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Our Great Physicist: Professor Joseph Henry of Princeton and the Rise of Science in the Antebellum College

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OUR GREAT PHYSICIST
Professor Joseph Henry of Princeton and the Rise of Science in the Antebellum College

A Thesis
Presented to
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The College of William and Mary in Virginia

In Partial Fulfillment
Of the Requirements for the Degree of

Master of Arts

by
Sarah Swords
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APPROVAL SHEET

This thesis is submitted in partial fulfillment of
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ABSTRACT

There is an old adage among educators that changing a curriculum is like moving a graveyard. It is usually a labor intensive, messy, and controversial task, but more often than not one that is necessary if a department or an institution is to keep up with the ever-changing needs of their students. In the first half of the nineteenth century many United State colleges were faced with just such a problem; they could either restructure their curriculum to align more closely with the practical needs of a rapidly industrializing nation, or they could face the possibility of closing their doors forever. While some contemporary educators tried to substitute adjunct programs instead of significantly restructuring their curriculum, it was largely due to a handful of dedicated scientists at key institutions who insured that a new liberal and scientific collegiate curriculum would become the norm in the new nation.

This investigation attempts to examine this change in the scientific instruction at the American colleges through the papers of one notable reformer, Professor Joseph Henry of the College of New Jersey in Princeton. By going beyond the explanations of a broader study, which might focus on the pressures of an industrializing market, this more detailed study seeks to uncover the specific personal reasons and methods that Professor Henry used to affect scientific reform at one of the nation's foremost institutions.

To do this the first chapter sets up the background, briefly surveying the history of the College of New Jersey in particular, and the curricular history of the American colleges more generally. Within this framework, the second chapter examines the specific ways in which Henry worked to insure that both the students under his own tutelage and those who would come after he left, would receive a broad scientific and practical education. Finally, the conclusion offers some reflections on how such a broad change affected Henry's own students, and how the legacy of such scientific curricular reform influences the general education of modern university students.
OUR GREAT PHYSICIST
INTRODUCTION

PROFESSOR JOSEPH HENRY

Carefully putting down his pen, Professor Joseph Henry rested his eyes as he waited for the ink on his letter to dry. A large man with bright blue eyes, Henry was an imposing figure in a classroom, but now his frame sat slightly stooped in his chair. Around him the room slowly grew darker as the thin winter sun struggled to break through one of the worst snow storms Washington D.C. had seen in years.

It was the 17th of December 1846 and already Henry had been away from his family in Princeton, New Jersey for almost a week. He had traveled to the capitol to begin his work as the first secretary of the Smithsonian Institute. It was an exciting opportunity, and one that Henry thought would enable him to do much for the “interest of science, and the good of mankind.”¹ But it was also a daunting task. That week, Henry had already attended debates in congress, met with the institute’s regents, and surveyed possible locations for the new building. All of this, with the added hindrance of the snow outside, had left him incredibly tired, so much so that he had mixed up the date on the letter which he had just finished to his wife.² And now after this long day of appointments, he next needed to write his resignation letter to the College of New Jersey, so that it could arrive in Princeton before the trustees’ meeting on the 21st of the month.

² Ibid.
While Henry was undoubtedly looking forward to his new position with the Smithsonian, he struggled with the decision to leave Princeton. He had, after all, put so much of himself into his courses at the College, that it was understandable if he paused for a moment to contemplate how to phrase his resignation.

Having come to Princeton in the fall of 1832, Henry was in the middle of his 14th year of teaching. Although he had never attended college himself, his prior experience teaching at the Albany Academy and his groundbreaking work with electromagnetism and self-induction had made Henry particularly well-suited for his position as the premier science professor at The College of New Jersey. The trustees had hired Henry not just to teach but also to improve the science curriculum and to win prestige for the institution with his discoveries.

With these goals in mind, Henry had first arrived on the campus expecting to find a modern laboratory in which he could continue his experiments, as well as scientific equipment with which he could demonstrate the basic principles of physics to his students. Instead, he found a paltry collection of out-of-date instruments crammed into an older building that shared space with the library and the literary societies. Postponing his own research, Henry spent much of his first years at the College concentrating all of his efforts on obtaining and improvising as many instruments as he could for his classes. He worked to renovate the College’s Philosophical Hall and make room for a new laboratory, while at the same time lobbying for a greater variety of more effective teaching methods for science courses. With an already full week of four lectures and the normal round of recitations, Henry had often sat up late into the night working on ways he could help his students to better understand the laws of natural philosophy.
But Henry was not the only professor in American colleges trying to change the curriculum. He was part of a larger movement in antebellum American colleges. Before the nineteenth century, the curriculum at most American colleges still concentrated on ancient languages, theology, and classical learning, but a growing demand for a more practical education forced American colleges to change what and how they taught their students, or risk losing them to other institutions. Although this curricular change was most noticeable at the institutional level, it was the work of individuals such as Benjamin Silliman at Yale, Alexander Bache at the University of Pennsylvania, and Joseph Henry at Princeton who worked every day to establish science as an integral part of the American curriculum. By looking closer at the professional lives of such men as Joseph Henry, we can see not only what changed about the curriculum, but how that change took place.

With thoughts of what he had already accomplished in Princeton, and of what was still to do in Washington, Henry opened his eyes and, taking up his pen once again, began a draft of his resignation. He had not gotten far though, before looking up and realizing the lateness of the hour. He would have to rush if he was to make it to the post office in time for the 4:00 mail. Setting the draft aside, he quickly folded and addressed the letter to his wife and hurried from the room. After all he had neglected to write yesterday, and he would not want his wife Harriet to worry.

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CHAPTER 1
THE COLLEGE OF NEW JERSEY AND THE CURRICULAR CONCERNS OF EARLY AMERICAN COLLEGES

Like most American colleges, Princeton did not begin as a great center of scientific learning. What was then known as The College of New Jersey started with only a handful of students primarily destined for Presbyterian pulpits. With no buildings, books, or substantial financial backing, the college first met in Elizabeth, New Jersey, at the home of the new president, the Rev. Jonathan Dickinson. There the students used extra bedrooms in Dickinson’s house and in the houses of his neighbors as dormitories, read from Dickinson’s own personal library, used the dining room as a refectory, and listened to lectures in the parlor instead of a formal classroom. Each day the small group of students gathered around Dickinson to study Latin, Greek, philosophy, and divinity, or met in the parlor to recite their lessons to their tutor, the young Rev. Caleb Smith. Thus with only two instructors, meager resources, and six or seven students, the early classes must have been quite informal. They must have been sufficient, though, for on November 9, 1748, just over two years after the college opened, the first class of six young men graduated from the College of New Jersey. Though it would be many years

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5 Ibid, 28.
before the college established itself in the pantheon of American colleges, this was the first of a long line of commencements, which stretches unbroken to the present day.

Although The College of New Jersey was founded by New Light Presbyterians to train ministers in the wake of the religious revivals in the 1730s and 1740s, the trustees intended the college to be more than a seminary. Aware that a school exclusively for New Light Presbyterians would not survive, they opened their college to students of “every religion” in hopes of creating a “free and equal” environment that would afford the “liberties and advantages” of education to all types of students. Such a place would “raise up men that will be useful in other learned professions – ornaments of the State as well as the Church.”

Aaron Burr, one of the founders, noted that at the time the middle colonies had no institution of higher learning. Young men from these colonies who wanted to attend college had to travel a considerable distance either to Yale in New Haven, Connecticut, or to William and Mary in Williamsburg, Virginia. Thus the trustees felt that a college located in New Jersey would be ideally situated to serve the needs of the young men from the middle colonies. After considerable lobbying and persuasion, the governor of New Jersey granted the trustees a charter on October 22, 1746 for a college to train clergy and lay leaders alike.

Keeping the original goals of the charter in mind, Aaron Burr, the second president of the college who assumed the presidency after the death of Dickinson in May 1747, tried to design a diverse curriculum, which would prepare his students for whatever pursuits they chose. Burr moved the students from Elizabeth to his home in Newark and

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worked tirelessly to coordinate housing for the students, teach classes, and raise funds to keep the young school afloat. He took special pains in choosing the subjects his students would study. He wanted to avoid the criticism of insufficient education leveled at William Tenant's "Log College," and so he looked to Harvard, Yale, and the dissenting academies of England as models. Like the other colonial colleges, Burr offered instruction in the classics, philosophy, divinity, and logic. But he and his successors chose to follow the path of the dissenting academies by shifting the focus of the curriculum away from the classics in favor of more mathematics and natural philosophy.

Burr's decision to incorporate more science into the curriculum represented a larger trend in the colonial colleges. Although most of the colonial colleges were associated with a particular denomination (Harvard and Yale with the Congregationalists, Brown with the Baptists, Rutgers with the Dutch Reform Church, William and Mary with the Church of England, and Princeton with the Presbyterians) they were not merely seminaries. In an increasingly complex society, the colleges needed to train their students for all manner of professions, not just the ministry. In fact, the number of Harvard and Yale graduates who went on to become ordained ministers dropped from sixty to forty percent from the end of the seventeenth century to the early 1740s, and over the next hundred years would drop another twenty percent. The increasing numbers of students who pursued non-ministerial professions persuaded the colonial colleges to offer a wider
variety of practical subjects, such as mathematics or natural philosophy, which would be useful in business or trade.

By the time the College of New Jersey opened, most colonial colleges loosely followed the course of study presented to Harvard's trustees by President Henry Dunster in 1642. The basic tenets of this plan called for the first one or two years to be spent in the study of the academic languages, Latin, Greek, and Hebrew. In this year (or two years) the student was to gain the tools he needed to acquire the knowledge he would acquire in later years. In the next year, the student would be introduced to philosophy, logic, and rhetoric, all skills he would use to interpret what he could now read in Latin, Greek, or Hebrew. In the student's last year, his hard work would be rewarded with exposure to natural philosophy and mathematics. In addition to this progression of skills, each student was required to study the catechism and portions of history and botany throughout his three or four years. Believing that recitation yielded the best academic results, Dunster had his students attend recitations in the mornings, while he reserved the afternoons for declamations and debates. It was thought that if a student assiduously applied himself to this course of study, he would gain not only basic factual knowledge, but also the interpretive and rhetorical skills he would need to be inducted into the community of educated men.

While Dunster's educational plan included scientific subjects in the curriculum, it usually only allowed for limited study in the student's last year. Instructors viewed

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12 Interestingly, this plan makes no provision for physical exercise; in fact, as in the earlier schools in England, exercise other than walking was forbidden. Later educators would point to this omission as the cause of the student unrest in the early nineteenth century. Craig R. Thompson, *Universities in Tudor England* (Washington DC: Folger Shakespeare Library, 1959), 23-24.
science as a reward reserved for experienced students, or an exercise of their previously learned skills in languages and philosophy. This hoarding of science might have been more a result of scarce resources than a dearth of information in the discipline as a whole, for in Europe science was making significant advancements under the influence of the Scientific Revolution. No longer did European academics describe the physical world in terms of the four elements and qualities; instead, by the end of the seventeenth century they spoke of particles and forces. The microscope and the telescope had opened up unseen universes for biologists, physicists, and astronomers alike. The works of Newton, Descartes, and Leibniz revolutionized mathematics, while Galileo, Kepler, and Boyle redrew the maps of the sky. Outside of the universities, such groups like the Circle of Savants in Prague at the court of Rudolf II, in Paris the Montmor Academy, or the more regular societies, such as the Accademia dei Lincei, the Accademia del Cimento, the Acadamie Royal des Sciences and the Royal Society of London all enabled intellectuals to pursue science free from the duties associated with teaching.\footnote{Hilde Ridder-Symoens, ed, \textit{A History of the University in Europe, Volume II: Universities in Early Modern Europe: 1500-1800} (Cambridge: Cambridge University Press, 1996), 481-85.} Taken individually, the work of any one man did not completely revolutionize natural philosophy, but taken together, the advancements made in Europe in the seventeenth century changed how academics viewed the material world. It was an exciting time for both scientists and academics, but unfortunately the scarce resources of the colonial colleges prevented the schools from communicating much of the new knowledge to their students.

