

MATHEMATICS AND STATISTICS
AT THE UNIVERSITY OF
VERMONT: 1800–2000

Two Centuries of Achievement



April 2018

Overleaf: Lord House at 16 Colchester Avenue, main office of the Department of Mathematics and Statistics since the 1980s.

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Preface

As the bicentennial of the founding of UVM approached in 1990, a committee was formed to organize a proper celebration of the occasion. This committee solicited proposals from the faculty for projects suitable to the celebration. At the suggestion of my colleague Jeff Dinitz, I proposed to write the history of mathematics at UVM. The essays that follow constitute a revised and updated version of the article that resulted from that proposal. Many of the people named in the original essay have died in the quarter-century that has elapsed since the writing. That sad fact, and the wish to correct what I now see as the wrong slant on certain events, has prompted the present revision. The reader is warned, however, that I have certain cantankerous political and historical opinions that I do not attempt to disguise. (It goes without saying that no one is obliged to agree with them.) The general organizing principle for what follows is that of a matrix whose rows are indexed by historical periods and whose columns are indexed by the areas of relevance to the mathematical history: personalities, teaching, research, students, and the mathematical environment. Not every position in this matrix will be occupied, but these are the general categories that will be discussed.

The reader will notice early on that I appear to wander away from the subject matter of mathematics and statistics. That deviation from the straight and narrow path is deliberate. I believe that the greatest interest in this story lies in the *people* who were involved. The promotion of teaching and research is a human enterprise, and I have chosen to follow a number of story lines that are tangential to the subject whenever they involve human activities that give a flavor of what it was like to be at UVM at a given time. In any case, I think a strict, orderly recital of what was taught and what was discovered would be deadly dull. To that end, it will be noticeable that I give the exact date of birth for all the people referred to, the only exceptions being personalities from ancient Greece and Rome, famous authors, Presidents of the United States, Supreme Court justices, and United States senators and representatives, whom I consider well-enough known from general history books.

Sources

The following material was gleaned from a wide variety of sources. The most important source of documentary material was the University Archives. I am particularly indebted to David Blow, the University Archivist at the time of the original writing, for his constant and efficient help and suggestions in locating the documents I needed. These documents include the personnel files on the characters involved, the minutes of the meetings of the Board of Trustees (known originally as the Corporation), and the University Catalogs. The Wilbur Collection at the

Bailey–Howe Library has also been a valuable source of material. Finally, I am indebted to various retired colleagues for their personal reminiscences: Heath Riggs, Ivan Hershner, N. James Schoonmaker, Joseph Izzo, and most especially George Nicholson, whose mathematical career spanned more than one-third of the history of mathematics at UVM up to the time when this project was begun.

Note added 24 March 2018: I am especially grateful to my fellow emeritus professor John Lawlor for reading the semi-final version of this document and sending me many suggestions that have greatly improved it. For that, and for many other things, especially hundreds of cryptic puzzles from Cox–Rathvon, and Maltby, I am much indebted to you, Jack.

The Administrative Support Staff

Because of the way records are kept, it is a nearly impossible task to report on the activities of the essential support staff, without which no office can function. These administrators are the unsung warriors in the battle against ignorance. They generally do not get recognized, and are forgotten by history. They were the ones who booked travel, handled textbook requisitions, sent notices around to the faculty, and facilitated the ceremonial and social occasions—the student awards, the fall picnic, the end-of-semester potlucks, and much else—that helped to knit us all together. I can only note with gratitude the invaluable help I received during my years on the UVM faculty and mention the names of the three that I remember best during the years from 1970 to the present. To Jackie Marlow, Janet Ferguson, and Karen Wright, *thank you!* for all that you did to keep the Department of Mathematics and Statistics running smoothly.

Having mentioned the social and ceremonial occasions, I find this an appropriate place to express the joy I have had in belonging to this wonderful organization, as a faculty member for 35 years, and now 15 years in retirement. I remember with particular fondness the quarter-century of playing softball with the “Eulers.” To all my colleagues among the faculty and staff, and to the students who made the whole enterprise worthwhile, *thank you!*

Roger Cooke
25 March 2018

And now, to work.

The Context of UVM Mathematics

For the general history of UVM there are various secondary sources, for example Lindsay ([3]). For that reason, the details of many issues that have come before the trustees of the University since its founding will be neglected. Only the issues that have led to fundamental changes in the way the University operates will be discussed. Before we begin expounding the details of the mathematical development of UVM, it may be well to expend a few words on the perspective within which this mathematics is to be judged, whether local, national, or global. We might consider UVM in the context of its educational mission in Vermont and northern New England, or as an example of an early American university, or in the context of world mathematics. Each of these perspectives provides a special kind of insight into the mathematical activity that has taken place at UVM.

