachers in the primary education of children," being "less expensive teachers than men."⁵

What was to be the proper course of study for girls? Because the mind of a woman, like that of a man, needed discipline, some educators argued that girls should be instructed in the "solid" branches of science rather than in the merely "ornamental" branches of drawing, painting, and needlework. Although classical studies had traditionally played the role of training the mind, many educators argued that science could serve the same function by training students to observe critically and think logically.⁶

Advocates of science touted its social and physical benefits. According to the well-known female educator Almira Hart Lincoln Phelps, scientific study would result "in enlarging [women's] sphere of thought, rendering them more interesting as companions to men of science, and better capable of instructing the young." Concerned about the physical strength of young American girls, educators and doctors alike recommended botany, a subject many contemporaries viewed as particularly suited to females because "its pursuits leading to exercise in the open are conducive to health and cheerfulness."⁷

The rhetoric of natural theology, which portrayed the study of the natural world as spiritually and morally uplifting, made highly desirable the inclusion of the sciences into the curriculum. Natural theology, which

⁵The first quotation is from John Pierce Brace, nephew and successor to Sarah Pierce as head of Litchfield Female Seminary, and appears in Harriet Webster Marr, *The Old New England Academies founded before 1826* (New York, 1959), 105–6. The second quotation is from C. G. Memminger, "Address at the Opening of the Female High and Normal School in Charleston, South Carolina, 1859," in *A Documentary History of Education in the South before 1860*, ed. Edgar W. Knight (Chapel Hill, N.C., 1950), 5: 273. The last quotation is a statement by Joseph Emerson quoted in Marr, *Old New England Academies*, 106.

⁶James Mulhern, *A History of Secondary Education in Pennsylvania* (Philadelphia, 1933), 394; Lorraine Smith Pangle and Thomas L. Pangle, *The Learning of Liberty: The Educational Ideas of the American Founders* (Lawrence, Ks., 1993), 102–3; Elizabeth Keeney, *The Botanizers: Amateur Scientists in Nineteenth-Century America* (Chapel Hill, N.C., 1992), 58ff. According to Keeney, Amos Eaton and Almira Hart Lincoln Phelps, sister of Emma Willard, were highly influential in promoting this view of the sciences among educators. For an example of similar views in a southern state, see "A Syllabus of a Course of Vacation Reading is Provided for the Students at South Carolina Female Collegiate Institute, 1836," in *A Documentary History of Education in the South*, ed. Knight, 5: 412–13.

⁷Almira Hart Lincoln Phelps, *Lectures to Young Ladies* (Boston, 1833), 218. Almira Hart Lincoln Phelps quoted in Keeney, *The Botanizers*, 73–74.

gained popularity at the beginning of the eighteenth century in Great Britain, was founded on the premise that God could be known by consulting either Scripture or nature itself, both of which led to the same truths. Central to natural theology was the argument of design, in which the mechanism, instrumentality, or design in nature attested to the existence of an intelligent and benevolent Creator. "The analysis of science and revealed religion," proclaimed John Ludlow in his 1834 address at the opening of Albany Female Academy, "will ultimately terminate in the same point. . . . the invisible God." As did many members of the British and American scientific communities during this period, textbook authors frequently invoked natural theology as they extolled the benefits of studying the sciences. In a statement fairly representative of the period, the popular textbook author J. L. Comstock assured his readers that chemistry was a suitable vehicle for moral instruction, because "this subject teaches, that nothing has been formed by the fortuitous concurrence of atoms, but that even the 'stocks and stones' bear the impress of creative agency and design."⁸

While such influential Americans as Thomas Jefferson felt that the subjects of study most useful for American boys included both the classics and the sciences, relatively few reformers claimed that girls should study the classics. Traditionally, a classical education had been the prerogative of middle-class males, and it remained so until several decades into the nineteenth century.⁹ Many educators looked to find rigor in a program for girls, not to the classics at first, but to the sciences.

During the eighteenth century, local grammar schools provided advanced education for boys, usually offering instruction in Latin and Greek. As the century progressed, the growth of scattered villages, the

⁸Peter J. Bowler, *Evolution: The History of an Idea* (Berkeley, 1989; 1984), 53; Thomas L. Hankins, *Science and the Enlightenment* (Cambridge, Eng., 1985), 115; John Ludlow, *Address Delivered at the Opening of the New Female Academy in Albany, May 12, 1834* (Albany, N.Y., 1834), 7; J. L. Comstock, *Elements of Chemistry* . . . (New York, 1839), preface.

⁹See "Jefferson to J. Bannister Jr., October 15, 1785," in *A Documentary History of Education in the South*, ed. Knight, 2: 4–5. While Jefferson did not advocate a classical education for girls, such prominent educators as Catharine Beecher and Mary Lyon thought that girls should study the classics. For a general overview of women's education in the early nineteenth century, see Joan N. Burstyn and Thalia M. Mulvihill, "The History of Women's Education: North America," in *The International Encyclopedia of Education*, ed. Torsten Husén and T. Neville Postlethwaite (Oxford, Eng., 1994), 2: 6761–65. Woody, *A History of Women's Education*, 1: 413, 563–65. Woody noted that Latin was offered in the more prestigious female seminaries after 1810. His sample of 162 school catalogs reveals that more than 50 percent of the schools listed Latin between 1810 and 1870, and approximately 25 percent listed Greek grammar. However, Woody's sample should be interpreted with caution, since only the larger and wealthier schools would have published catalogs during this period.

division of towns into school districts, and the growth of district schools accompanied a gradual decline in the number of grammar schools. To fill the void, advanced instruction was provided by increasing numbers of private schools and incorporated academies.¹⁰

Although science had been rarely included in the curricula of the colonial grammar or Latin grammar schools, a number of early academy charters included natural philosophy among the subjects to be offered, reflecting the newer views on education. The standard studies in boys' academies generally included the traditional subjects of English, Latin, Greek, declamation, writing, and arithmetic, and some portion of the newer subjects of French, geography, logic, geometry, and natural philosophy or astronomy. A similar curriculum appeared in a variety of private institutions serving boys, known by such names as "Mr. Lyon's School for Boys," "John G. Nelson's School," or "Norristown Boarding School."¹¹

From an early date, some boys' schools opened their doors to girls, educating females in a separate department. For example, Robert Leeth's school placed an advertisement in the *New York Gazette-Weekly Post Boy* in 1751, offering instruction to both sexes in "two handsome Rooms, with Fire-places, the one for Boys and the other for Girls." Near the end of the eighteenth century, a few teachers opened schools exclusively for girls, supporting their efforts financially with funds raised by selling shares. For instance, Sarah Pierce opened her school for girls in the dining room of her home in Litchfield, Connecticut, in 1791. Two pupils from her school, Catharine and Mary Beecher, opened the Hartford Female Seminary in 1823. Their school was incorporated in 1827, the same year as the parent school at Litchfield.¹²

Troy Female Seminary, which opened in 1821 under the leadership of Emma Willard, became an important center for the diffusion of new educational ideas in the early nineteenth century. The curriculum at Troy included mathematics, science, modern languages, history, philosophy, geography, and literature. Gifted speakers and prolific writers—such as Catharine Beecher; Emma Willard and her sister Elmira Hart Phelps; Zilpah Grant, head of Ipswich Female Seminary; and Mary Lyon, head of Mount Holyoke Seminary—were highly influential in disseminating the

¹⁰Theodore R.Sizer, ed., *The Age of the Academies* (New York, 1964); Ellwood Patterson Cubberley, *Public Education in the United States: A Study and Interpretation of American Educational History* (Boston, 1934), 29–31; Clifton Johnson, *Old-Time Schools and School-books* (New York, 1917), 147.