Several factors combined to hold scientific subjects back from wider instruction in the colonial colleges. For one, there was no standard system of secondary schools in the colonies. Since most college-entrance exams tested only Latin and Greek, the colleges
could not assume any prior knowledge in subjects such as arithmetic or geography. This meant that many colleges had to provide remedial education in the first and second year before any sort of higher science courses could be offered. Also, the system of hiring recent college graduates as general tutors for an entire class provided the students with teachers who were only slightly more educated than themselves. Since the tutors instructed an entire class in all subjects, they had to be jacks-of-all-trades and thus masters of none. Additionally, financial constraints prevented some colleges from hiring science professors or from acquiring philosophical apparatus. However, even when a college did have the money to hire a professor, the lack of scientific education in the colonies meant that very few applicants were qualified to take the positions.\footnote{As late as 1824, Jefferson was so frustrated in his search for an adequate science professor for the University of Virginia that he was forced to seek one in Europe. Theodore Homberger, \textit{Scientific Thought in the American Colleges 1638-1800} (Austin: University of Texas Press, 1945), 4.} Some colleges solved this problem by hiring local physicians to give adjunct lectures in anatomy or the natural sciences, but even these supplements were unreliable. With so many factors hindering science in the colonies, it is no wonder that scientific instruction rarely went beyond a simple list of definitions in the century after Dunster first introduced his educational plan.\footnote{Guralnick, "American Scientist," 4.} Thus it seems that by the mid-eighteenth century, very little actual science was being taught in the American colleges.

This is not to say that scientific education completely stagnated in the colonial period. There was no steady improvement in the colonial colleges as a whole, but small gains continued throughout the eighteenth century. Since any advancement in mathematics or natural philosophy depended heavily on a single professor at each institution, and on the financial backing that may or may not have been available to pay
that professor's salary, advances occurred only sporadically. In 1711 William and Mary became the first colonial college to employ a professor exclusively to instruct the students in natural philosophy and mathematics. Later, Harvard and Yale joined William and Mary to become the first colleges to acquire philosophical apparatus for use in their classrooms. While these were important steps, only a few colleges could afford to implement scientific change.

In the mid-eighteenth century, science and mathematics received a considerable boost from two Newtonian scientists, Professor John Winthrop at Harvard (1738-1779) and Thomas Clap, the rector of Yale (1739-1766). An avid advocate of observation and experimentation, Winthrop led an expedition to Newfoundland to observe the transit of Venus in 1761. Back in Massachusetts, he established the first American laboratory of experimental physics, which helped to redefine how academics viewed the place of research in education. At Yale, Clap reduced instruction in logic in favor of mathematics, and purchased microscopes, barometers, and surveying equipment for the use of the students. He also made Yale the first college to require some arithmetic on its entrance exams, clearing the curriculum for more advanced studies.\(^\text{18}\)

In Princeton, continuing financial concerns and a tragic series of short-lived presidents conspired to hinder the college's academic development. Without funds to purchase the same types of equipment that Clap was using at Yale, professors in Princeton relied on textbooks and discussion to teach their students modern scientific techniques. The students memorized their lessons before morning recitation, after which they were asked to propose possible problems with or ways of testing the theories which

\(^{17}\) Rudolph, *Curriculum*, 34.  
\(^{18}\) Ibid.
they had just read. In the absence of the philosophical apparatus needed to provide practical demonstrations, this method of recitation and limited discussion was the only way to help the students understand the scientific principles about which they were reading. While the science taught in Princeton was undoubtedly less sophisticated than that at Harvard, Yale, or William and Mary, by the time John Witherspoon came to Princeton in 1768 the college’s graduates were studying a higher level of science than the graduates of the universities Witherspoon had just left in Scotland. On the eve of the Revolution, Princeton, like other colonial colleges, was continuing to enrich its curriculum and, it was hoped, the minds of America’s young leaders.

While the Revolutionary War did not cause any appreciable decline in Enlightenment ideals, which promoted science in the curriculum, it did inflict significant material damage on most of the schools. Every colonial college (except Dartmouth) has its own story of sacrifice, occupation, or declining enrollments, but Princeton was one of the hardest hit. After hosting troops from both the British and the American side, being the location of a battle, and serving briefly as the nation’s capital, the campus was almost unusable. Nassau Hall, which in 1756 was “the largest and most imposing structure in the [British] colonies,” sustained so much damage that it would be years before the upper floors were habitable again. With the students and faculty scattered and with President Witherspoon occupied with political matters in Philadelphia, the trustees did not know if the college would continue. Nevertheless, just as in previous years, the college again opened her dilapidated doors to her students, and, as always, held commencement ceremonies in honor of her graduates.

A tumultuous time for the nation as a whole, the years following the Revolution were especially difficult for the college and its peer institutions. Not only did they have to rebuild their campuses and enrollments, they faced the task of redefining themselves as American, rather than colonial, colleges. Before the Revolution the educational system in America had a surprising lack of standardization. Without any comprehensive system of grammar schools or unifying goal, each college followed its own guidelines and teaching philosophies. This resulted in a collection of colleges where instruction was offered over three or four years and either a bachelor’s degree or a master’s degree was awarded for what ostensibly should have been a similar education. In the midst of such variance, it was not clear just what method of education would serve the new nation best.

Very little change in the college curriculum occurred immediately after the Revolutionary War. Previously, the colonial colleges had constantly looked to the universities and academies of England as models, but now anti-English and anti-Jacobin sentiment helped to limit such emulation. Additionally, living in a primarily agrarian society, Americans did not feel the same impulse to industrialize that motivated European scientists. Thus while scientists in Europe used the telescope to discover Uranus, found new atomic elements, began to understand the effects of infrared and ultraviolet radiation, harnessed the power of steam, and established geology and scientific agriculture as legitimate fields of study, students at Harvard were still learning about static charge because the college could not afford a battery to demonstrate any stronger form of electricity.20

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Continuing financial concerns meant that the quality and quantity of scientific education largely lay in the hands of one individual at each institution. When trustees were faced with a constrained budget, science was often the first subject to go and the last to receive appropriations for new equipment. Nevertheless, some colleges continued to make small gains. From 1796 to 1806, Princeton followed Union College in instituting a special non-degree program in science. Although these students would not receive a traditional Bachelor of Arts degree, they could earn a sort of scientific certification after spending three years at the college attending scientific lectures and discussions. Around the same time, other colleges added to their scientific instruction by hiring new professors of natural philosophy. As early as 1802, Yale asked Benjamin Silliman to abandon his religious pursuits in favor of a position teaching natural philosophy and mathematics to its students. Soon James Dean at the University of Vermont, Parker Cleveland at Bowdon, and Chester Due at Williams had been asked to leave the ministry for careers as science professors.21 Slowly, but steadily, the American colleges worked to bring their curricula up to par with those of Europe as universities.

While the American colleges were still struggling to include science in their core curricula, the United States Congress established West Point in 1802, the first technological institute in America. Here the cadets used cutting-edge European textbooks, only recently translated by their professors. They studied chemistry, advanced mathematics, astronomy, engineering, drawing, and French. Without the encumbrance of traditional subjects and conceptions of education, the professors at West Point were free to include only the most modern and the most practical material in their classes. This type of technical education proved extremely useful for the graduates of West Point. When the

21 Ibid, 20.
country needed engineers to help build canals and railroads in the early nineteenth century, it was primarily graduates of West Point and Union College who were most qualified for the job.\textsuperscript{22}

In 1824, the Rensselaer Polytechnic Institute became the country's second technological institution. Though RPI did not grant its graduates a formal degree, it did offer course work in applied sciences and became the home of American scientific experimental research.\textsuperscript{23} Soon it became apparent that if a young man wanted to go into engineering, even if he had a degree from a liberal arts college, he would probably have to attend West Point, Union College, or RPI before he could find a job. Thus while the technical schools began to train the country's designers, surveyors, and engineers, the other colleges continued to struggle with the problems of strained budgets, insufficient numbers of professors, and ill-prepared students. After 1824, this predicament would change.

In the early years of the nineteenth century, the American colleges received long-overdue help from the lower levels of academia. After the Revolution, a plethora of new academies sprang up throughout the country. By 1797, Massachusetts had acquired 15 new schools; by 1819, Pennsylvania had 55, and over all the country had acquired almost a thousand new secondary academies. The appearance of these academies meant that now American colleges would not have to function more as secondary schools than as colleges. No longer would the occasional ill-prepared 12-year-old student be admitted to the college and no longer would the tutors be responsible for so much remedial instruction. As these secondary academies too were working to broaden their curricula,

\textsuperscript{22} Rudolph, \textit{Curriculum}, 62.
\textsuperscript{23} Ibid.
many new applicants to colleges usually had already been exposed to algebra, astronomy, chemistry, and botany. The average student was now approximately seventeen years old and came to college with at least a rudimentary understanding of the sciences. The development of the academies meant that a whole new realm of education was open to the colleges. They could omit instruction in the basics and offer courses in more advanced subjects. It also meant that the colleges had to make some decisions as to what they should expect from the academies, what types of admission standards they should set, and what types of higher subjects should now make up the college curriculum. It soon became apparent that whatever standards the colleges chose, they would have to raise their standards quickly, for as soon as students started to realize that they could learn the same information at a secondary academy as they could at the colleges, attendance at the colleges began to decline.\textsuperscript{24}

With so many new colleges opening their doors, and with enrollment failing to keep up with population growth, the American colleges could not afford to fall behind both the technical schools and the academies. Thus on September 18, 1818, representatives from Union, Bowdon, Harvard, Middlebury, Vermont, and Yale gathered in New Haven to discuss the future of higher education in the United States. At this first meeting, John Kirkland, president of Harvard, and Jeremiah Day, president of Yale, formed a special committee to review and “propose measures to affect a greater uniformity in the requisite attainments for admission into college, and in the books to be used previously and subsequently to admission.”\textsuperscript{25} Before this meeting, colleges had been largely local insular institutions founded by specific groups and drawing their students

\textsuperscript{24} George H. Daniels, \textit{American Science in the Age of Jackson} (New York: Columbia University Press, 1968), 34-36.
\textsuperscript{25} Quoted in Guralnick, \textit{Science and Ante-bellum American College}, 23.
from a particular region. Focusing their attention on their own missions and the needs of their particular students, the colleges had rarely conferred with other institutions on matters of curriculum or policies. However, the New Haven meeting and especially Kirkland and Day’s report proved highly useful in initiating constructive comparisons between the schools. The faculty and students at many institutions already were pushing for increased instruction in the physical sciences and modern languages, but by accepting the standards of the committee, the colleges would have a basic outline on which they could more easily build their own particular curricula. Not quite a year later, on May 24, 1819, other colleges such as Brown and Dartmouth joined the original institutions in the Boston courthouse for the (now) annual meeting of the Collegiate Convention.\textsuperscript{26}

Around this time many American colleges began to publish course catalogs, which provided course descriptions, information on the faculty, and the college’s requirements for admission and graduation. With so much information now at their fingertips, prospective students could review the offerings at several colleges before deciding on one. Since a distinct weakness or an innovation in one college would easily show up when compared to several other institutions, competition between the colleges increased markedly. The publication of descriptive catalogs also had the unexpected effect of opening the college’s curriculum to public discussion. Once the catalogs became public, the colleges began to come under attack from critics outside of academia, who thought that the colleges spent too much time on traditional subjects and not enough time teaching the students the practical and vocational knowledge they would need to succeed in the modern marketplace. “Were the current college structure and disciplinary methods the most effective?” they asked. Could the colleges keep step with the ideals of an

\textsuperscript{26} Ibid, 23.
"enlightened" Jacksonian society, if their students spent the majority of their time studying dead languages? These questions seemed all the more pressing because they came while many colleges were struggling with a series of student uprisings. In the face of such public criticism, administrators at the various colleges rushed to find a public solution to the accusations.27

 Appropriately enough, Harvard, the oldest of the American colleges, was the first to respond to this critique with significant reform. In 1823, immediately following a student rebellion, Professor George Ticknor presented Harvard's board of trustees with a report of what he saw as the weaknesses of the college's current curriculum. A professor of modern languages, Ticknor had been greatly influenced by his time studying at a German university and now wanted to rebuild Harvard on the same Germanic model. Among other things, Ticknor's 48-page document attacked the teaching method of recitation, which he thought taught a student a book, not a subject. Lecturing, in his opinion, was also too passive and a waste of the students' time. Ticknor pointed out that the system of separating the students according to their class year and not according to their abilities held some students back, while it deprived slower students of the time and individual instruction they needed to learn. He also argued that Harvard was not using its ample resources as efficiently and judiciously as it might. He felt that since Harvard had the ability to make such institutions as "the agricultural schools, the law schools, and the other establishments for special purposes"28 unnecessary, then why should they not open up the school to all students who could afford the education? To match his long list of complaints, Ticknor had an equally long list of solutions, which ranged from shortening

vacations to completely restructuring the college to resemble a German university. Although Harvard did not implement the majority of Ticknor’s suggestions, the report did spur Harvard to make some concessions, such as separating faculty and professorial chairs into specialized departments and instituting a limited number of electives. Over the next few years the college worked to initiate even greater changes, until Harvard became one of the leading research universities in the country.