Taking the local point of view, we find some rather well-educated mathematicians at UVM, even in the early nineteenth century, when large parts of Vermont were a howling wilderness and Burlington was two long days' journey in a horse-drawn carriage distant from better established institutions such as Dartmouth and Williams College. These professors were teaching mathematics in some depth to ordinary citizens aspiring to careers as lawyers, physicians, clergy, or farmers. Some of them even conducted original research and published it.

The national perspective reminds us that, although UVM is the twentieth oldest university in America, there many New England colleges already in existence at the time of its founding in 1791. These institutions provided the early UVM faculty. Harvard, which was founded before Newton was born, had already celebrated its sesquicentennial before UVM was even conceived. The national point of view also brings an awareness of the expansion and democratization of education after the Civil War, in which UVM faculty participated.

A Digression: Who Reads an American Book?

The perspective of worldwide mathematics invites comparison with European universities founded about the same time as UVM but on the periphery of the scholarly world whose primary centers were in Paris, Göttingen, Berlin, and London, universities such as Christiania (Oslo) in Norway (founded in 1811 as Royal Frederick University) and Kazan in Russia (founded 1804). From this perspective one can see clearly the retarding influence exerted by an ocean 3,000 miles wide that separated American scholars from the great centers of European learning. The University of Oslo, for example, was hardly founded when it produced one of the giants of nineteenth-century mathematics, Niels Henrik Abel (5 August 1802–6 April 1829), who died at the age of 26, but not before producing some of the most profound work ever done on elliptic functions, theory of equations, and analysis. Oslo went on to produce a steady stream of such figures throughout the nineteenth century. At its formation, Kazan already had the young Nikolai Ivanovich Lobachevskii (1 December 1792–24 February 1856), one of the creators of hyperbolic geometry, as an upper-level student, even though conditions in Russia were less conducive to mathematical achievement in the more remote areas such as Kazan, and no other prominent mathematicians worked there until the twentieth century. (Another famous graduate of Kazan University was the writer Leo Tolstoy (9 September 1828–20 November 1910), who attended while Lobachevskii was rector there. Lenin (22 April 1870–21 January 1924) also spent a brief time there before being expelled for radical activity.) Abel and Lobachevskii were geniuses, but had they been in Vermont it is unlikely that any European now alive would have heard of them. Abel traveled to the major centers of mathematical activity, and the University of Kazan imported such scholars as Johann Christian Martin Bartels (17 April 1769–20 December 1836), former teacher of the mathematical giant Carl Friedrich Gauss (30 April 1777–23 February 1855), to inspire Lobachevskii and his classmates.

UVM, in contrast, was significantly smaller than these European universities and dedicated primarily to teaching. Although UVM was founded in close cooperation with the government of the State of Vermont and the village of Burlington, these governments were not seeking to win international prestige by the excellence of their scholars. The aim was education for the professions. The early faculty,

graduates of such places as Harvard, Dartmouth, and Williams, tended to frame the curriculum in accordance with their own background. Very few Americans, and none at all from Vermont, studied at the feet of the great German and French masters until late in the nineteenth century, and until the last few decades of the period of this narrative no mathematicians from Europe came to UVM to impart their knowledge. The situation in America was described with breathtaking arrogance and condescension in 1820 by an egregious ass known as the Rev. Sydney Smith (3 June 1771–22 February 1845), who wrote what is surely the cheapest shot ever to appear in the *Edinburgh Review*:

In the four quarters of the globe, who reads an American book? Or goes to an American play? Or looks at an American picture or statue? What does the world yet owe to American physicians or surgeons? What new substances have their chemists discovered? Or what old ones have they advanced? What new constellations have been discovered by the telescopes of Americans? Who drinks out of American glasses? Or eats from American plates? Or wears American coats or gowns? Or sleeps in American blankets? Finally, under which of the old tyrannical governments of Europe is every sixth man a slave, whom his fellow-creatures may buy and sell and torture?

The Reverend conveniently forgot to mention that some of the support for the American Revolution a half-century earlier had come from Americans who were attempting to establish the very manufacturing industries whose absence he deplored, and that they were being forbidden to do so by his government, which was protecting the interests of the wealthy classes that controlled Parliament. Even more conveniently, he forgot that the abomination that was slavery had been established in America by his own government, and that its continuation had been one of the “tyrannical acts of the British King” listed by Thomas Jefferson in the original draft of the Declaration of Independence.¹

All that is proof that Smith was an incompetent social commentator. That he was, in addition, an upper-class twit, is shown by his sneering at the condition of arts and sciences in the United States. British culture, and European culture in general, was built on a continuous tradition of art and scholarship dating back centuries to Medieval times and before. To reproach people living in frontier conditions for not producing works of comparable quality is simply stupid. Nationalist polemics aside, the community of American scholars in the early nineteenth century, though small, contained some people of international stature, whom the Reverend Smith might have known about, had he been less myopic and better informed about science. Among them were the following five:

- Joseph Henry (17 December 1797–13 May 1878), a physicist and professor at Princeton after 1832, who discovered the phenomenon now known as electromagnetic induction in 1831, almost simultaneously with the great British scientist Michael Faraday (22 September 1791–25 August 1867). Faraday, of course, had the advantage of communicating what he had discovered to the transcendent genius James Clerk Maxwell (13 June 1831–5 November 1879), and as a result, Faraday’s law that a changing magnetic

¹Mark Twain pointed out that in 1820, England still possessed more slaves in its overseas colonies than were in the United States.

field creates an electric field became one of the four famous Maxwell laws. In honor of Henry's work, the unit of electrical inductance is named the henry.

- Benjamin Silliman (8 August 1779–24 November 1864), an American chemist and geologist, who taught at Yale and founded the first American scientific journal, *The American Journal of Science*, in 1818. (It was commonly called *Silliman's Journal* in the nineteenth century.) After getting the A. B. and A. M. at Yale in 1796 and 1799 respectively, he became a tutor at Yale and studied for the law. He then traveled to the University of Pennsylvania in 1802 to study chemistry. When he returned to Yale in 1804, he gave the first course of lectures in chemistry there. He traveled to Edinburgh, Scotland in 1805 for further study and returned that year with a new interest in geology.
- Nathaniel Bowditch (26 March 1773–16 March 1838), perhaps the greatest autodidact America has ever produced. Although very poor and working as an apprentice, he began to teach himself algebra in 1786 at the age of 13. Within six years, he had taught himself calculus, Latin, and French as well, and was able to read Newton's *Principia* and Laplace's *Mécanique céleste*. In 1802, he produced the first edition of *Bowditch's Practical Navigator*, a work that became a standard reference on all American ships. He became a member of the American Academy of Arts and Sciences in 1799 and was elected to the American Philosophical Society in 1809. Over a decade or more, he labored on a translation of the first volume of Laplace's masterpiece of astronomy, expanding the latter's terse arguments and producing an influential work of American scholarship. The value of these works was recognized abroad, and Bowditch was elected to the Edinburgh Royal Society and Royal Irish Academy. Besides astronomy and navigation, he was also interested in statistics and actuarial work and refused several offers of professorships at prestigious universities, since he was making more money running his own companies.
- James Dean (26 November 1776–20 January 1849), UVM's first professor of mathematics and natural philosophy. Not quite on a level with the previous three, he nevertheless wrote a number of scientific and mathematical papers, some of which merited inclusion in the *Royal Society Catalogue of Scientific Papers* for the period 1800–1863. He had some professional contact with the three mentioned above, and can nearly hold his own as a scholar in their company. He published papers in *Silliman's Journal* and corresponded with Joseph Henry, to whom he bequeathed his scientific instruments.
- Robert Adrain (born in Carrickfergus, Ireland on 30 September 1775, died in New Brunswick, NJ on 10 August 1843). Adrain became a member of the group known as United Irishmen (a mixed Catholic–Protestant society), which led an unsuccessful rebellion against British rule in 1798. He then emigrated to the United States, where he became, along with Bowditch, one of the two most eminent mathematicians in the country. In 1808, he published an investigation of the normal (“Gaussian”) distribution, one year before Gauss himself did so. (Neither of them was the

first to do so, both having been anticipated by Pierre-Simon Laplace (23 March 1749–5 March 1827).)



The Math/Stat Eulers, 1989. Kneeling, left to right: Andrew Cooke, Dan Archdeacon, Jeff Dinitz, Jim Burgmeier. Standing, left to right: Larry Kost, Roger Cooke, Lloyd Simon, Jim Fenwick, Dave Dummit, Jack Lawlor, Jonathan Sands, Dave Morency, Sandy Karstens, Taka Ashikaga.

CHAPTER 1

The Early Years, 1800–1825

The University of Vermont was chartered in 1791 by act of the Vermont legislature and given the right to collect rent from a large amount of land in Vermont. There were apparently many difficulties to be overcome, and no progress was made in acquiring a physical plant or a faculty until the citizens of Middlebury procured a rival charter in 1800 and petitioned for the transfer of the University's lands to their institution. Perhaps by coincidence, that was the exact year when UVM finally appointed a president.¹ UVM's first president was a Congregational minister, the Reverend Daniel Clarke Sanders, born at Sturbridge, MA on 3 May 1768, who had graduated from Harvard in 1788. From 1794 to 1800, he was pastor of the Congregational Church in Vergennes. He remained at UVM as president until 1814, when the University, short of funds and students, closed down and leased its buildings to the government for use in the war against the British. During his time as president of the University, he published a small book entitled *History of the Indian Wars with the First Settlers of the United States* (Montpelier, 1812), which contains, among other information, some material on the then-recent campaigns of Andrew Jackson against the Creek tribe. After leaving UVM, Sanders returned to Massachusetts (Medfield), where he took the same path as the Boston Transcendentalists, out of Congregationalism and into Unitarianism. He was pastor of the Medfield Unitarian Church from 1815 to 1829. During this time, he continued to be active in promoting education and served as a delegate to the Massachusetts Constitutional Convention of 1820. He died in Medfield on 18 October 1850.