¹¹Sizer, *The Age of the Academies*; Johnson, *Old-Time Schools and School-books*, 147; Marr, *Old New England Academies*, 203; *Columbian Centinel*, 26 Dec. 1827; *Richmond Enquirer*, 24 Nov. 1835, 5 Aug. 1836.

¹²*New York Gazette-Weekly Post Boy* quoted in Thomas Woody, *A History of Women's Education in the United States*, 1: 225; Marr, *Old New England Academies*, 3.

new views of female education. Many of their graduates became teachers in distant states, bringing these ideas to different parts of the country.¹³

Newspaper advertisements published in both northern and southern states during the 1820s reveal a growing number of schools claiming to provide a relatively advanced form of education for girls. Such institutions described themselves variously as female academies or seminaries, day schools, boarding schools, or ladies' select schools. Some enrolled students from the ages of eight to sixteen or eighteen; others admitted pupils at age twelve; still others, perhaps needing the extra tuition to stay afloat, admitted any prospective students that applied, even those younger than eight.¹⁴ Because of the diverse nature of the schools serving females, for the purposes of this study, precollege institutions providing instruction beyond learning to read and write are referred to simply as "secondary schools."

Newly founded girls' secondary schools advertised their courses of study in local newspapers in order to attract students. During the period from 1800 to 1845, such advertisements often provided a complete list of the subjects offered in a given school, sometimes accompanied with the titles of the textbooks used in various courses. Catharine and Mary Beecher's 1824 advertisement is representative in its degree of detail (see Plate 1). Although advertisements are unreliable as a means of evaluating either the content or method of the actual instruction delivered in educational institutions, as marketing tools, these sources illuminate the degree to which educational institutions differentiated their curricula according to the gender of their desired clientele.

During the first half of the nineteenth century, the curricula of girls' schools expanded enormously. Between 1800 and 1820, most female institutions offered reading, writing, grammar, geography, arithmetic, and plain needlework on a regular basis; for additional fees, students could study a foreign language (usually French) and an assortment of such ornamental subjects as drawing, painting, Dresden, or lacework as electives. But increasing criticism of the emphasis on ornamentals in girls' education, and a rising belief that girls were indeed endowed by nature with minds to be trained by discipline, led many schools to include such presumably solid subjects as natural philosophy, astronomy, chemistry, and (more rarely) botany during the 1820s and 1830s.¹⁵

¹³For a discussion on the influence of these female educators, see Anne Firor Scott, "The Ever Widening Circle: The Diffusion of Feminist Values from the Troy Female Seminary, 1822-1872" in *History of Education Quarterly* 19 (Spring 1979): 3-25; Warner, "Science Education for Women in Antebellum America," 58-67.

¹⁴Marr, *Old New England Academies*.

¹⁵Emma Willard and her sister Almira Lincoln Hart Phelps actively promoted the idea that a woman's education should include solid subjects. See Mulhern, *A History of Secondary Education in Pennsylvania*, 394; Woody, *A History of Women's Education in the United States*, 1: 108ff.

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WILL commence their summer term on the first Wednesday after Election, (May 12) For those who may attend from out of town, a list of the books to be used in the School during the summer is subjoined. Murray's Grammar, Woodbridge's large and small Geography, Blair's Rhetoric, Mrs. B.'s Conversations on Philosophy and Chemistry, Goldsmith's Histories of Greece and Rome, Russell's Modern Europe, Adams' Arithmetic, Day's Algebra, Euclid's Elements of Geometry, Paley's Moral Philosophy, Pal. Natural Theology, Adams' Latin Grammar, Historiæ Græcæ, and Virgil. The arrangements of the school will be such, that it will be a great advantage to enter at the commencement of the terms. Terms. For tuition, \$6. For drawing, \$2. For music, \$10, per quarter.

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Plate 1. An 1824 newspaper advertisement for Catharine and Mary Beecher's school in Connecticut. Courtesy of the Department of Special Collections, Stanford University Libraries.

In order to remain competitive in attracting students, schools advertised when they added new subjects to their courses of study, or when they added new teachers, textbooks, or scientific apparatus to their programs. A fairly typical example of the curriculum expansion in girls' schools can be seen in the growing number of subjects advertised by North Carolina Shocco Female Academy from 1818 to 1830 (see Table 1).¹⁶

The tuition rates in newspaper advertisements indicate that the sciences never attained the core status of such basic subjects as reading, writing, or arithmetic. Nevertheless, girls' schools included scientific subjects,

¹⁶The samples of newspaper advertisements used in this study were selected on the basis of the specificity of their content. In many cases, it was not possible to tell from the advertisement whether the school served males or females, or both. Nor, in all cases, was the entire course of study provided. Some advertisers claimed to offer "the usual branches of education" in their schools, and such advertisements were too vague to be included in the samples. The samples included here are drawn from advertisements that clearly specified the gender served in the school and provided a detailed course of study.

TABLE 1

**Expansion of the Curriculum of Shocco Female Academy,
North Carolina, 1818–30**

1818	1823	1826	1830
Reading	Reading	Reading	Reading
Writing	Writing	Writing	Writing
Arithmetic	Arithmetic	Arithmetic	Arithmetic
Grammar	Grammar	Grammar	Grammar
Geography	Geography	Geography	Geography
Needlework	Needlework	Needlework	Needlework
Drawing	Drawing	Drawing	Drawing
Painting	Painting	Painting	Painting
	Spelling	Spelling	Spelling
	Astronomy	Astronomy	Astronomy
	Nat'l Phil	Nat'l Phil	Nat'l Phil
		Chemistry	Chemistry
		Botany	Botany
		History	History
		Music	Music
			Mythology
			Lacework

Source: Data compiled from newspaper advertisements included in *North Carolina Schools and Academies 1790–1840: A Documentary History* (Raleigh, N.C., 1915), ed. Charles L. Coon, 604–12.

more often than the so-called ornamental subjects, in the basic course of studies, referred to as the English course. For instance, in a sample of thirty-one girls' schools in North Carolina, 42 percent included the sciences under the basic tuition, while 58 percent charged extra. In contrast, the so-called ornamental subjects, comprising music, painting, drawing, embroidery, and so on were almost always offered on a supplemental basis and were sometimes taught by adjunct faculty.¹⁷ The additional tuition charged for the ornamental subjects was often as much, or even greater than the tuition for the entire English course, which often included the sciences. In 1831, a girl seeking to study the subjects of drawing,

¹⁷It is a fairly common misconception among historians of education that the so-called ornamental subjects were a staple in the schooling of early nineteenth-century American girls. This interpretation of the place of ornamentals in female education has been preserved for decades in Thomas Woody's 1929 study of female education, in which Woody claimed that "the [female] seminary continued to offer the friperies of filigree, painting, music, and drawing in far greater profusion" from the time of Emma Willard and Catharine Beecher. See Woody, *A History of Women's Education in the United States*, 1: 415.

painting, and music in the Wake Forest Female School had to pay twice the tuition of the English course:

The course of instruction will be that usually pursued, viz; Reading, Writing, Arithmetic, History, Natural Philosophy and Astronomy, Composition, Plain Needle Work and Embroidery, Drawing and Painting, and Music on the Piano.