Following in the steps of Harvard, faculty members at both Amherst and the University of Vermont tried to breathe new life into their colleges with their own solutions to the public criticism. In 1826, Jacob Abbot Amherst, professor of mathematics and natural philosophy, organized a group of faculty members who presented the trustees with a detailed account of what they saw as Amherst’s weaknesses. In response, the trustees appointed a special committee to investigate the state of the college and to suggest appropriate changes. The resulting report called for a new course of instruction, which would emphasize theoretical mechanics, chemistry, natural philosophy, and other applied sciences. The plan also included modern languages, lessons in applying scientific techniques to practical arts and trade, and lectures on labor saving machinery, to better prepare their students for careers as merchants or farmers.

In Burlington, the threat of institutional bankruptcy drove the University of Vermont’s new president, James Marsh, to attempt to institute his own plan for curricular reform. Like the administrators of Harvard and Amherst before him, Marsh quickly divided the faculty into four distinct departments, made each professor responsible for only one particular field and added more physical sciences to the core curriculum. He also made Latin and Greek required only for degree candidates, who now had to

complete specific academic requirements, not just remain in residence for four years, before they could graduate. In one of the most direct concessions to the recent public critique of higher education, Marsh opened Vermont's campus to all students who could afford the tuition. Specifically trying to incorporate the ideals of Jacksonian democracy into the school, Marsh welcomed all students, not as immature charges of the university but as responsible student-citizens of the campus, who were expected to maintain an active and interactive role in the college and in their own education.30

With such improvements it seemed that finally, after years of often mediocre instruction, science was taking a prominent role in the core curriculum of leading American colleges. But was such drastic and sudden change the best course of action? Many educators agreed that "if the Colleges cannot so modify their systems, as to meet the public demand, or if they do not choose to do it, other seminaries equal in rank and of surpassing popularity, will spring up by their side."31 Most colleges found themselves with the choice of reforming their curriculum or closing their doors forever. For colleges such as Amherst and Vermont, that vital curricular change took the form of an increased emphasis on modern languages, and applied physical sciences. Still, to some educators, the Amherst and the Vermont plans seemed too drastic for a well-balanced education. How could a student expect to receive a liberal education if the studies were too skewed toward the sciences? Fortunately, it would be only a few years before the influential Yale report was published in 1828, which proposed a cautious solution to the current curricular problems. Born of Yale's own financial problems, this report provides a moderate influence on which other colleges could base their own curriculum for the next century.

31 Ibid, 27.
By the mid-1820s, Yale had the most geographically diverse student body in America. But even this could not shield Yale from the financial problems plaguing many colleges at the time. In serious danger of going bankrupt, Yale needed to find a way to attract more students to the college. Before the governing corporation delved into any sweeping reforms like those at Harvard and Amherst, they asked the faculty to assess the place of the classics in contemporary education. The trustees hoped that they could use such a short report as the baseline for later discussions of curricular reform. Instead, they received a lengthy work written by Yale’s president, Jeremiah Day, in which he carefully evaluated the place of each branch of knowledge in the curriculum. By the end of his discourse, Day came to the conclusion that all major branches of knowledge were vital to a higher education. Day did not want to clutter Yale’s curriculum with new subjects, as had the administrators of Bowdoin and the University of Vermont. As he wrote, “a college could not and should not be all things to all people.”32 They could not teach the students everything they would ever have occasion to need, so they should not try to serve as an academy, seminary, technical institution, vocational school, and liberal arts college all at once. What colleges could do was to provide their students with a liberal education, which included the skills, or as Day phrased it, the “intellectual furniture” they would need to tackle later tasks or professions.33 Instead of merely shifting the academic focus of the college from the classics to the sciences, Day advocated a broad curriculum that would test and challenge all of the student’s “faculties.” “As knowledge varies,” he wrote, “education should vary with it.”34 This meant that courses in the classics,

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33 Ibid.
34 Report of the Course of Instruction in Yale College; by a Committee of the Corporation and the Academical Faculty, as cited in Guralnick, 33.
languages, chemistry, history, mathematics, natural philosophy, literature, and political
economy were all vital components of a thorough liberal arts education.

Over the next decade, when colleges such as Brown, Columbia, the University of
Pennsylvania, and the College of New Jersey all faced their own financial problems, they
looked to the examples of Harvard, Amherst, Vermont, and especially Yale to find their
own methods of curricular reform. In the case of Brown, by the time Francis Wayland
assumed the presidency in the 1820s, the college had acquired a reputation for being one
of the least demanding schools, a place where students who were rejected from other
colleges usually found admission. To combat this image, Wayland followed Day by
designing a plan to raise admission standards and to strengthen the curriculum. In New
York, the threat of bankruptcy led Columbia’s trustees to try several different options.
They instituted a non-degree program in the sciences, offered public lectures to augment
a curriculum which they had already burdened with too much mathematics and natural
philosophy, and even offered the United States government a package where, for a fixed
annual sum, Columbia would take over the duties of a naval academy. So frenetic and
disorganized were the trustees’ efforts at improvement that when James Renwick started
to investigate the state of the college, he found that most of the science programs were
only partially implemented, the students were so overwhelmed with the amount of
scientific material they were given that they often gave up trying, and attendance in the
non-degree program was declining because the other students viewed the non-degree
students as intellectually inferior. Columbia was learning that a college could not simply
add adjunct programs to accommodate so many divergent interests and still provide a
high quality education. Thus with the threat of a new rival college on the island (what
would become NYU) foremost in their minds, in 1835 the trustees discontinued the ineffective programs to concentrate their efforts on creating a well-rounded curriculum, strong in each branch of knowledge.\textsuperscript{35}

In Philadelphia, the University of Pennsylvania was undergoing even more dramatic changes. With its long association with the Jefferson Medical College, Pennsylvania had always included science in its curriculum, but this reputation could not carry the college through the turbulent years after 1815. In 1825 the trustees had raised admission requirements and the minimum age to fifteen, separated the academy from the college, and stretched the program of study from three to four years. Even so, growing dissatisfaction with the curriculum and serious divisions between the faculty and the trustees led university president Nicholas Biddle to completely dissolve the faculty in 1823. In its place he created a system of well-defined departments for each discipline. He then looked to such outstanding educators as Robert Adrian and Alex Bache to help institute a challenging and well-balanced curriculum. Like most colleges of the time, the trustees at Brown, Columbia, and Penn found that the only way they could survive the epidemic of financial failure was to redesign their curricula to be more liberal, more scientific and practical, and thereby more attractive to potential students.

In Princeton, the college faced many of the problems plaguing the other northeastern colleges. Over the years it had acquired a reputation as a school for wealthier students, but by the late 1820s it simply was not matriculating enough new students.\textsuperscript{36} The college’s previous financial concerns had conspired to keep the faculty small, with only the president, two professors, and three tutors as late as 1821. The first

\textsuperscript{35} Guralnick, \textit{Science and Ante-bellum American College}, XXXIV.

\textsuperscript{36} In fact, the cost of attending Princeton in the early nineteenth century was $150-$170, which made it the most expensive college in the country. Hornberger, \textit{Scientific Thought}, 9.
three decades of the century in Princeton were punctuated by a series of fires and student uprisings. Thinking that such gross insubordination was caused by loose morals, the trustees tried to crack down on discipline and to refocus the course of study on more pious subjects such as Hebrew and divinity. But the students had grown used to the liberties they had gained over the past few years and many left the school rather than bend to the harsher disciplinary tactics. The college’s situation became desperate during the presidency of James Carnahan; it needed to find a way to attract more students or to close its doors permanently. After a plan to raise tuition and lower faculty salaries failed, Vice President John Maclean finally convinced the trustees that to make money the College would first have to spend it. What the college needed was not harsher disciplinary policies but a stronger curriculum and a better course of study in the physical sciences. It needed better facilities and better instruction in natural philosophy, it needed a bright young science professor, namely, Joseph Henry. After a long session of deliberations, the trustees finally acquiesced and appropriated the money needed to implement Maclean’s plans.

Later, in his Reminiscences of Princeton, Edward Wall, class of 1848, wrote that “Princeton left the task of making experiments in education to other colleges…But when progress became inevitable and Princeton moved, her friends said that she put herself at the head of the progressive movement in education in this country.”37 This line of thinking held true especially in the case of the curricular reforms made by American colleges in the first third of the nineteenth century. In his work, Sciences in the American Antebellum College, Stanley Guralnick wrote, “At no time since 1740 had the changes [in

the college curriculum] been more fundamental than in the decade 1818-1828.” While trustees and faculty members negotiated the specifics of their own new course of study, newly created textbook companies and alumni groups stood ready to lend their support to the new curriculum. Perhaps most important, curricular change was accepted as a proper and necessary part of education. Although many of these innovations came late to Princeton, when the trustees finally agreed to augment the science offerings at the school, they immediately sprang into action. While they would later institute a few reforms in the organization of the faculty and the core curriculum and would appropriate money for the renovation of the laboratory in Philosophical Hall and for the purchase of philosophical apparatus, most of the trustees’ hopes rested on the shoulders of the young Professor Henry. A talented scientist who was already known throughout the United States and abroad for his work in electromagnetism, Henry was looked to not only to reform science at the college, but to make the college a leader in scientific experimentation. Into this environment of new beginnings and great expectations, Joseph Henry moved to Princeton in the fall of 1832.

CHAPTER 2
HENRY AND THE SCIENTIFIC REFORMS IN PRINCETON

By the time Joseph Henry accepted the chair of natural philosophy at the College of New Jersey, he had earned a reputation as one of the most promising new scientists in the field of electromagnetism. His work at the Albany Academy for Boys had helped to establish him as both a well-respected teacher and an insightful scientific researcher. But in an age when most college professors were ordained ministers, Henry had only his previous research and reputation to recommend him to the trustees. Without a degree from a college or a seminary, Henry seems an unlikely candidate for the task of bringing modern science to one of the country’s oldest colleges. However, the choice becomes clearer when one looks more closely at Henry’s reputation for scientific study and, perhaps more important, his reputation for continually finding ways to supplement his sporadic formal education by reading, observation, and deep curiosity. Similarly, beyond his own studies, it was this same tenacity of spirit that helped Henry carry out the overwhelming task of restructuring the college’s scientific curriculum.

While Henry may have begun school in Albany, New York – where he lived with his relatively poor family – he did not regularly attend lessons until he was 8 or 9 years old, when he was sent to live in Galway, Ireland, with his step-grandmother.39 Henry’s

mother probably sent the young Joseph away to alleviate some of her responsibilities at home. Faced with the recent birth of her youngest son James, and a husband who had started to exhibit the symptoms of alcoholism, she probably felt that Galway offered a more stable environment for her eldest child.