The prices of Tuition for the Session of five months, will be; for the ordinary branches of an English Education \$10—Needle Work and Embroidery \$5—Drawing and Painting \$5—Music on the Piano \$15, payable always in advance.¹⁸

Although some of the most prominent female seminaries included such traditionally male subjects as Latin and Greek in their courses of study, only a minority of schools followed this pattern until later in the century, choosing instead to offer students an educational program deemed more suitable for females. During the second and third decades of the nineteenth century, an increasing percentage of institutions advertised a curriculum that included such subjects as astronomy, natural philosophy, chemistry, and, to a lesser extent, natural history. So prevalent was the addition of science to a girl's course of studies in North Carolina in 1826, that the female department of Tarborough Academy described its program as being "as extensive as at other Female Seminaries, including Chemistry, Astronomy, Natural Philosophy, Rhetoric and History." The Academy's advertisement added that "such as desire it, may be taught plain and ornamental Needle Work, Painting on Paper and Velvet, and Music." Similarly, the 1830 prospectus of Connecticut's New Haven Female Seminary claimed that its course of study embraced "all the scientific and ornamental branches necessary to complete the female education."¹⁹

Visitors from abroad were struck by the presence of scientific subjects in the schooling of American girls. The Englishwoman Frances Trol-

¹⁸*Raleigh Register*, 7 July 1831, quoted in *North Carolina Schools and Academies, 1790–1840: A Documentary History*, ed. Charles L. Coon (Raleigh, N.C., 1915), 533.

¹⁹Historian Christie Farnham argues that Latin appears more frequently in southern girls' schools than in northern institutions. See Farnham, *The Education of the Southern Belle*, 28–32. However, the sources examined for this study do not support Farnham's thesis. Newspaper advertisements published in North Carolina and Virginia reveal that relatively few girls' schools in these two southern states offered Latin. During the decade from 1810 to 1830, only seven (19 percent) of a sample of thirty-six North Carolina girls' schools included Latin in their advertised courses of study. Similarly, only four (13 percent) of a sample of thirty-one Virginia girls' schools mentioned Latin in advertisements published from 1835 to 1838. In contrast, ten (42 percent) out of a sample of twenty-four girls' schools in Connecticut, Massachusetts, New York, and Maryland advertised Latin from 1820 to 1842. See discussion in Kim Tolley, "The Science Education of American Girls, 1784–1932" (Ed.D. diss., University of California at Berkeley, 1996), ch. 8. Tarborough advertisement quoted in *North Carolina Schools and Academies*, ed. Coon, 79; New Haven prospectus quoted in Vera M. Butler, *Education as Revealed by New England Newspapers prior to 1850* (Ph.D. diss., Temple University, 1935), 188.

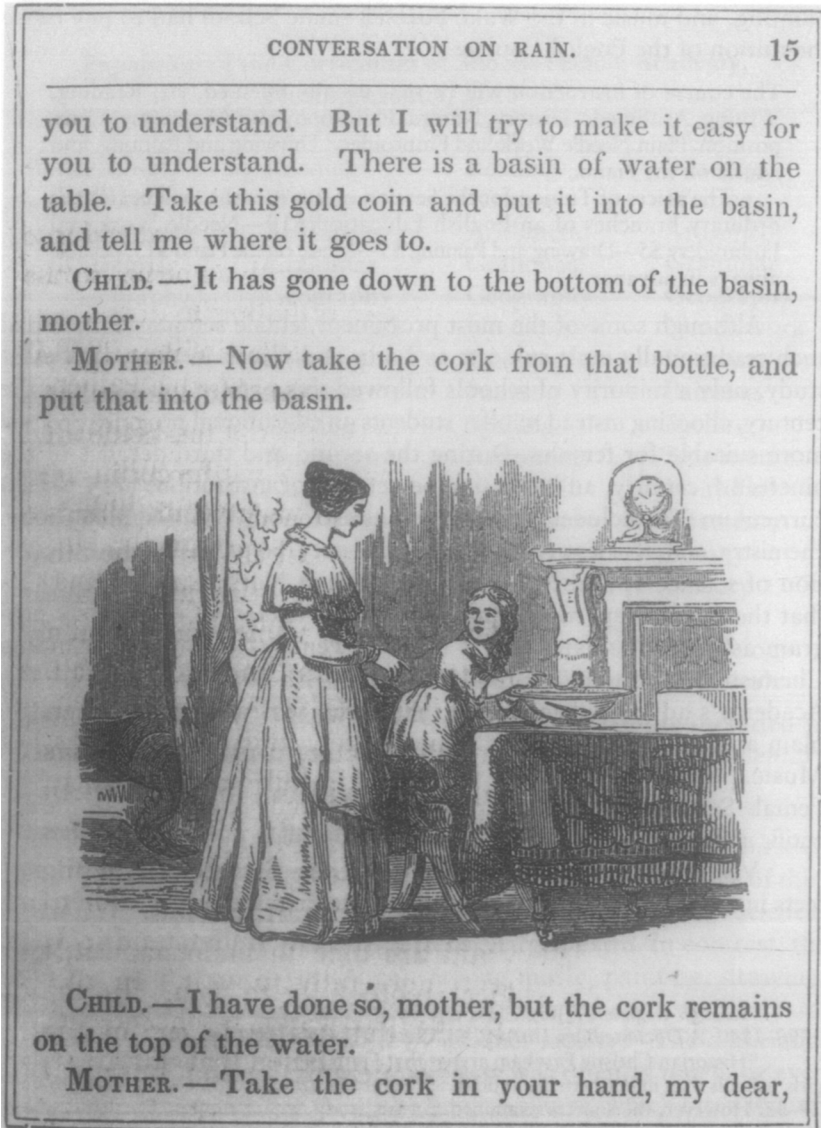


Plate 2. Courtesy of Cubberley Education Library, Stanford University Libraries.

lope, who lived in the United States for several years during the late 1820s, recounted her experience at the annual public exhibition of a Cincinnati girls' school, where she "perceived, with some surprise, that the higher branches of science were among the studies of the pretty creatures I saw assembled there." In 1850, the Swedish writer Fredrika Bremer concluded that

American girls advanced as far in their scientific studies as did American boys: “opportunity is afforded [girls] to advance as far as the young men in study and the sciences, which have hitherto been considered as too difficult for them, are as easy for them to acquire as that superficial knowledge and accomplishment to which hitherto their education has been restricted.”²⁰

In fact, relatively few American girls had either the leisure or financial means to study the sciences. Some of the textbooks published during the antebellum period reveal the assumptions of contemporaries about the social status of females who engaged in scientific investigation. For example, Richard G. Parker’s *Juvenile Philosophy*, a popular elementary text, conveys scientific principles through the medium of a mother’s conversation with her daughter. The elite status of this pair is implied in their surroundings and apparatus. One illustration depicts the two of them in a well-appointed drawing room, using a gold coin to perform a science experiment (see Plate 2).²¹

While the study of the sciences was largely the prerogative of the middle and upper classes, it was not restricted to the children of Anglo-Saxon, Protestant families. Indications of the movement to bring science into girls’ courses of study can be found in some Catholic schools and in several academies serving Native Americans.