Quieter than his other siblings, Joseph apparently enjoyed being the only child while he lived with his grandmother. Later describing himself as a thoughtful and serious boy, he often joked with friends about how seriously he took his first pair of boots. When his grandmother took him to the cobbler to be fitted, he could not decide between a square-toed and a rounded-toe boot. Over the next few weeks he returned many times to ponder the choice, until in exasperation the cobbler made him a pair of boots with one square and one rounded toe. While this meant that he would not have to choose between the styles, Henry would later joke that it made him easy to track in the snow.40

A few years later, when it was time for Henry to get his first job, his grandmother helped him secure a position working mornings in a local general store. This left limited time in the afternoon for his studies, but Henry did not seem to mind. He later said of himself that during this time he was not a very motivated student. More impressed with the acrobatics of the town’s chimney sweep than with his tutor’s books, he asked his grandmother if he could discontinue his studies in favor of an apprenticeship with the chimney sweep. Understandably, his grandmother was not as enamored with this plan as Henry was and encouraged him to stay in school. There he stayed until his father’s death, at which point an apprenticeship in a cousin’s silversmith shop brought him back to America and Albany.41

40 Moyer, Rise of an American Scientist, 18-19.
Much had changed in the intervening years in both Henry's family and the city of Albany itself. Not only had his mother decided to take in boarders to supplement her meager income after her husband's death, but the town had also grown significantly. In addition to the general spirit of growth that accompanied the beginnings of the industrial revolution in the United States, Albany was also close to a military post and had received a considerable boost from the increased presence of soldiers from the War of 1812. A growing population brought with it more houses and churches, three new schools, and an active theater. The town center had several new businesses, with better roads and a new steel aqueduct system going out to the recently developed residential neighborhoods. 42

With his mother now running a boarding house, Henry was expected to help with household duties while spending the majority of his time at the silversmith shop. This proved difficult for Henry; Albany was a much bigger town than Galway, and of all the new establishments, it was the theater and more specifically acting that captured Henry's attention. Never very interested in his apprenticeship (later Henry would tell his Princeton students that he was considered too dull for the trade) he found the prospect of playing someone else exciting and he auditioned for several plays. The managers of the Green Street Theater in particular believed that Henry had talent and offered him not only a role in their upcoming play, but a full-time position as an actor. 43 The offer was tempting, with a considerably higher salary than he was currently earning, but Henry also had to consider that acting was not as stable a profession as a silversmith. For weeks he tried to decide how he should respond to the theater's offer, unsure if he should follow his dream of becoming an actor or choose the more respectable silversmith trade. It was

43 Henry Papers, 1: xxi.
while Henry was weighing these options in his mind that he almost literally stumbled upon his love of science.

One morning as he was helping his mother prepare the dining room for breakfast, he came upon a book that one of the boarders had left on the table the evening before. Entitled *Popular Lectures on Experimental Philosophy, Astronomy, and Chemistry* by George Gregory, the volume contained a collection of conversational essays explaining various natural phenomena. Intrigued, Henry sat down and began to read, completely forgetting the task at hand. When the book’s owner came downstairs and saw the boy reading so intently, he gave the book to Henry. Within days Henry had read the entire volume and resolved to learn more about the scientific principles covered in its pages.44

While this story has more of the providential flavor of hagiography than reality, it is the story that Henry told to explain his initial interest in science – so much so that over two decades later when he gave his copy of George Gregory’s work to his own son, he wrote in the cover:

This book, by no means a profound work, has under Providence exerted a Remarkable influence on my life. It accidentally fell into my hands when I was About sixteen years old, and was the first book I ever read with attention. It Opened to me a new world of thought and enjoyment, fixed my attention upon the Study of nature, and caused me to resolve at the time of reading it that I would Immediately commence to devote my life to the acquisition of knowledge.45

As the inscription suggests, soon after he found this book his life took a dramatic turn. He declined Green Street Theater’s offer, left the silversmith shop, and began actively to pursue a career in science. As the first step in this process, he began to look into attending the Albany Academy for Boys. Henry believed that the academy, a

45 Charles I. Weiner, “Joseph Henry’s Lectures of Natural Philosophy: Teaching and Research in Physics, 1832-1847” (Ph.D. diss., Case Institute of Technology, 1965), 13. Henry’s volume is still on display at the Smithsonian.
prestigious school with a broad scientific curriculum, was the ideal place to begin his scientific education. Within a few months he had applied to the school and been accepted into the lower classes; he could study there, if he could pay the tuition.46

Unfortunately, his apprenticeship at his cousin’s silversmith shop did not leave him with the funds necessary to pay the $12.50 per quarter tuition. So he decided to postpone attending the academy and instead to take a job as a country schoolteacher.47 It was his plan to save as much money as possible in this position, and then return to Albany to attend classes at the academy. At first he earned only eight dollars a week, but within the first two months the school raised his wages to fifteen dollars in recognition of his inherent skills in the classroom. This raise helped considerably, but in an attempt to save as much as possible, he continued to take advantage of the reduced board offered by his students’ families, sleeping in back rooms, basements, or parlors of several different families over the course of a school term.48 For months, he would spend his days in the schoolhouse teaching, and his evenings studying such things as Benjamin Silliman’s new *American Journal of Science*. When he had finally collected sufficient funds, he returned to Albany and matriculated at the Academy. Unfortunately, on such a low salary it was difficult to save enough money to complete his course of study. Each time his money ran out he was forced to leave the academy and return to teaching.49 Of course, such breaks disrupted Henry’s formal schooling, but with constant reading and research he managed to continue his education even outside the classroom.

49 Coulson, *Joseph Henry*, 16-17.
When Henry was at the academy, he studied subjects ranging from English literature to algebra and surveying. His notebooks reveal a careful student who spent hours copying vocabulary and meticulously solving complex trigonometric exercises. One family story from the time tells of how Henry, absorbed in his studies often stayed up late trying to work out particular problems. Taking a piece of coal, he would write the equations out on a white-washed wall in his room. Once he had solved the equation he would rinse the wall and re-whitewash it for the next day’s problem.

It was just such diligence in his studies that caught the attention of T. Romeyn Beck, the academy’s president. Knowing that Henry needed to find a way to earn money if he was to stay in school, Beck hired Henry as an assistant to help him with his teaching notes. He was so pleased with Henry’s work that after Henry had graduated from the academy, Beck continued to employ Henry as a research assistant for a series of popular lectures he was giving around the state. Taking a personal interest in his bright young assistant’s future, Beck encouraged Henry to join the newly formed Albany Institute. Later he helped his former student secure a job first as a private tutor in the house of General Steven Van Rensselaer and then as a surveyor for a state highway from West Point to Lake Erie.

For Henry, working as a surveyor was particularly enjoyable. Not only did it give him a practical application for his new technical skills, it offered him the opportunity to make geological, topological, and agricultural observations as he traveled throughout southern New York. All through his years at the academy he had been particularly careful to learn as much as he could from reading or observation, both inside and outside the

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50 Henry Papers, 1: 54-56.
51 Moyer, Rise of an American Scientist, 30.
classroom. To continue this practice, Henry read widely, took ample geological notes while he was working as a surveyor, and joined the newly formed Albany Institute. Created when Albany's previous two scholarly societies, the Lyceum and the Society for the Promotion for the Useful Arts, merged in 1824, the Institute comprised over 250 members, representing both the humanities and the sciences. Usually meeting each month, the society provided a forum for local scholars to present their original research and to discuss current topics of interest. When Henry joined the institute, it was the first time that he had interacted as an equal with such a group of highly educated men. In fact, several of the members only a short time ago had been his teachers at the Albany Academy. However, any concern he might have felt must have soon faded, for right away he became an active member, serving as the Institute's librarian. On October 30, 1824, he presented his first paper entitled "On the Chemical and Mechanical Effects of Steam." Other papers, a paper on light and vision on April 3, 1828, and one on "Sciences Electro and Thermal Magnetism" of November 25, 1828, soon followed, securing his reputation as a rising member of Albany's scientific community. Indeed, Henry's talent for observation and experimentation earned him such a degree of respect in Albany's learned community that when a position at the Albany Academy became vacant shortly after his term as a surveyor ended, the trustees offered him a professorship of mathematics and natural philosophy.

Putting his reservations aside, Henry accepted the position and set about preparing for his new duties. In the weeks leading up to his first term, he took a research trip to

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54 Ibid, 78.
56 Ibid, 132-33.
gather information and materials he would need in the classroom. He first joined Amos Eaton and a group of his students who were traveling along the Erie Canal to observe and catalogue the geological formations of western New York. Although Henry would refer to this trip in his lecture notes for years to come, he could stay with this group for only a few days, next rushing to West Point to be there in time for the annual meeting of the Board of Visitors. Taking advantage of the special demonstrations prepared for the board members, Henry toured the laboratory facilities, examined the scientific apparatus, and sat in on several lectures. The lecture halls were divided by a low railing, behind which the students were expected to sit quietly taking notes, while in front the professor explained and demonstrated the material. Particularly impressed by John Torrey and Lewis Black's lectures, Henry made several notes in his diary about the blackboards, which both men employed in the classroom. For someone who used to write out problems on a whitewashed wall, such a board must have seemed a special innovation. It enabled the professors to solve complicated equations in front of the whole class, made note-taking easier for the students, and erased quickly and cleanly. Always looking to improve his own teaching methods, he resolved to use such a board when he returned to the academy.

After leaving West Point, Henry made one more stop in New York City to visit the libraries and museums there, and more importantly to procure a few instruments he needed for demonstrations. Visiting one instrument-maker in particular, Henry apparently spent some time discussing magnet-making with the artisan. More specifically, the man showed Henry how to make a more powerful magnet by bolting the north ends of many

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57 Ibid. 136-55.  
58 Ibid. 155-60.
thin magnets together. The combined pull of the smaller magnets was then stronger than
the force of one solid magnet of equal mass. It would be these same principles that Henry
would use later in his experiments on electromagnetism.59 Armed with a new set of
magnets and with the examples of the West Point professors fresh in his mind, Henry
returned to Albany to begin his teaching career in earnest.

Previously as a country schoolteacher, Henry had been responsible for teaching
all grade levels and subjects simultaneously, but teaching at the academy would be much
different. Begun in 1817, the Albany Academy for Boys catered to the sons of upper- and
middle-class families in and around Albany. A boy as young as eight could enter the
academy’s English school, if his family could afford the tuition. There he would study
reading, penmanship, arithmetic, grammar, and geography, bookkeeping, and history.
Older students could enroll in the advanced five-year course, taking subjects such as
Greek, Latin, geography, literature, geometry, algebra, chemistry, and natural philosophy.
This curriculum emphasizing the math sciences was a result of President Beck’s earlier
reforms. Following the growing trend among other American colleges and academies,
Beck believed that his students could benefit most from practical subjects, so he added
accounting, navigation, and surveying to the curriculum.60

Of course, by including so many subjects in the curriculum, the academy put a
considerable strain on its teachers. In his first two years, Henry was expected to teach
seven arithmetic courses, two Euclidean geometry classes, and one course each in
trigonometry, algebra, bookkeeping, and the proper use of a globe. Teaching over a
dozen classes, Henry had little time to experiment with different teaching methods, but he

was always on the lookout for ways to improve his students' understanding of the subjects. He had successfully incorporated a blackboard into classroom, using it not just for lectures but also for recitations. Never a strong proponent of traditional recitation, Henry seemed to have little success with the method. He had noticed that rote memorization, which characterized many recitations, was ineffective for younger students, who did not understand the concepts behind the words they were memorizing. Instead, he found that his beginning students did much better if he presented the material orally, accompanied with examples on the blackboard, and a set of problems that the students could solve as homework. If he could just use this more interactive form of lecturing, coupled with practice exercises, regularly in his classes, he thought that his students would more thoroughly comprehend the material.