Although Catholicism was a minority religion of relatively new immigrants, some of the academies run by various orders of the Catholic church adapted to the newer American views of female education by offering scientific subjects to middle-class girls. For example, in 1842 the Maryland Carmelite Sister’s Academy advertised natural philosophy, botany, and astronomy in its course of study, along with such other subjects as sacred history. In frontier St. Louis, the Society of the Sacred Heart reserved scientific subjects for the daughters of well-to-do families. In the Society’s free school catering to indigent girls, students studied reading, writing, spelling, arithmetic, and religion. Advanced studies, offered in the 1830s for a small fee, included grammar, geography, and sewing. In contrast, girls in the Society’s prestigious academy studied natural philosophy, astronomy, chemistry, and geography along with the other usual branches of a presumably solid education.²²

²⁰Frances Milton Trollope, *Domestic Manners of the Americans* (New York, 1949; 1832), 82; Adolph B. Benson, ed., *America of the Fifties: Letters of Fredrika Bremer* (New York, 1924; 1853), 285.

²¹Richard Green Parker, *Juvenile Philosophy: or, Philosophy in Familiar Conversations Designed to Teach Young Children to Think* (New York, 1857; 1850), 15.

²²*Baltimore Sun*, 12 Aug. 1842; Nikola Baumgarten, “Education and Democracy in Frontier St. Louis: The Society of the Sacred Heart,” *History of Education Quarterly* 34 (Summer 1994): 171–92. Baumgarten attributes the inclusion of scientific subjects in the Catholic curriculum to the influence of such female educators as Emma Willard and Catharine Beecher.

If the formula in the note below be applied to the third example in numbers, the loss of weight will be equal to

$$\frac{2000(2 \times 4000 \times 500 + 250,000)}{16,000,000 + 2 \times 4000 \times 500 + 25,000} = \frac{8,500,000,000}{20,250,000} = 419\frac{21}{31} \text{ lbs.}$$

If the height is not more than half a mile, x^2 may be neglected, and then the formula will be $W - W' = \frac{W \times 2x}{r + 2x}$.

Fig. 17. * Let A, *Fig. 17*, be the earth, C its center, x the height from the surface, then will the weight at s be to the weight at x as the squares of the distances Cx and Cs . Now, to find the loss of weight, we must subtract the weight at x from the weight at s , and then, if we represent the weight at s by W , and at x by W' ; also, Cs by r , and sx by x , we shall have the proportion

$$W : W - W' :: (r + x)^2 : 2rx + x^2, \text{ or } W : W - W' :: r^2 + 2rx + x^2 : 2rx + x^2.$$

The loss of weight, then, will be $= W - W' = \frac{W(2rx + x^2)}{r^2 + 2rx + x^2}$.

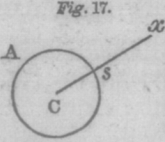


Plate 3. A representation of Newton's Law of Gravity, in Alonzo Gray's *Elements of Natural Philosophy* (1850). Courtesy of Cubberley Education Library, Stanford University Libraries.

The daughters of elites in the Cherokee Nation also received some instruction in scientific subjects. Since 1839, wealthier mixed-blood Cherokees had sent their daughters to the Fayetteville Female Academy in Arkansas, where they were instructed in geography and ancient history, logic, natural philosophy, literature, astronomy, and other subjects conducive to elevating the "female character in the Nation." Established in Tahlequah in 1843, another option for young Cherokee females was the Cherokee Female Seminary, where pupils studied a curriculum that included the natural sciences.²³

In 1847, the Cherokee National Council enacted a law requiring the teachers of the Female Seminary to teach "all the branches of literature and science commonly taught in the academies of the United States." As a source of faculty for the Seminary, Cherokees looked to Mary Lyon's Mount Holyoke Female Seminary. According to the historian Devon A. Mihesuah, between 1839 and 1856, twenty-four Mount Holyoke alumnae taught among North American tribes. Modeled on the curriculum at Mount Holyoke Female Seminary, the course of study at Cherokee Female Seminary was distinguished from that in the Nation's common schools by its emphasis on literature and the sciences. In 1852, students in Cherokee common schools studied a basic course of reading, spelling, geography,

²³Devon A. Mihesuah, *Cultivating the Rosebuds: The Education of Women at the Cherokee Female Seminary, 1851-1909* (Urbana, Ill., 1993), 21. According to the author, there were two Cherokee female seminaries. The earlier institution, established in 1843, was short lived. The second Cherokee Female Seminary, which is the subject of Mihesuah's book, was established in 1851.

and arithmetic. During the same period, the daughters of wealthier Cherokee families were instructed in such additional subjects as botany, natural philosophy, and astronomy.²⁴

Facing educational restrictions more severe than those of any other ethnic group in the United States, African Americans had few opportunities to study the sciences. Before the Civil War, several states passed legislation outlawing the teaching of slaves. In cases where common schools were established for their benefit, the quality of instruction provided to free African Americans was often both rudimentary and poor.²⁵

In spite of enormous obstacles, however, free African Americans occasionally gained access to schooling generally reserved for elites. Such an individual was Charlotte Forten, who came of a middle-class free Philadelphia family. In the 1850s, she attended school with white students in Salem, Massachusetts. Her journal entries reveal that while a student at Higginson Grammar School, she studied geography, geology, natural philosophy, and entomology.²⁶

What sort of science did girls encounter in their schoolbooks? An analysis of 54 astronomy, chemistry, and natural philosophy texts commonly used in male and female institutions reveals that boys and girls studied the same content: descriptive and physical astronomy, mechanics, pneumatics, hydrostatics, properties of matter, and so on. Before 1830, the science texts appearing in girls' schools generally included less mathematics than those in boys' schools; however, the introduction of algebra and geometry into their curricula during the 1830s and 1840s allowed some girls to undertake a mathematical study of the physical sciences at mid-century. For example, Alonzo Gray, an instructor in Brooklyn Female Academy, included algebraic formulae in his natural philosophy text, published in 1850 "for the use of pupils under the immediate instruction of the author" (see Plate 3). By the 1860s, the most difficult texts appearing in girls' schools were comparable in their mathematical complexity to those used in boys' schools, with the exception of military academies.²⁷

²⁴Ibid., 27.

²⁵See Knight, ed., *A Documentary History of Education in the South*, 5: 459–515. For instance, in their 1845 report, the examining committee of the Boston schools noted that conditions were deplorable in the Smith school, an institution catering to the children of free African Americans. See "Boston Grammar and Writing Schools," in *Common School Journal* 7 (Oct. 1845): 299–300; Caroline Alfred to Lucretia Crocker, 21 Feb. 1874, Caroline Alfred Letters, Freedman's Aid Society Papers, Massachusetts Historical Society. Conditions in the South after the Civil War were no better. Caroline Alfred, a teacher of free African Americans in Georgia, complained despairingly that "in the public colored school in this city great pains are taken that the pupils shall only learn to read."

²⁶Brenda Stevenson, ed., *The Journals of Charlotte Forten Grimké* (New York, 1988), 1–31, 82, 63, 89, 105, 107–8, 122. The quotation is from her entry of 28 May 1854.

²⁷Alonzo Gray, *Elements of Natural Philosophy* (New York, 1850), iii; Kim Tolley, "The Science Education of American Girls," ch. 3.

TABLE 2
Percentage of North Carolina and Virginia
Secondary Schools Advertising Various Sciences, 1800–1840

	<i>Natural Philosophy</i>	<i>Astron- omy</i>	<i>Chem- istry</i>	<i>Botany</i>	<i>Mineralogy</i>	<i>Natural History</i>
Girls' Schools (n=78)	74%	47%	54%	35%	5%	13%
Boys' Schools (n=86)	47%	22%	21%	2%	3%	1%

Source: Data compiled from newspaper advertisements for 61 Virginia schools published in the *Richmond Enquirer* (Virginia, 1835–38), and 103 schools included in *North Carolina Schools and Academies*, ed. Coon.

TABLE 3
Percentage of Secondary Schools in Selected Northern
States Advertising Various Sciences, 1820–42

	<i>Natural Philosophy</i>	<i>Astron- omy</i>	<i>Chem- istry</i>	<i>Botany</i>	<i>Mineralogy</i>	<i>Natural History</i>
Girls' Schools (n=24)	63%	50%	58%	25%	0%	4%
Boys' Schools (n=15)	53%	33%	53%	27%	20%	0%

Source: Data compiled from newspaper advertisements for 39 schools published in the *American Mercury* (Connecticut, 1820–29 [incomplete]); *Columbian Centinel* (Massachusetts, 1827–31); *Baltimore Sun* (Maryland, 1841–42); *New York Evening Post* (1 Aug. 1835–31 May 1836); *The Globe* (Washington, D.C., 1831); *Daily National Intelligencer* (Washington, D.C., 1825).

TABLE 4
Percentage of Pennsylvania Secondary Schools
Offering Various Sciences, 1830–89

	<i>Natural Philosophy</i>	<i>Astron- omy</i>	<i>Chem- istry</i>	<i>Botany</i>	<i>Mineralogy</i>	<i>Natural History</i>
Girls' Schools (n=90)	88%	67%	72%	77%	33%	—
Boys' & Coed Schools (n=116)	54%	47%	56%	33%	28%	—

Source: Data compiled from tables in James Mulhern, *A History of Secondary Education in Pennsylvania* (Philadelphia, 1933), 328–29, 428–29.

A variety of contemporary sources indicate that while the sciences maintained a relatively marginal presence in boys' academies before 1840, they were highly visible in girls' schools. Newspaper advertisements published in both northern and southern states reveal that a larger percentage of female institutions advertised scientific subjects than did male institutions during the same period. As shown in Tables 2–4, natural philosophy, astronomy, and chemistry comprised the most commonly advertised sciences in both male and female institutions. Botany appeared in a majority of girls' schools only after 1840.

In comparing the results for northern and southern states, there appears to be little regional variation in the percentage of girls' schools advertising scientific subjects; the higher figures reported for Pennsylvania are attributable to the later time period (1830–89) represented by the schools in Mulhern's sample. However, although evidence is sketchy, the newspapers examined for this study indicate that a larger percentage of boys' schools in northern states advertised the sciences than did their southern counterparts, a trend that may have developed in response to the growing industrialization of the North.

While a girl's education commonly included doses of scientific subjects, a boy's education more often centered around Latin and Greek, particularly in the South. For example, in Virginia and North Carolina, Latin was the most frequently advertised subject in boys' academies and private schools from 1790 to 1840; 91 percent of boys' schools advertised Latin, and 85 percent advertised Greek. In contrast, only 18 percent of girls' schools advertised Latin, and a very meager 5 percent advertised Greek. In the North, only a slightly larger percentage of boys' schools than girls' schools advertised Latin, although female institutions usually offered the subject on an elective basis only.²⁸

Another way to compare the curricula offered to the two sexes is to examine the courses of study in schools with both male and female departments. Of the 103 schools represented in the North Carolina sample, seven placed advertisements describing curricula for the male and female departments of the same institution.²⁹ Six of the seven institutions advertised a different science curriculum for their male and female departments. The curriculum of Vine Hill Academy exemplifies variations in the sub-

²⁸This conclusion is based on an analysis of the newspaper advertisements mentioned in the above tables. Out of a sample of twenty-four girls' schools in New England states from 1820 to 1842, 42 percent advertised Latin, usually on an elective basis, in contrast to 47 percent of a sample of fifteen boys' schools.

²⁹New Bern Academy in Craven County, Fayetteville Academy in Cumberland County, Tarborough Academy in Edgecombe County, Greensborough Academy in Guilford County, Vine Hill Academy in Halifax County, Salisbury Academy in Rowan County, and Raleigh Academy in Wake County.

jects available to middle-class males and females; the classics, higher mathematics, navigation, and surveying were offered to males, whereas natural philosophy, astronomy, chemistry, botany, and several other subjects were offered to females (see Table 5).

TABLE 5

**Comparison of the Male and Female Courses of Study
Advertised by Vine Hill Academy, North Carolina, 1837**

<i>Male Department</i>	<i>Female Department</i>
Spelling	Spelling
Reading	Reading
Writing	Writing
Grammar	Grammar
Geography	Geography
History	History
Arithmetic	Arithmetic
Rhetoric	Rhetoric
Logic	Logic
French	French
Latin	_____
Greek	_____
Algebra	_____
Geometry	_____
Navigation	_____
Surveying	_____
_____	Natural Philosophy
_____	Chemistry
_____	Astronomy
_____	Botany
_____	Moral & Intellectual Philosophy
_____	Natural Theology
_____	Elements of Criticism
_____	Drawing & Painting

Source: Data compiled from the *Raleigh Star* (17 May 1837), in *North Carolina Schools*, ed. Coon, 176–77.

In New York's Genesee Wesleyan Seminary, which offered the same number of scientific subjects to both sexes in separate departments, girls predominated in the science courses. Despite the fact that males comprised 62 percent of the student body in 1834, enrollment data reveal that a significantly larger percentage of females than males studied the sciences (see Table 6). According to historian Nancy Beadie, "males, by contrast, dominated in Latin, algebra, Greek, Hebrew, bookkeeping,

trigonometry, various branches of applied geometry (for surveying) and navigation.”³⁰

School examinations provide another source of information about the relative importance of scientific subjects in the curriculum. Newspa-

TABLE 6
Number and Percentage of Each Sex Enrolled in Science Courses at Genesee Wesleyan Seminary, New York, 1834

	<i>Total Enrollment</i>	<i>Natural Philos.</i>	<i>Astronomy</i>	<i>Chemistry</i>	<i>Botany</i>
Girls	144	85 (58%)	7 (5%)	33 (23%)	11 (8%)
Boys	232	64 (28%)	0 (0%)	20 (9%)	0 (0%)

Source: Nancy Beadie, “Emma Willard’s Idea Put to the Test: The Consequences of State Support of Female Education in New York, 1819–67,” *History of Education Quarterly* 33 (Winter 1993): 559–60n.

pers occasionally published accounts of the examinations of the larger and more prestigious local academies and seminaries, often including the names of examinees and the subjects on which they were examined. While institutions may have included scientific subjects in their advertised courses of study in order to appeal to a broad market of parents and guardians, the published reports of examinations indicate to a far greater degree the subjects that students actually studied.