Toward the end of his second year at the academy, Henry took his observations to the trustees, hoping to instigate some educational reform. To demonstrate his point, he used his blackboard to illustrate a lecture on advanced geometry, which he gave to a group of second-year students while a few trustees watched from the back of the room. Later, when Henry orally examined the boys to ascertain how much of the information they had retained, the trustees were surprised at the level of the students' understanding. They were so impressed that they eventually allowed Henry to limit traditional recitation in the lower grades in favor of oral instruction. Further, in response to a larger campaign launched by President Beck and other professors including Henry, the trustees recognized that all of the professors spent a disproportionate amount of their time teaching elementary courses. Consequently they created a fourth department responsible for all of
the lower level courses, freeing Henry and his colleagues to concentrate on the more advanced students.61

Even with these changes Henry still spent over seven hours a day in the classroom. This, coupled with the time spent preparing for class, left him little time to pursue his own research. Where as a surveyor he had the opportunity to record extensive observations while in the field, as a teacher Henry had to wait until the summer or winter breaks to find the time or the space to engage in any meaningful experiments. Limiting as this schedule was, Henry still found ways to continue his scientific education. As the librarian of both the Albany Institute’s journal collection and of the academy’s scientific library (which were conveniently both housed in the basement of the Albany academy), he spent most of his evenings systematically reading through the entire collection, looking for any information which might help his experiments once he was able to resume them during the holidays.

It was here in the basement of the academy building that Henry first came upon an article concerning the recently discovered field of electromagnetism. In previous months Henry had begun to investigate the cause of the Aurora Borealis, after a particularly impressive display captured his attention. Thinking that the lights were somehow caused by the earth’s own magnetism, Henry picked up an article written by the English chemist and his future rival Michael Faraday. The article described Faraday’s discovery that a wire formed into an open circle would mimic a compass when a current was applied to one end of the wire.62 Interested to see how terrestrial magnetism reacted with electricity, Henry investigated the idea further. Fascinated by what he was learning,

61 Ibid. 49-53.
Henry soon shifted the focus of his research and experiments from terrestrial magnetism to the much newer field of electromagnetism.63  

Always the teacher, Henry’s first major project in the field was to make the subject of electromagnetism more accessible to students and the interested public. Until this point, most schools and popular lectures did not include electromagnetism in their lists of topics because the equipment to demonstrate the principles, especially the central apparatus of an electromagnet, was prohibitively expensive and cumbersome. The first electromagnet, developed by Italian researcher Dominique Arago, consisted of a glass tube of iron needles wrapped in a copper wire. When the wire was soldered to a galvanic battery, the circular current magnetized the iron needles in the tube.64  By the time Henry became interested in the subject, an English scientist named William Sturgeon had improved the magnet by using a horseshoe-shaped bar, so that the north and south poles of the magnet were in the same plane to create a stronger pull. Further, he had loosely wrapped this bar with a current-carrying wire. As in Faraday’s earlier experiment, the circular current mimicked a magnet, enhancing the magnet’s strength.65  For his own part, Henry theorized that if one wire could increase the magnet’s strength, multiple current-carrying wires would further enhance the magnet’s pull. To test this idea, he wrapped copper wire with an insulating layer of silk ribbon, and then tightly wound these wires around an iron bar. When the wires were connected to a galvanic battery, the result was a magnet so strong that it could hold over 1,000 pounds.66  Smaller, more powerful, and more cost effective than previous models, Henry’s electromagnet soon caught the eye of

64 Ibid, 59.
65 Henry Papers, 1: 213-14.
Yale's science professor, Benjamin Silliman, who asked Henry to construct a magnet for Yale. With more time to perfect his technique, the magnet Henry built for Yale was slightly larger and even more powerful than his prototype, with a pull capacity of over 2,000 pounds, making it the strongest electromagnet in the world.

Although the success of the Yale magnet precipitated a flurry of orders from other colleges, Henry was able to fill only a few of these requests, preferring instead to spend his spare time continuing his research. In the preceding months spent studying the process by which electricity could induce a magnetic force, he had surmised that perhaps this process could be reversed and a magnet could induce an electrical current. This idea would lead to his most significant scientific theory, that of self-induction, but it would be a complicated success. With only limited time to devote to his experiments, Henry proceeded slowly. Even after he succeeded in drawing sparks (a positive sign of electrical current) from a magnet, he was reluctant to publish his findings until he had more conclusive results. So while Henry was trying to cram hurried bursts of experimentation into his spare moments while teaching a full load in Albany, other scientists in Europe were working on similar projects. In fact, Michael Faraday, the principle chemist at the Royal Institute in London, published a brief history of the questions surrounding what would soon come to be known as self-induction, in which he asked many of the same questions Henry had been working on for the past few years. While Faraday's article generated some discussion among the scientific community, the piece did not come to Henry's attention until early in the 1829 winter term. Right away Henry decided to publish his own work and his observations of sparks as soon as he could. But since he

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67 Henry Papers, 1: 318-19.  
68 Ibid, 331-33.  
was at the beginning of the school term, other duties and his own quest for perfection waylaid his progress. Unfortunately for Henry, in those few months that he took to finish up his own work another scientist, Gerrit Moll of Holland, published his own observations on drawing electricity from a magnet in the October 1830 edition of *Edinburgh Journal of Science*.

In response, Henry quickly finished his own article for publication and sent it off to the *American Journal of Science,* but not before Silliman had arranged to republish Moll’s piece in the next edition. Thinking it imperative that the young American scientist could have his results published alongside those of Moll; Silliman made arrangements to publish Henry’s piece but only “by way of appendix.” Thus while Henry was perhaps the first person to induce a current with a magnet, he was recorded as merely the first person to verify Faraday’s conjectures and Moll’s experiments.

Although Henry would always regret that he did not receive the recognition he felt he deserved for his experiments in self-induction, it did not noticeably hinder his research. Building on his work with the electromagnets, Henry developed an electromagnetic engine, which used a series of electric pulses to turn a magnetized iron bar. With the addition of a fly wheel, the magnetized bar could consistently spin in a circle for several hours. Along similar lines, Henry was also able to develop a prototype for the telegraph, again using electromagnets. First, he mounted a regularly magnetized iron bar on a horizontal pivot with one end between the two ends of a horseshoe electromagnet. Because the electromagnet was only magnetized when the copper wires surrounding it

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72 Ibid, 302.
73 Moyer, *Rise of an American Scientist,* 73.
were in contact with a battery, at rest the bar magnet would not be attracted to either pole of the electromagnet. However, when Henry touched the wires to a battery, the bar magnet would be drawn to one end of the magnet, swinging on the pivot, and would strike a small bell placed there for the purpose. By looping the wires around his demonstration auditorium, and through to the next classroom at the Albany Academy, Henry was able to ring the small bell in regular patterns from over a mile of wire away.\textsuperscript{74} Curiously enough, Henry never bothered to patent any of his new devices because he considered them mere “philosophical toys” for use in the classroom and laboratory.\textsuperscript{75} But he did take time to present his results to the scientific community, officially recording them at either the Albany Institute meetings or in articles in the \textit{American Journal of Science}.

It was these articles, and his growing reputation among American men of science, which first caught the eye of John Maclean, vice president of the College of New Jersey. Like many American colleges of the time, Princeton needed to update its science curriculum. The college was in serious financial trouble, with a falling enrollment, dilapidated buildings and equipment, and a somewhat antiquated curriculum. To save the school from closing its doors, the trustees needed to make it more attractive to prospective students. As a central part of improvements, the college would need a new science professor, to bring Princeton to the forefront of scientific discovery. Maclean felt that the young Joseph Henry, with his reputation for innovative research and effective teaching, Maclean would be perfect for the position. And so while he was still lobbying

\textsuperscript{74} Ibid, 69-70.
\textsuperscript{75} \textit{Henry Papers}, 2: 447.
the trustees to appropriate the money to hire Henry, Maclean wrote to tentatively offer Henry the job.\footnote{Henry Papers, 1: 433-34.}

Henry’s mildly self-deprecating response to Maclean’s initial letter betrayed his cautious ambitions for the position. Only recently he had married his cousin Harriet Alexander, and the couple had just welcomed the birth of their first child, William Henry. Now with a family to support, Henry had all the more reason to look to advance his career. This new job in Princeton would not offer significantly more money than his current position at the Albany Academy, but it did include the use of a house and it would give Henry access to all of the resources that the college could afford. Perhaps most attractive of all, Maclean had promised Henry that he would have significantly more time outside the classroom to continue his scientific research. Such an opportunity was not to be missed, but Henry still had misgivings. In his letter to Maclean, he admitted that he was “not a graduate of any college and [was] principally self educated.” He did hold an honorary degree from Union College in recognition of his work with electromagnetism, but he thought such a “cheaply purchased” honor would “have but little weight with [the] trustees.”\footnote{Ibid, 436.} Consequently, in the place of formal degrees, Henry cited his teaching experience and listed several people who would gladly write references for him. Only as an after-thought did he add his most famous accomplishment, that of demonstrating self-induction. His list of accomplishments proved to be irrelevant, though, for as soon as the trustees approved the appointment, and before he had actually received any of the personal references Henry had offered, Maclean wrote to Henry to officially offer him the
chair of natural philosophy. Readily accepting the appointment, Henry and his family packed their belongings and moved to Princeton in the beginning of September 1832.

The first few letters Henry sent back to his brother James in Albany portray a man concerned primarily with the domestic tasks of moving. He described how William was taking to his new environment, his wife’s travails buying a new stove, and the layout of their new home. Apparently pleased with his decision to move, he only complained of missing the society of his friends and family in Albany. It was not until the week leading up to Henry’s first term at the college that his letters began to belie his anxieties or apprehensions about his new position.

Aside from the pressures of preparing lectures experienced by all professors teaching a new course, Henry was acutely disappointed by the general state of scientific instruction at the college. Having come from a preparatory academy, Henry probably expected to find a department at least comparable to the Albany Academy. But as he wrote later, “Before I was called to the chair of Natural Philosophy in this institution no lectures had been given on the subject nor experiments shown to the class for many years. The apparatus was not only very imperfect but what existed were in an imperfect state deficient in quantity the articles in a very bad state of preservation”. Even though the Princeton annual catalog boasted from 1830 on of “a very valuable philosophical and chemical apparatus,” it was not at all comparable to the equipment Henry had in his Albany classroom or in his experiments. After the 1829-1830 academic years, the college’s financial troubles had prevented the trustees from purchasing any additional equipment. Further frustrating matters, the library lacked the scientific journals Henry

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78 *Henry Papers*, 2: 166
79 “Catalogue of the Officers and Students of the College of New-Jersey” (Trenton: George Sherman, printer 1830).
needed to research material for his courses; even Philosophical Hall, the building where his laboratory and classroom was to be located, was in a state of disrepair.

Clearly, such a lack of suitable facilities frustrated Henry. But since the beginning of term was fast approaching, he had to focus his attention first on preparing his new course of lectures. Although Henry had taught in Albany for six years, his courses in Princeton would be much different. Whereas at the academy he had taught several shorter courses in trigonometry, algebra, or globe-reading each day to relatively advanced students, in Princeton Henry was now expected to teach a general natural philosophy course to older students, but students who had not necessarily ever been exposed to serious scientific principles. Listed as a course in mechanics and physics, a required course for all seniors, it was designed to provide the students with a working knowledge of “the general properties of matter and force to their specific manifestations in heat, electricity, and so forth.”\footnote{Henry Papers, 1: xx-xxi.} Henry covered so many topics, in fact, that for the first two years of teaching he spent the majority of his time preparing for his lectures, often only one step ahead of the class.

A meticulous researcher, Henry filled his class notebooks with the latest information he could find on the pertinent topics. When his class came to a topic such as electricity or terrestrial magnetism in which he had prior experience, he drew on his previous knowledge or his own work. But when it came to topics in which he had little experience, he had to work especially hard to gather the proper information. On December 8, 1832, right before he was to begin mechanics with his class, Henry wrote his brother, “I have been very much employed [this week] in preparing my lectures on mechanics and attending to my recitations. My duties are somewhat more arduous on
account of my never having before lectured on this subject."\textsuperscript{81} In such cases, Henry often took a few days' research trip to West Point, New York City, or more frequently to Philadelphia, to the Franklin Institute or the American Philosophical Society. In these places he could find the current journals he needed for his lecture notes. Perhaps more important for Henry's own personal development as a man of science, he could take the opportunity to discuss scientific matters with other scientists and friends such as Alexander Bache, the professor of natural philosophy and chemistry at the University of Pennsylvania, and John Torrey, who spent half the year teaching chemistry at the College of Physicians in New York and the other teaching in Princeton.