Because the success or failure of its students reflected on the quality of instruction at each institution, it is unlikely that subjects taught incidentally were included in examinations. Public examinations were high-stakes performances, conducted orally, often in the presence of a large audience of relatives, ministers, trustees, and visiting preceptors from other schools. In an era when few forms of public entertainment were available, the examinations in some cases assumed the form of a spectacle. When Mary Lyon was teaching at Ipswich Female Seminary with Zilpah Grant, “public examination carryalls from Andover rolled over to Ipswich to help swell the audience.” The examinations sometimes lasted for several days, no doubt creating an atmosphere of terror and excitement for students.³¹

In their academies, boys were almost always examined on the classics and on such core subjects as geography, arithmetic, and grammar. For example, at North Carolina’s Raleigh Academy in 1807, while the rest of

³⁰Nancy Beadie, “Emma Willard’s Idea Put to the Test: The Consequences of State Support of Female Education in New York, 1819–67,” *History of Education Quarterly* 33 (Winter 1993): 543–62, 560n.

³¹Mary Lyon quoted in Marr, *Old New England Academies*, 247. Depending on the school’s charter, examinations might be held at the end of each term or more frequently. At

his classmates endured questions on such topics as Horace, Virgil, Caesar, *Selectae Veterii*, Erasmus, Aesop's Fables, the Greek Testament, and Latin Grammar, Thomas Gales was the sole student examined on natural philosophy and astronomy, evidencing "by his ready and unembarrassed answers, his perfect acquaintance with them." It was not uncommon for a boys' academy to include natural philosophy or astronomy in its advertised course of study but to exclude these subjects from its examinations.³²

Published accounts of examinations in North Carolina reveal that a greater percentage of girls' schools included scientific subjects in their exams than did boys' schools of the same period. Although the majority of girls were examined on such core subjects as geography, reading, spelling, and grammar, and on such ornamentals as fancy needlework and painting, it was not uncommon also to find classes of girls examined in natural philosophy, astronomy, or chemistry. Female students generally impressed their audience with their knowledge of various scientific subjects. For instance, in 1826, the examiners of Charlotte Female Academy noted with admiration that "the abstruse principles of Natural Philosophy and Astronomy were fully comprehended and understood by those who are yet but children."³³

In New England, the examinations given in the common schools of Boston, Massachusetts, under the leadership of Horace Mann reveal a similar situation. The Boston common schools of this period offered free instruction to the children of Boston's citizens. Each school was really two schools in one, a writing school and a grammar school. The master of the writing school taught the subjects of writing, arithmetic, algebra, geometry, and bookkeeping, and the master of the grammar school taught

Salisbury Academy in North Carolina, both private and public examinations were held. Each year was divided into two sessions, each session consisting of two quarters. At the end of each quarter, a committee of the Trustees was appointed to conduct the quarterly examination. The committee took the last two days of the quarter to examine the classes privately on their various studies. Twice a year, a public examination took place, and the Trustees' report of the public examination was published in the papers. See *Western Carolinian*, 19 Sep. 1820, in *North Carolina Schools and Academies*, ed. Coon, 360.

³²*Raleigh Minerva*, 4 June 1807, in *North Carolina Schools and Academies*, ed. Coon, 399. For example, this was a common practice of the Classical School in Charlottesville, Virginia, from 1835 to 1836. See the issue of the *Richmond Enquirer* for 10 Nov. 1835, which advertises its course of study, and the issue for 29 Dec. 1835, which reports its examinations.

³³Of the schools that published reports of examinations, seven (78 percent) of nine girls' schools included scientific subjects, as compared to two (14 percent) of fourteen boys' schools. Data compiled from newspaper advertisements in Coon, ed., *North Carolina Schools and Academies. Catawba Journal*, 5 Dec. 1826, in *North Carolina Schools and Academies*, ed. Coon, 235–36; see also *Raleigh Star*, 10 Jan. 1812, in *ibid.*, 601. The examiners' report discusses the students' extensive knowledge of astronomy in Mordecai's Female Academy in Warrenton, North Carolina.

the subjects of grammar, reading, geography, history, and sometimes natural philosophy and astronomy.³⁴

The School Committee of the City of Boston appointed a subcommittee in 1845 to examine the highest, or first class in each of the nineteen grammar schools in Boston. Five schools catered exclusively to girls, five to boys, and the remaining nine were coeducational. The students in the first classes were about to graduate, being on average fourteen years old. Among the tests created for this purpose were those in natural philosophy and astronomy. The same examinations were administered to each of the schools in the city, and the tabulated results published in detail, question by question and school by school.³⁵

Thirteen of the nineteen common schools in Boston reportedly offered natural philosophy as an elective, and four offered astronomy on the same basis. Because taking the examinations in these subjects was optional, schools that did not provide instruction in astronomy or natural philosophy declined to submit scholars for questioning.³⁶

All five of the girls' schools produced scholars for the natural philosophy examination, and two of these schools, Franklin and Johnson, produced scholars for the astronomy examination as well. In contrast, only two boys' schools produced scholars for the natural philosophy examination, and no boys' school consented to be examined on astronomy (see Table 7).

Because students from both the top-ranked girls' and boys' schools took the examination in natural philosophy, it is possible to compare the relative performance of boys and girls. According to the examining committee, Bowdoin was the top-ranked girls' school, and Brimmer was the top-ranked boys' school. Although the scores overall were rather disappointing to the citizens of Boston, the girls' scores were much higher than those of the boys. The girls from Bowdoin correctly answered 36 percent of the questions on the natural philosophy examination, whereas the boys from Brimmer correctly answered only 19 percent.³⁷

³⁴"Boston Grammar and Writing Schools," in *Common School Journal* 7 (15 Oct. 1845): 311–17. Lengthy extracts from the report of the Boston School Committee were published in numbers 19–23 of the *Journal* in 1845; Otis W. Caldwell and Stuart A. Curtis, *Then and Now in Education, 1845–1923: A Message of Encouragement from the Past to the Present* (Yonkers-on-Hudson, N.Y., 1925), 11, 14.

³⁵Caldwell and Curtis, *Then and Now in Education*, 22–226. It is possible to identify the girls' and boys' schools from extracts of the Boston School Committee Report. Copies of the original tests are reproduced both in Caldwell and Curtis's text and in *Common School Journal* 7 (1 Dec. 1845): 361–63.

³⁶Caldwell and Curtis, *Then and Now in Education*, 168–69; 342–43. Apparently neither astronomy or natural philosophy was offered in the Smith school, an institution catering solely to African American children; Smith declined to produce scholars for examination on either subject.

³⁷*Ibid.*, 182, 229. Ironically, although the examiners ranked Brimmer as the highest quality boys' school, its scholars were consistently outranked by other schools on the exam-

TABLE 7

**Students in Boston Common Schools Examined in
Natural Philosophy and Astronomy, 1845**

<i>Girls' Schools</i>	<i>Enrollment</i>	<i>Number Examined in Nat. Philos.</i>	<i>Number Examined in Astronomy</i>
Bowdoin	508	45	0
Wells	307	27	0
Franklin	418	14	19
Hancock	509	20	0
Johnson	547	44	50
Total	2289	150	69

<i>Boys' Schools</i>	<i>Enrollment</i>	<i>Number Examined in Nat. Philos.</i>	<i>Number Examined in Astronomy</i>
Brimmer	513	35	0
Eliot	456	0	0
Adams	418	0	0
Mayhew	368	19	0
New South	136	0	0
Total	1891	54	0

Source: Data compiled from Otis W. Caldwell and Stuart A. Courtis, *Then and Now in Education, 1845–1923: A Message of Encouragement from the Past to the Present* (Yonkers-on-Hudson, N.Y., 1925), 342, 344.

The evidence provided by newspaper advertisements, tuition rates, and reports of school examinations reveals a distinctly greater emphasis on scientific subjects in schools for middle-class girls than in similar institutions for boys. At first offered to the children of elites in academies and

inations in all subjects. The examiners, perhaps unable to see beyond the social status of Brimmer's students, nevertheless held unflinchingly to a belief in the intelligence of the school's scholars: "The boys of the first class have . . . a general intelligence, which was perfectly obvious to the committee, but of which no record can appear in our tables" (*ibid.*, 184). Caldwell and Courtis, *Then and Now in Education*, 342–44. In fact, the girls' schools Bowdoin and Wells ranked within the top three schools on each of the remaining examinations as well, a phenomenon that must be interpreted with caution. Generally, girls stayed in school longer than boys. In Boston, boys were required to leave school at the end of the term after their fourteenth birthday, while girls could remain until the end of the term after their sixteenth birthday. The average age of the girls examined at Bowdoin was fourteen years and eight months, while the average age of the boys at Brimmer was thirteen years. However, age alone did not account for all the differences in scores. On the history examination, for example, boys from Adams school, whose average age was only twelve years and eleven months, outscored the girls from Wells, whose average age was thirteen years and three months (Caldwell and Courtis, *Then and Now in Education*, 14, 330). See also "Boston Grammar and Writing Schools," in *Common School Journal* 7 (Oct. 1845): 292, 296–97.

seminaries, the sciences began to appear more frequently in common schools in the late 1830s. A sampling of the school returns in Massachusetts reveals a substantial increase in the percentage of towns reporting the use of science textbooks in the common schools during a brief four-year period beginning in 1837.³⁸

In order to understand why the sciences were more prevalent in girls' schools than in boys' schools before 1840, it is important to consider the social and cultural context influencing these institutions in the early nineteenth century. One explanation for the dominance of the traditional classical curriculum in boys' academies lies in the entrance requirements of local colleges. In 1810, the University of Pennsylvania required candidates to translate Caesar's *Commentaries* and Virgil, to translate English exercises into Latin, and to translate the Gospels from Greek. Thirty years later, admission requirements of male colleges generally covered parts of Caesar, Virgil, Cicero, the *Anabasis*, and the *Iliad*. For college-bound students, the years of study necessary to achieve mastery in the classics must have left little time for other subjects. Nathaniel True, a student at Maine's North Yarmouth Academy during the 1820s, recalled his classical studies as being all-consuming: "I sat up one night a week during the term without retiring and studied every night until midnight. I averaged more than eighteen hours a day in getting my two Latin lessons each day for recitation."³⁹

A second reason for the durability of the classical curriculum was the social prestige of classical study in American nineteenth-century culture. Although the great majority of academy students may not have gone on to college, the attainment of classical knowledge conferred a gentlemanly polish on boys who eventually planned to manage their fathers' plantations or pursue a career in business. In their interviews with British middle-class parents in the 1860s, inspectors for the Taunton Commission discovered that parents simply did not wish to experiment with the education of their sons. Instead, parents expressed the belief that "to learn the classics was a definite mark of an upper class and clearly separated the education of their sons from that of a merely commercial school."⁴⁰ Ameri-

³⁸Data compiled from a random sampling of thirty towns each in *First Abstract of the Massachusetts School Returns for 1837* (Boston, 1838), and *Abstract of the Massachusetts School Returns, 1840–41* (Boston, 1841). In 1837, 17 percent of towns reported using natural philosophy textbooks in their common schools, 10 percent reported chemistry and 7 percent astronomy textbooks. In 1841, 73 percent reported using natural philosophy textbooks, 20 percent reported chemistry, 23 percent astronomy, and 3 percent natural history textbooks.

³⁹Mulhern, *A History of Secondary Education in Pennsylvania*, 323–24; Woody, *A History of Women's Education in the United States*, 2: 163ff. True quoted in Ruth Arline Wray, *The History of Secondary Education in Cumberland and Sagadahoc Counties in Maine* (Orono, Me., 1940), 47.

⁴⁰As late as 1864, the state superintendent of Pennsylvania reported that "It is not probable that more than one-eighth of the students in the academies and seminaries pass on

cans were undoubtedly equally anxious to maintain or elevate the social status of their children.

The schoolmasters in boys' academies constitute a third factor in the resistance of these institutions to offer scientific instruction. Having been trained in the classics themselves, many instructors were probably reluctant to add new subjects to the curriculum. Often, those who defended Latin as the ideal educational instrument for mental training had vested interests in maintaining the status quo, being either schoolmasters or professors of Latin in college classics departments.⁴¹

A fourth influence on the curricula in male academies was the existing job market. Because there were relatively few profitable career opportunities for young men as physicists, astronomers, geologists, or botanists in the early nineteenth century, there was little incentive to promote these subjects in the academies on the basis of their vocational value. By the third decade of the century, the era of the great surveys was just beginning. In 1830, a writer noted that the science of geology was virtually unknown in the smaller communities of the United States: "A geologist in a retired town, engaged in his examination of rocks, is often surrounded by a collection of individuals, eying him with contempt; pity, or suspicion." Even forty years later, the appearance of a scientist in a small town was a novelty.⁴² Although entrance to the medical profession required scientific study, those aspiring to become doctors traditionally studied the sciences in college after a rigorous classical training at the academy. A similar path, in which classical training preceded scientific study, lay ahead of those seeking to become professional scientists.

In fact, what might be termed vocational subjects were relatively scarce in academies before 1840. For example, while some forms of employment required knowledge of navigation, mensuration, or surveying, fewer than a third of academies in Pennsylvania and North Carolina

through a college course." Quoted in Rev. J. Fraser, *Report on the Common School System of the United States and of the Provinces of Upper and Lower Canada* (1867) [3857] XXVI.293 mf 73.216–20, 106. Taunton Commission report quoted in Phillips, *The Scientific Lady*, 239–40.

⁴¹For example, see William Hooper, "Imperfections of Our Primary Schools, 1833" in *North Carolina Schools*, ed. Coon, 729–50. Hooper was professor of ancient language in the University of North Carolina. In a speech designed to alert North Carolinians to the dangers posed by the new trends in education, Hooper announced that students entering Andover Academy "cannot decline their Greek nouns and verbs with any tolerable accuracy" (*ibid.*, 734).