Although Henry had always enjoyed discussing current research with other scientists, the gatherings in New York and Philadelphia proved especially helpful for him during his early years in Princeton. Ostensibly, such gatherings were designed to create a forum for scientists to discuss current topics and officially to present the results of any original research in a more timely manner than allowed by the contemporary scientific journals. But the meetings had another, more social, purpose. Like Henry, many of the new science professors had been educated in a larger city or in a community where some sort of scientific guild met. But when they left these centers of scientific learning to take posts frequently as a college's sole scientific professor, they often found themselves as the only representative of a professional scientific community on their campus.\textsuperscript{82} Thus meetings like those of the American Philosophical Society had a rejuvenating effect on Henry and his colleagues, who were working on what could be considered the frontier of scientific higher education. For Henry especially, the meetings provided not only a place

\textsuperscript{81} Henry Papers, 2: 19.
\textsuperscript{82} Guralnick, \textit{Science and the Ante-Bellum American College}, 18-46.
where he could discuss his research with others interested in the field, but they connected him with a wider scientific community. In the first years living in Princeton, Henry came to rely on the men he met through the American Philosophical Society and the Franklin Institute as professional colleagues and later as personal friends. It was undoubtedly the support, professional advice, and social support of these fellow scientists that helped Henry cope with the extreme demands of synthesizing original lecture notes.

Previously, other professors of natural philosophy at the college had avoided the type of extensive research that Henry undertook by employing general textbooks in their classes. Such professors may have supplemented their lessons with the results of a few recent experiments, but the majority of the information presented in class would have come directly from the textbook. In addition to these lessons, the students later recited memorized passages from the same book during a formal recitation. It was thought that by having the students recite portions of the book aloud, they would remember the individual facts and better understand the concepts presented in class. The method also had the added advantage that very little capital investment in apparatus was required. By the time Henry came to Princeton, however, some professors had started to reject traditional recitation in favor of lectures. Many of the older professors were highly skeptical of lecturing, preferring their students to take the active role of reciting a passage aloud to the passive act of listening to a professor speak. For years this idea prevailed, but when Henry came to Princeton, the college gained her most outspoken proponent of the lecture method.

As Henry had demonstrated to the trustees of the Albany Academy when he first started teaching, reading a passage in a book was not as effective as oral instruction. He
especially found that novice students gleaned little to nothing from a difficult scientific passage. Without the prior knowledge needed to interpret the concepts presented in the books, they ended up merely memorizing a string of words. While it followed that advanced students would benefit from recitation, Henry’s natural philosophy course at Princeton was required of all seniors and as such needed to cater to both seniors already familiar with the subject and those completely new to the field. Consequently, for his own courses, Henry chose to teach through lectures and demonstrations. This would require, of course, a substantial investment of time. But as Henry’s extensive notebooks suggest, he was willing to invest the time if it meant that his students would better understand the concepts.

Beyond his own classes, Henry advocated lecturing as a superior teaching method in all academic fields. Over the course of his first few years in New Jersey, Henry found that his students were responding very well to all of the information he had gathered into his lectures, both in his philosophy class and in a short series of architectural lectures he taught as an elective. The series of lectures on architecture was not a required course for graduation, but one lecture a week to help broaden the horizons of interested students. It was so popular with the undergraduates that when Henry decided that his schedule would no longer permit him to teach the course, he asked Professor Dod to continue the lectures. Since Professor Dod was the professor of mathematics and well-loved by the students, Henry thought that Dod would be “an excellent person to continue teaching architecture in Henry’s lecture method.”83 In time the success of both Henry’s and Dod’s lecture courses helped to popularize the method on the Princeton campus.

Along with lectures, demonstrations were a major component of Henry’s teaching. He had had great success with involving his students in the experiments during class in Albany, and in Princeton he hoped to do the same. Unfortunately, however, the college had little money to spare for scientific equipment, leaving Henry to improvise. However, as with most obstacles in his life, Henry approached the lack of sufficient apparatus with creative optimism. As he later told his classes, although “the apparatus [was] deficient” they could “make one article serve many purposes… making up in industry what we may be deficient in instrument.”

To supplement the college’s own holdings, he had drawings made, borrowed equipment from other scientists, and even used his silversmithing skills to repair damaged instruments. In one case, during a particularly arduous process of building a battery for the College, Henry wrote Benjamin Silliman that the project had “cost him nearly all of [his] leisure time for a year past.” The process took much longer than Henry had anticipated because he found materials extremely difficult to procure in Princeton. Usually Henry was able to obtain materials on his trips to New York and Philadelphia, but for this particular battery the specific sized zinc plates he needed were not available in either city. After an extensive search, he finally found one manufacturer in Massachusetts, which agreed to make the plates to Henry’s specifications. But he would have to wait several months for the plates; the extreme heat needed to produce the plates meant that they could only be made during the winter months, when the cooler weather made working conditions bearable for the artisans. Such limitations chronically delayed Henry’s progress. But persisting, he managed to slowly improve the college’s

84 Henry Papers, 3: 520.
85 Henry Papers, 2: 263-64.
86 Ibid, 2: 50.
scientific collection and to build yet another galvanic magnet, this one even stronger than the one he had built for Yale in 1831.

With so much time spent preparing lectures and improvising demonstrations, Henry had little time to pursue his own experiments. He spent only seven hours a week actually teaching, but so many hours went into preparing for class that Henry continued to be forced to cram his personal research into the brief vacation periods. This made for an exhausting schedule of intense experimentation and rushed publication. But he persisted with his work, staying closely competitive with Michael Faraday at the Royal Institution in London. The college, after all had hired Henry to improve its scientific reputation; since part of this reputation was based on Henry’s own prestige as a scientist, the college encouraged him to continue his work. Even more pressing, Henry believed that as a man of science it was his personal duty to continue his pursuit of knowledge for his own betterment and the wider understanding of the scientific community.

By the end of Henry’s second year in Princeton, his teaching and research schedule had settled into a fairly manageable pattern. He still had to update his lecture notes, but the initial period of frenzied preparation was over. He could now devote some attention to improving other aspects of the college’s scientific facilities. Taking the most imposing problem first, Henry along with Vice President Maclean began to lobby the trustees to renovate Philosophical Hall, which the students called the Refectory. Philosophical Hall housed the kitchens for the students on the first floor and the dining room on the second. The third and top story contained a room lined with cabinets, which served as the college’s museum, and “the chemical and philosophical rooms” where most
of Henry’s time was occupied. Like most of the older buildings on campus, the hall was badly in need of repair. Cramped and cluttered with various outdated and dilapidated instruments, as well as a collection of sundry items people had donated to the museum, the space was simply not big enough for Henry to set up the equipment he needed for his own experiments, making demonstrations during class an exercise in spatial wizardry. Early in March 1835, Henry proposed to the trustees an addition to Philosophical Hall. The plan included a three-story addition which would provide more space for a lecture room on the second floor, and a new laboratory and work room on the third, but it would also prop up the back wall, which had begun to bow and buckle under its own weight. Because the renovations were so badly needed if Henry was going to teach effectively and with both Henry and Maclean lobbying for the renovations, the trustees soon agreed on April 15 to fund the project. The project was completed in late March 1836, creating efficient space for both Henry’s natural philosophy experiments and John Torrey’s chemistry lectures. Now with a new laboratory, Henry needed only to fill it with the appropriate apparatus.

Even though the fortunes of the college continued to improve, by 1836 Henry still had to improvise demonstrations in his courses. The trustees had managed to give Henry

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87 Ibid, 48.
88 Ibid.
89 Ibid, 371
90 Ibid, 375
91 The newly renovated Philosophical Hall was comparable in space to the laboratory that Faraday used at the Royal Institute, and even larger than the space that Yale provided for its natural philosophy department, but much smaller than the entire building that Yale devoted to chemistry. Now with bigger space, the major difference between Princeton’s facilities and those at other institutions was the inferior apparatus the college owned. Henry Papers, 2: 383-84.
92 In addition to his efforts to renovate Philosophical Hall, Henry also drew up a comprehensive plan in 1836 for the organization of the entire campus in conjunction with a fundraising drive for the American Whig debating society, of which Henry was a faculty member. While some elements from this plan were incorporated into the design that the campus still maintains today, other key elements of the plan were discarded during a building campaign while Henry was in Europe in 1837. Henry Papers, 3: 88-92.
$420 to purchase a telescope in 1833, and $500 to spend on equipment as he saw fit, but the college’s collection was still greatly deficient. In the summer of 1836, when Maclean took an extended tour of other colleges, he made note of this deficiency in a letter to Henry. “As it regards [their] philosophical apparatus, in the colleges mentioned, we can, at a small expense, surpass the best of them and we must do so; and if you are willing, arrangements must be made for you to proceed next spring to Europe, to spend there as much time as you desire, and procure whatever apparatus we need.” This is probably the first recorded suggestion that Henry travel to Europe, but no doubt he had thought about such a trip and perhaps had been planning for it for some time.

Aside from securing well-trained scientists to fill teaching positions, a college’s investment in philosophical apparatus was perhaps the single most important step in improving its status as a modern institution. Whereas most American colleges had around $100 invested in apparatus in 1820, by mid-century most had invested upwards of $2,000 in a set of highly sophisticated instruments that were able to measure and induce all sorts of mechanical, chemical, or optical reactions. Indeed, as the trustees of Transylvania College, the first trans-Appalachian college, learned five-thousand dollars spent on philosophical apparatus would be “more promotive of the welfare of the college than any single step that could be taken.” As Stanley Guralnick noted in his Science and the American Antebellum College, “by the 1830s it seemed that wherever there was a college, the philosophical apparatus was the thing which demanded the greatest

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93 Henry Papers, 2: 175.
94 Henry Papers, 3: 81.
95 Guralnick, Science and the Ante-bellum College, 72-73.
96 Ibid, x.
If the College of New Jersey were to remain competitive in such an environment, it would have to do something about its lack of modern scientific equipment.

While sophisticated scientific apparatus could be obtained in the United States, most colleges preferred to send their science professors to Europe to purchase instruments directly from the finest English, French and German artisans. Without the extra step of an importing merchant, the scientists were able to obtain even custom-made instruments at a much lower price than they could in the United States. For the professors themselves the trip had the added advantage of allowing them to visit the great European centers of learning. They could attend the Royal Institute in London or the Academie des Sciences in Paris, observe experiments in these institutions, and establish professional relationships with some of the top Continental scientists. With so many potential advantages, other prominent scientists such as Benjamin Silliman, Henry Darwin Rogers, Elias Loomis, Asa Gray, Alexander Dallas Bache, and John Torrey had already made the trip. Not one to let his institution fall behind, Maclean successfully urged the trustees in September of 1836 to allow Princeton’s own natural philosophy professor to take a purchasing tour abroad.

As part of a larger fund-raising campaign for the College, the trustees estimated that they would be able to raise five-thousand dollars for Henry to obtain instruments, $500 of which they would give him before he left for the continent. Unfortunately, they could not offer him any money to defray his actual travel expenses. Since he was scheduled to leave in the spring of 1837, Henry doubled the number of lectures he gave

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97 Ibid.
98 Henry Papers, 3: xv.
each week in the 1836 fall term so that he could compress an entire year of teaching into one term. This meant that the college would continue to pay his salary while he was away. With this salary, together with the money he would get from renting out his house (his family would board with friends in Schenectady while he was gone), Henry found that his “tour in Europe will not in all probability cost [him] much more than [his] ordinary living.”