⁴²Ralph S. Bates, *Scientific Societies in the United States* (Cambridge, Mass., 1965; 1945), 33; A. Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities to 1940* (New York, 1964), 383–86; "Geological Studies," *American Annals of Education* 1 (Oct./Nov. 1830): 141; "Lucy Millington," unpublished manuscript by Liberty Hyde Bailey, file 1, box 8, Liberty Hyde Bailey Papers, Carl Kroch Library, Cornell University. Bailey, who grew up in South Haven, Michigan, wrote that he had seen only one botanist, a visiting lecturer in the town lyceum, before meeting Lucy Millington in 1876.

provided instruction in these subjects before 1840. This state of affairs can be explained by the existence of competing institutions. Such institutions as mechanics' institutes and other evening schools offered vocational training to young men needing to work during the day. The following advertisement for an evening school in North Carolina is fairly representative: "The subscriber will open an Evening School . . . [where] will be taught Reading, Writing, English Grammar, Geography, Arithmetic, Trigonometry, Mensuration of Surfaces and Solids, Navigation and Surveying."⁴³

We can infer that many upper- and middle-class American parents considered the study of the sciences an unnecessary frill in the education of their sons. Marketing their programs to this audience through local newspapers, southern male academies advertised the classics far more frequently than the sciences. And whereas a greater percentage of institutions in some northern states advertised scientific subjects, in practice, classical study probably predominated in most northern institutions as well. It is likely that parents disdained the sciences because such subjects were not needed to gain entrance to college, had little value in imparting the gentlemanly polish of liberal culture, and afforded relatively few career opportunities. When he visited America in the 1850s, Swedish commentator Per Siljestrom noted with surprise that Americans appeared to hold the natural sciences in relatively low esteem.⁴⁴

Although parents may not have considered the sciences quite good enough for their sons, they viewed them as acceptable for their daughters. The most important factor in the rise of scientific subjects in girls' schools is the novelty of the institutions themselves. Unlike boys' academies, which were preceded by the Latin grammar schools, there was no precedent for the curriculum in female seminaries. As a result, educational reformers seeking to bring the sciences into secondary schools were far more likely to succeed in girls' schools.

College entrance requirements, so influential in the male academies, held little sway over educational institutions for girls. Because colleges were generally not open to women before 1850, girls' schools were free of the burden of preparing students for entrance requirements in the clas-

⁴³Data compiled from Mulhern, *A History of Secondary Education in Pennsylvania*, 328; Mulhern's sample of forty-seven academies (1750 to 1829) reveals that 9 percent offered mensuration, 19 percent surveying, and 13 percent navigation; data compiled from *North Carolina Schools and Academies*, ed. Coon: the advertisements of 56 academies from the period 1794 to 1840 reveal that 9 percent offered mensuration, 29 percent surveying, and 13 percent navigation. See *Columbian Centinal* (Boston, Mass., 6 Oct. 1827); *Raleigh Register* (30 Sep. 1828), in *North Carolina Schools and Academies*, ed. Coon, 494; Mulhern, *A History of Secondary Education in Pennsylvania*, 472; "A Night School," in *Raleigh Register*, 30 Sep. 1828, in *North Carolina Schools and Academies*, ed. Coon, 494.

⁴⁴Per Siljestrom, *The Educational Institutions of the United States, Their Character and Organization* (London, 1853), 393.

sics. In addition, the study of the classics was traditionally the prerogative of males. In 1803, one writer who supported the education of girls nevertheless cautioned against allowing them to study the classics, advising parents to “Let your girls go in hand with your boys, as far as reading, writing, and accounts; there draw a line, for girls have nothing to do with Latin and Greek.”⁴⁵

The influence of trends from Europe undoubtedly played a part in the development of women’s scientific interests in the United States. The eighteenth century witnessed an increase in the production of popular science in both Great Britain and France, and the numbers of science books written for a female audience gradually increased. These publications were primarily elementary textbooks for women and children, in which concepts of natural philosophy, chemistry, or natural history were conveyed through the medium of female characters, a format that effectively emphasized the appropriateness of women’s scientific interests. Since the seventeenth century, there had been a steady flow of ideas from Great Britain and Europe to North America, and the same sources of transmission increased in the eighteenth century. Newspapers, books, pamphlets, and periodicals reprinted European and British articles and stories. In addition, personal contact by travel and correspondence guaranteed an exchange of ideas between countries. Soon, Americans published their own popular science books for women, and their texts quickly appeared on bookstore shelves next to European imports.⁴⁶

The almost complete lack of public opposition to the study of science in girls’ schools can be attributed to the tacit acceptance of this movement among many American scientists. For America’s fledgling scientific community, there were benefits to be gained by encouraging females to study the sciences. First, as popularizers of science, women helped to create a supportive public. In an era when few public funds were available for scientific enterprises, the popularization of science ensured a public receptive to the necessary financing of experiments, surveys, and expeditions. Second, as consumers of popular science, women’s numbers swelled the audiences at Lyceum lectures, helping to pay the salaries of male scientists who traveled the lecture circuit. Also, such scientists as Benjamin Silli-

⁴⁵Mulhern, *A History of Secondary Education in Pennsylvania*, 323; Woody, *A History of Women’s Education in the United States 2*: 163; quoted in Mulhern, *A History of Secondary Education in Pennsylvania*, 391.

⁴⁶The exchange of ideas between America and Europe is discussed in Bernard Bailyn, “Political Experience and Enlightenment Ideas in Eighteenth-Century America,” in *An American Enlightenment: Selected Articles on Colonial Intellectual History*, ed. Peter Charles Hoffer (New York, 1988), 134–46. For an overview of women’s participation in natural history and their authorship of popular science books for women, see Marcia Bonta, *Women in the Field: America’s Pioneering Women Naturalists* (College Station, 1991); Vera Norwood, *Made from This Earth: American Women and Nature* (Chapel Hill, N.C., 1993).

man, Denison Olmsted, Asa Gray, and others wrote science textbooks and developed scientific apparatus for the use of academies and seminaries, and the royalties from the sales of these materials in girls' schools must have produced handsome profits. Third, as collectors of mineral and botanical specimens, women amateurs served as unpaid assistants aiding the research efforts of professional male scientists in herbaria, museums, and colleges.

The social and cultural influences briefly outlined here helped to create an educational climate in which scientific subjects easily gained entry into the curriculum of educational institutions for middle- and upper-class girls. While science was initially included in the courses of study of academies and seminaries, by the mid-nineteenth century its presence was also beginning to be felt in common schools.

The central conclusion of this study is that increasingly toward the middle decades of the nineteenth century, a young woman's education included the study of the sciences. The reported courses of study of early girls' schools, seminaries, and academies evidences a greater emphasis on scientific subjects than the curricula of similar, contemporary institutions for boys.

Historians of science have frequently noted the rapid entry of women into scientific fields in the United States in the latter half of the nineteenth century. Heretofore, explanations of this phenomenon have centered either on the extracurricular scientific literature increasingly aimed at a female audience during the late eighteenth and early nineteenth centuries, or on the opening of colleges and universities to women during the latter decades of the nineteenth century.⁴⁷ This study presents a consistent body of evidence to support the conclusion that a scientific curriculum was widely implemented in schools for American girls from the first decades of the nineteenth century. The science education of American girls in the antebellum period thus constitutes a likely and hitherto overlooked factor in the rise of science as a female interest after the Civil War.

⁴⁷See Margaret W. Rossiter, *Women Scientists in America: Struggles and Strategies to 1940* (Baltimore, Md., 1982), 1–28; Lynn Barber, *The Heyday of Natural History, 1820–1870* (Garden City, N.Y., 1980); Keeney, *The Botanizers*.