In the weeks before he left for England he excitedly prepared for the trip, making sure that every detailed was properly handled. When his wife and children were comfortably settled in Schenectady, Henry was to take a packet for England. Once he arrived, the college was to send him the rest of the money it had promised, with which he could insure that “the institution should be well furnished with the necessary implements of instruction.” On his own account, Henry had saved a few hundred dollars and borrowed a few more from friends with which he hoped to purchase items for his personal use. With the amount of money Henry brought with him, plus the amount the college was to have sent him, Henry should have had more than enough. Unfortunately, the panic of 1837 created significant financial problems in the United States. With the economy slowing in America, the college was not able to raise the anticipated five-thousand dollars. It did manage to raise a smaller sum, but only sent a few hundred dollars, because the exchange rates were highly unfavorable. Once again Henry was left to improvise in the face of the college’s deficiencies.

Undaunted, Henry drew more heavily on his own letters of credit, determined to procure “on my own account the instruments most essentially necessary for my own use.

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100 Ibid, 145.
101 Ibid, 347.
in the way of original research" and a limited number of instruments for his classroom.\textsuperscript{102}

Even with these limitations, he was able to obtain 151 pieces of apparatus, including several optical instruments made by the French artisan Solair, electrical devices made by Pixsyone, the fairly expensive and highly prized Magneto electric generator, and a Dent chronometer, as well as current scientific books.\textsuperscript{103} Perhaps most important, he was able to participate in the European scientific community. He met and spent several days discussing magnetism with Faraday in London. Attending the meetings of the scientific societies about which he had been reading for years, Henry was surprised to find that most of the members already knew of him through his own experiments with electromagnetism. On March 21, 1837, an excited Henry wrote to his wife "my reception thus far in England has surpassed my most sanguine expectations. Every person I have met has treated me with the greatest kindness and attention. I have as of yet delivered but one letter [of introduction] and believe I could gain access to everything I could wish without further introduction than the mention of my own name."\textsuperscript{104} For a man who had once dreamed of being a chimney sweep, such recognition must have been very gratifying. Even if the trip did not work out as expected, Henry was able to return to Princeton with a respectable number of instruments and a greater confidence in himself as a member of the international scientific community.

Returning to Princeton with renewed energy for his classes, research, and the cause of science in general, Henry was now able to concentrate all of his efforts toward

\textsuperscript{102} Ibid.

\textsuperscript{103} Ibid, 540-45; Overall, Henry spent approximately $1,410, only $600 of which was provided by the college. Upon his return to Princeton there was some discussion of the trustees trying to pay Henry back in installments, and in fact a five-dollar natural philosophy fee was instituted to help this process. But in 1844, when Henry applied for repayment of $1,143 for the instruments, the debt remained unpaid. It was not until 1865 (one year after Henry had accepted a seat on the board of trustees) that the debt was finally paid in full. Ibid, 545

\textsuperscript{104} Ibid, 187.
teaching and his own experiments. With his new European instruments and the renovated science lab in Philosophical Hall, Henry finally had the tools necessary to announce to his class, "I pledge myself to give an experimental illustration of every important principle in natural philosophy." Instead of spending a disproportionate amount of time compensating for his lack of equipment, Henry could now divide his time between his original experiments and his teaching duties. Soon he found a comfortable pattern of research, while his lectures assumed the form they would more or less retain for the duration of his teaching career.

The task of reconstructing the course of Henry's lectures on natural philosophy at Princeton is made more difficult by the fact that, unlike many of his colleagues, he never produced a coherent textbook. As high-quality and up-to-date textbooks were hard to obtain in early nineteenth-century America, professors such as Denison Olmsted at Yale, John Farrar at Harvard, James Renwick at Columbia, and Alexander Bache at Pennsylvania all published their own books in their specialties. Since the country's population of science professors and students was growing rapidly, many professors found the endeavor both practically useful and lucrative. But for various reasons, Henry never contributed his own volume to the growing library of American science texts. It was not for lack of solicitation; several publishing houses asked Henry to write such a book. On March 1, 1844, Professor William H. C. Bartlett of West Point wrote Henry, "I cannot conclude without asking you why you do not give us a text book on magnetism. I feel the want of it to be daily increasing... You alone of our country are deemed

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105 Ibid, 520.
106 Weiner, "Lectures of Natural Philosophy," 54, n.4.
competent of authority to attempt this. Do think of it." But Henry did not want to take
the time away from his own research. He had so little time as it was in which to conduct
original experiments that he preferred to concentrate on teaching his own classes and
conducting his own research. Thus, without an organized overview of his course provided
by a published text, we are left to piece Henry’s courses together from his extensive, if
scattered, lecture notes and from the careful notes of his students. The student notebooks
are particularly useful because they are quite extensive owing to a particular rule of
Henry’s classroom.

Like most modern professors, Henry opened his courses with a set of rules, of
which mandatory note-taking was only one. The foremost of these was “never lose a
lecture,” a phrase which appears several times throughout his introductory lecture
notes. As Henry told his students, he spent at least three hours preparing for and
writing down the experiments for each lecture, and would not repeat the process for late
comers or those who skipped the class. Further, any student who missed a lecture would
be examined separately in the weekly examinations. Held in lieu of a formal recitation,
which would determine class standing, Henry used these weekly examinations as a
teaching tool to discover and correct any weaknesses in the students’ understanding.

The other weekly requirement Henry imposed on his students was to turn in their
notebooks to him at the end of class on Friday. In response to any skeptical professors at
the college who might think that lecturing was too passive of a method, Henry required
his students to actively take notes, both during and after class. Each student was to fill the
left side of a notebook with his observations from the lecture and the experiments. The

107 Quoted in Ibid, 55.
108 Henry Papers, 6: 428.
right pages were left blank for later additions, corrections, or reflections on the material. It was Henry's goal that "by writing out in full [their] thoughts," his students would be able to "discover [their] defects and reduce the whole to clearness." They would thereby not only understand the material more readily, but they would also hone their listening skills and their faculty of attention. After discussing these basic rules of the classroom, Henry would then go on to discuss his overarching goals and expectations for the course.

Unlike older teaching methods, where a natural philosophy class might concentrate on reading and memorizing principles from a possibly outdated European textbook, Henry tried to actively engage his students with the material. Instead of memorizing a specific fact such as a particular formula, he would concentrate on walking the students through the discovery and derivation of that particular formula. This would leave the student not just with knowledge of a physical principle, but it would allow him to understand the physical forces and reasons behind that rule, so that he could apply it to other situations in later life. Henry knew that the majority of the seniors in his course would go on to careers in business, medicine, politics, or the ministry, and so would have little need to know highly specific things, such as how to calculate the velocity of a ball thrown into the air. But what they would need was a basic understanding of the physical world around them and, perhaps more important, analytical skills both inside and outside the classroom. Consequently, Henry structured his course to concentrate on just such analytical and derivation skills, or as he told his class, "my object has been to teach you to think - to philosophize - to arrive at general principles."  

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109 Henry Papers, 3: 520.
110 Henry Papers, 6: 413.
To implement these goals, the class usually spent several weeks on each topic. For example, in the spring of 1833, they spent at least two weeks studying steam and steam engines.\textsuperscript{111} In this time Henry had the opportunity to lecture to the students three times a week on the origins and uses of steam engines. In the recitation periods or during the lecture, he used detailed drawings and a small working model of a steam engine to demonstrate how the steam could move the valves. If after listening to the lecture and observing the demonstration the students had any questions, they were encouraged to either ask Henry during lecture or go to Philosophical Hall between 2:00 and 4:00 for a question period each day. Once the class had finished a section, there was no exam other than the weekly exercise; instead, Henry would wait until the end of the term when he gave both comprehensive written and oral exams. The exams included questions such as: “How do you graduate a thermometer? Give the difference between a high and low-pressure engine. Give the theory of electricity. Explain the process of induction. [And] Explain how two rays of light may be made to produce darkness.”\textsuperscript{112} The written portion tended to test how well the students listened and took notes; the oral portion in which a student was required to explain why a principle worked relied more on the student’s ability to observe and understand the frequent experiments.

The key difference between Harry’s teaching method and those used previously at the college, experiments and demonstrations, made up the heart of Henry’s teaching. He firmly believed that all lecturing needed to be accompanied by visual aids because they helped people remember the information. As he told his class “knowledge taken in by the eye, this is durable.” For this reason he purchased large rolls of black paper on which he

\textsuperscript{111} Henry Papers, 2: 52.
\textsuperscript{112} John R. Buhler, “My Microscope,” diary of senior year at College of New Jersey, Manuscripts Division, Rare Books and Special Collections, Princeton University Libraries.
wrote out common formulas or drawings, so as to free space on the blackboard for the day’s outline and for current equations. He also employed a magic lantern to project images on the wall to further illustrate a point. Of course, he set up simple experiments or demonstrations for his class regularly. These ranged from learning how to balance the acids in a galvanic trough to produce electricity to measuring the vibrations on the strings of a guitar-like instrument while studying harmonics. In one of the most popular demonstrations, Henry had eight men stand on a wooden plank placed across the scale pan, while three others pressed down on the iron bar. When the magnet was not connected to the galvanic battery, one man could easily remove the metal keeper; when the wires surrounding the magnet were electrified, the combined strength of the eleven students could not equal the magnet’s pull. To professors outside Henry’s department, such demonstrations may have seemed merely showy tricks. But as Henry found, allowing his students to pit their strength against his magnet was just the sort of display which captured their attention best. If we are to believe the diary of one of Henry’s students, John Buhler, it was one that the students would not soon forget.

Henry spent a great deal of time researching and preparing the experiments he used in class. Especially in the last seven or eight years he lived in Princeton, when he had acquired most of the equipment he needed, he spent the majority of his free time studying the latest discoveries in the scientific community. Many of his later contributions to science came from his research in preparing a syllabus for his natural philosophy course. In 1846 Henry wrote in a letter to one of his colleagues, that when he (Henry) began to prepare his syllabus, he often found that one subject or another

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113 Henry Papers, 6: 428.
114 Buhler, “My Microscope.”
“required more profound investigation than I had given them.”\textsuperscript{115} Unwilling to teach his students a subject that he did not fully understand himself, Henry spent months and even years studying aspects of capillary action, the film on soap bubbles, and the classification of mechanical power. In each subject, he would research the topic until he found his “mind in a proper state to advance the subject and accordantly [I] commenced a series of experiments, the results of which found favor with the scientific community at home and abroad.”\textsuperscript{116} This tendency to combine his original research with his teaching duties reflected his opinion that the ideal professor was one “who has not only a critical knowledge of the known, but is also capable of making excursions into the unknown.”\textsuperscript{117} In short, an ideal educator was one much like himself.

This concept of an ideal professor was one that was somewhat under debate in the scientific community, because it directly conflicted with the popular views of Denisin Olmsted. An astronomy professor at Yale, Olmsted had delivered a speech entitled “On the Beau Ideal of the Perfect Teacher” before the annual meeting of the American Institute of Instructors held in Hartford in August 1845.\textsuperscript{118} Published in Boston later that year, the speech encouraged persons considering a career in science to first examine where their “professional enthusiasm” lay. For example, if a person wanted to concentrate on research, he should become a “man of one idea,” concentrate all of his energies on one field of study. Such a path, Olmsted thought, “would be the most likely of any to add to the sum of truth, and to gain him a deathless name.”\textsuperscript{119} On the other hand, if a person’s sympathies lay with teaching, he would be best advised to study a

\begin{footnotes}
\textsuperscript{115} Quoted in Weiner, “Lectures of Natural Philosophy,” 59-60.
\textsuperscript{116} Quoted in Ibid, 59-60.
\textsuperscript{117} Quoted in Ibid, 53.
\textsuperscript{118} \textit{Henry Papers}, 6: 412, # 6.
\textsuperscript{119} Quoted in Ibid, 474-475, # 7.
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broad range of subjects, never concentrating on one in particular. This theory Olmsted subscribed to himself. Although he was the author of several important articles on various aspects of astronomy, he considered himself first and foremost a teacher. He spent the vast majority of his time in the classroom or preparing for lectures, and under his tenure the philosophical apparatus at Yale were primarily used not for original research but for practical instruction.

In contrast, Henry believed more in the Scottish common sense philosophy, which held that insightful researchers made insightful teachers. As Henry wrote in a letter to a colleague, “there is always an enthusiasm in an original investigator and a breath of thought which awakens in a class a spirit which a second hand teacher can never arouse.”

Further, Henry believed that any man of science who had the capacity to master one field of knowledge would be wasting his intellect if he did not investigate at least related fields. Thus he advised researchers to be men of “one purpose,” who were focused, but who had the broad knowledge needed to see the connections that men of “one idea” might miss.

While it is difficult to say which of these two competing educational theories was more effective, it was probably Henry’s fairly public stance on the issue that made him an attractive candidate for the position of secretary of the newly created Smithsonian Institution. When James Smithson died in 1829, he left his fortune to the United States government with the only provision that they use it to “found in Washington, under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge.”

With such a vague dictum, there was understandably much debate over

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120 Quoted in Weiner, “Lectures of Natural Philosophy,” 53.
what the institution should do. Surprisingly, there was very little debate over just who
should be appointed to head the new organization. With his reputation for original
research in a broad range of fields and as a highly successful educator, Joseph Henry was
an ideal candidate. Without his ever formally applying for the position, the committee
offered him the first secretaryship of the Smithsonian in 1846.\textsuperscript{122} Previously, other
schools such as Harvard, the University of Pennsylvania, and the University of Virginia
had offered Henry professorial chairs that paid more than he was earning at Princeton,
but he had turned them all down. Now Henry felt that he could not refuse the opportunity
that the Smithsonian offered. So after fourteen years in Princeton, Henry and his family
moved to the nation’s capital. Although he would return to Princeton for a number of
years to deliver short lectures series and would serve as a professor emeritus and later as
a member of the board of trustees, Henry’s official career as a professor was over. But his
influence on the college would continue for years to come. Having first found the
college’s scientific equipment and curriculum in an “imperfect state,” Henry had worked
hard over the intervening years to rebuild Philosophical Hall as to update and enlarge the
apparatus.\textsuperscript{123} Perhaps most important for the education of the college’s students, by
demonstrating the effectiveness of both lecturing and demonstration, he changed the way
sciences were taught at Princeton.

\textsuperscript{122} Henry Papers, 6: 556.
\textsuperscript{123} Henry Papers, 4: 166.
CONCLUSION
THE LEGACY OF CURRICULAR CHANGE

For years after Henry left Princeton, those curricular changes continued to have a significant impact on the academic life of the college. This was partially due to the wider spirit of industrialization, internal development, and improved education in the United States which had spurred the revitalization of the American colleges originally. However, more directly, the improvements at the college were due to Henry's own determination to enhance the scientific curriculum at the college generally and to improve the practical understanding of his students in particular. Although Henry achieved a remarkable measure of success with both of these goals, it is probably Henry's impact on the college as a whole which is most easily identified. Even after Henry left for the Smithsonian, the mathematic and scientific offerings at the college, as well as its academic standing among the other American schools, continued to improve.124

As Henry's personal writings from his time in Princeton attest, he considered himself a teacher primarily, and thus it would probably be his impact on his students that would have concerned him most. Unfortunately, as no system of recording student opinions or evaluations of courses was then in place at the college, the task of quantifying

124 After Henry moved to Washington D.C., his cousin and brother-in-law Steven Alexander, who by that time was a professor of the college, continued to advocate an expanded use of lecturing and practical experimentation in the classroom, as well as a greater variety of mathematic and scientific courses. He advocated, and was successful in convincing the college to offer, a permanent series of lectures on geology and astronomy. Maclean, College of New Jersey, 315-16, 320, 428.
the students’ reactions to Henry’s lectures is made more difficult. We are left with those few student notebooks and reminiscences from the time that mention Henry, which, as unrepresentative as they may be, suggest that Henry’s students generally held a high opinion of their natural philosophy professor.

Most of these descriptions depict him as a demanding instructor. After all, Henry had set himself the task of both reshaping the college’s curriculum and instituting practical hands-on instruction in what were too often less-than-ideal conditions. With such high goals, it was not surprising that he set high standards of attention and diligence for his students. In fact, Edward Wall from the class of 1848 later wrote of Henry’s classes that

>When the attention of any student flagged, he brought down the rattan cane that he used in the lecture room with an impatient whack on the high table before him, and with a vigor that showed that there was plenty more nervous energy behind the arm that wielded the cane. If the whack came, when the nerves were tense while writing, it was like an electric shock."125

Undivided attention was a strict rule in his classroom, as Henry regularly reminded his classes, along with careful note-taking, observation, and study both inside and outside the lecture hall. Indeed, Henry was so determined to teach his students as much about natural philosophy as he could in two terms that most of his introductory lecture was usually taken up with enumerating the rules of the course and stern warnings about the consequences of breaking his protocol.126 Since Henry’s expectations of critical reasoning and careful note-taking were much higher than the instructors in the lower classes, it’s likely that more than one student felt, as did John R. Buhler, class of 1847, “the Lilliput of my Mind crouches before the Brobdignag of His!”127

127 Buhler, “*My Microscope,*” May 28, 1846.
His reputation for strictness was mediated by the fact that Henry not only expected diligent work from his students, he put in long hours himself. Beyond the two hours each weekday that he set aside to answer student’s questions, Henry also took time to set up those illustrative experiments that several students would remember as “most instructive” and “more and more interesting.” Further, in June 1841, when members of the senior class wrote to collectively request that Professor Henry give a course in geology, Henry responded by researching and giving such a course later that term and each year for the remainder of his time in Princeton. He even continued the tradition after he had left for Washington D.C., returning each year to give a short series of lectures in geology, “true science,” or whatever subject that year’s graduating class requested of him.

It seems, too, that beyond his teaching duties Henry garnered a reputation as a somewhat eccentric and not wholly humorless figure. For those students who had not yet entered his classes, Henry was known as the tall man who could be seen in his homemade suits hurrying from his home to Philosophical Hall and vice versa at all hours of the day and night. He was also the professor who was said to have once stripped all of the silk ribbon from his wife’s petticoats to wrap around the wires of a magnet, and who had strung a live wire directly from the top story of Philosophical Hall to his own home, by means of which he could signal each afternoon when he was ready for lunch. Older students enrolled in his lectures came to know Henry as both a teacher and a personable

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128 Ibid, June 1, 1846.
129 Henry Papers, 5: 43-45
131 Wall, Reminiscences, 10.
man whose laughter often came slowly, but when it came turned his "Bass Viol Belly
into a perfect Jelly of Mirth." Not above joking with his class, Henry once tried to ease
his students' nerves during an exam by convincing a few trustees who had unexpectedly
turned up to observe the examinations, saying,

The Head is a kind of Barometer & is affected correspondently with the Condition of the
Atmosphere; therefore, Dr. Shippen, if the Gentlemen don't [sic] chance to pass as good
an Examination as usual you must attribute somewhat of the fact to this Anology.

Having recently studied the effects of low barometric pressure, the students
immediately recognized Henry's joke, and so watching the trustees nodding vaguely
lightened the mood considerably for the students. On another occasion, when the trustees
tried to prohibit the senior class ball, Henry successfully offered both his home and his
premises in Philosophical Hall as a possible location for the outlawed festivities. It
seems, then, that all of these aspects of Henry's personality gave him the reputation of
not just another professor but, as Basil L. Gildersleeve from the class of 1849 wrote, "our
great physicist."

It was for their great physicist that so many of his students consented to his
demanding syllabus and over the course of two terms gained a greater respect for both
him and his subject. For some, such as Richard Sears McCulloh and Henry Wurtz, their
early training in Philosophical Hall led to distinguished careers as men of science
themselves. For others, such as John Miller from the class of 1836, who continued on
after commencement as Henry's assistant for a year before becoming a Presbyterian

133 Buhler, "My Microscope," June 3, 1846.
134 Ibid, May 8, 1846.
135 Moyer, Rise of an American Scientist, 92.
136 Basil Lanneau Gildersleeve, "Personal Recollections of Princeton Undergraduate Life. I-The College in
137 Henry Papers, 6: 476.
minister, the study of science was a shorter-term pursuit.\textsuperscript{138} For the majority of students who passed under Henry's tutelage, it was his method of emphasizing induction and reason that would later most benefit their chosen careers in everything from business to medicine. As Edward Wall wrote years later, Henry's "method was capable of application to many of the circumstances of practical life." It was to him, and presumably many of his colleagues, "a most instructive and mind-quicken method. It gave not merely a congeries of physical facts but truths as connected with the inductive process to which their discovery was due."\textsuperscript{139}

Whatever level of applicable knowledge the students gained from the course, those remaining student accounts suggest that most students left with a high respect for their natural philosophy professor. John R. Buhler, a student inclined more toward the literary arts than sciences, wrote of Henry,

> he is like a canal in its Constancy Uniformity, Depth & Majesty of Flow. Or like his own \textit{Galvanism} – a Strong & Constant & Powerful Current – not possessing the momentary pungency & the Rapid Brilliance of \textit{Electricity} is true, but having that which it has not, a Continuity & a Deep Power in it that lasts & lasts with strong \textit{Effect}....\textsuperscript{140}

Even those most irreverent writers of \textit{College As It Is}, James Buchanan Henry and Christian Henry Scharff, wrote of Henry as a valuable asset to the college.\textsuperscript{141} Basil Gildersleeve, who held a low opinion of his time at the college, wrote of Henry that "it is a great thing for a boy to be brought face to face with a man who has done great things, and we Princetonians were proud of our great physicist."\textsuperscript{142} "Our physicist" indeed, for in the intervening years Joseph Henry has come to be remembered as one of Princeton's

\textsuperscript{138} John Miller Papers, Rare Books and Special Collections Box 4, Princeton University Library.
\textsuperscript{139} Wall, \textit{Reminiscences}, 11.
\textsuperscript{140} Buhler, "My Microscope," June 1, 1846.
\textsuperscript{141} Henry and Scharff, \textit{College As It Is}, 16.
\textsuperscript{142} Gildersleeve, "Personal Recollections," 378.
own legends - a man famous for his work with electromagnets, as the first secretary of
the Smithsonian, and, most important to the college, the man who helped establish
Princeton as a center of scientific learning.

Today the Princeton campus bears only slight resemblance to that which Henry
and his family found when they arrived in 1832. While both Whig and Clio halls remain
in the same location where Henry’s 1836 plan for the campus placed them, what was
once the Henry family home no longer stands in its original location. Having been moved
several times, the building now can be found just off Nassau Street facing the Princeton
Firestone Library. Gone too is Philosophical Hall where Henry conducted his
experiments—long replaced with a series of progressively more modern buildings.
Nevertheless, Princeton continues to remember her physicist with a permanent exhibit of
his instruments in the current home of the Physics Department, Jadwin Hall. Tucked in a
corner of the front lobby are a cluster of glass cabinets which house several horseshoe-
shaped magnets wrapped in green and white silk ribbon, one of Henry’s original
electromagnets, and a small green and brown writing desk where Henry undoubtedly
spent many hours writing out notes for his lectures. This display is only feet from the
building’s front door. During the academic term, the hourly ebb and flow of classes
brings students through the small room. Some are older students, rushing off to state-of-
the-art labs where they are conducting research for their senior theses. Others, perhaps
more bewildered arts students in pursuit of fulfilling their science and technology
requirement, walk towards the largest lecture hall in the building, where their “physics-
for-poets” professor will teach them, through a combination of lectures and practical
laboratory experiments, the basic tenets of mechanical and electrical physics. Perhaps this
last image of students on their various ways to class, more than the instruments in the corner, attests to the achievements of Henry and his colleagues. For it was scientists such as Benjamin Silliman at Yale, Alexander Bache at the University of Pennsylvania, and Joseph Henry in Princeton who helped to both improve practical teaching methods and to embed scientific subjects in the canon of American liberal education.
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VITA

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