Perhaps spurred into action by the rivalry with Middlebury, Rev. Sanders began tutoring four students in 1800, although they were not yet formally matriculated as we would describe students today. Formal instruction began, with Sanders as the only faculty member, in 1801. For all but one semester from 1800 to 1806, he personally supervised the studies of all UVM students, a task that kept him occupied eight hours a day. The minutes of the Board of Trustees' meeting of 13 January 1801 (Vol. 1, p. 51) record that, "The president appointed to procure a tutor reported that no sufficiently qualified and respectable character was to be obtained in this State at present." Perhaps because of the year of tutoring, Sanders ruled that these students were ready to receive their degrees in 1804.²

¹Biographical sketches of ten of the first eleven presidents of UVM can be found on pp. 39–42 of the second volume of the *The National Cyclopaedia of American Biography* (J.T. White, Clifton, NJ, 1893), which is the source of much of the information about them contained in the present work.

²Union College in Schenectady, NY, which obtained an official charter as a university from the State of New York, in 1795, had been functioning as "the Academy" before its founding. Despite being chartered four years later than UVM, it was able to hold its first commencement in 1797, seven years before UVM.

1. The Curriculum

Lindsay ([3], pp. 85–88) gives the admission requirements and the curriculum for the four-year course of study as described in the laws of the University from that time. The admission requirements were all classical: the ability to translate the first six books of the *Aeneid*, the four orations of Cicero against Cataline, and the four Gospels in Greek.³ Admission to the University at this time, and until late in the nineteenth century, was by examination. The prospective student would appear at the University at a specified time—usually the week before UVM’s commencement—and present himself for examination by the faculty. In keeping with the admission requirements, the curriculum also placed a heavy emphasis on a literary and classical education, but mathematics was not neglected. In fact, one may well ask who today has an intimate knowledge of all the mathematics courses in the following list, some of which have passed out of the standard curriculum or been absorbed into more comprehensive courses:

Second year. 1st: Vulgar Arithmetick. 2d: Logarithms and Algebra 3d: Geometry and Euclid’s Elements. Plane Trigonometry. Mensuration of superficies and solids. Gauging. Mensuration of heights and distances

Third year. 1st: Surveying and Levelling. Navigation. Conick Sections. Dialling. Spherical Geometry. Projections of the Sphere. Spherical Trigonometry and Spherical Astronomy

(“Dialling” is the theory of sundials.)

The emphasis on spherical geometry, trigonometry, and astronomy is explained by the needs of navigation. These subjects, along with geography (another important obligatory part of the curriculum) were considered essential parts of one’s knowledge of the world. Without them one’s appreciation of even English literature is impoverished.⁴ Lindsay ([3], p. 69) expresses some puzzlement that the calculation of eclipses was universal in all colleges of the time and considers its presence in the curriculum “probably a hangover from the medieval curriculum.” In fact, the calculation of eclipses has some potential application in commerce: observation of a predicted eclipse can be used to determine terrestrial longitude approximately.

Latitude is easy to determine, at least in the northern hemisphere. One has only to go outdoors at night and observe the elevation of the pole star. That elevation is the latitude of the point of observation. This statement is a slight oversimplification, since the pole star isn’t exactly true north, but the point is that latitude is easily determined. Any known star can be observed at its culmination (transit of the local meridian), and the local latitude can then be worked out from spherical trigonometry. Even if one lives at the bottom of a mine shaft, one can work out latitude; for example, it is the arcsine of the fraction of a revolution that a Foucault pendulum precesses in one sidereal day, and the direction of precession distinguishes northern latitude from southern.

³A student who could meet these requirements nowadays would be considered to have completed a good portion of a classics major!

⁴Many people have found that the chief difficulty in coming to an appreciation of works like Milton’s *Paradise Lost* is occasioned by the numerous allusions to rivers, mountains, and mythological figures that were familiar to educated people in earlier centuries but mean nothing to most people nowadays.

Longitude, on the other hand, is more difficult to calculate. All observers at a given latitude observe the same stars following the same path each day, and the only difference between two points on the same parallel is in the time at which a given star is at a given right ascension. The problem is to determine how many degrees one's own location is west or east of the intersection of its circle of latitude with the Greenwich meridian. Direct measurement is precluded by the topography of the earth. If one knew what time it was in Greenwich when it is noon locally, of course, the longitude would be determined exactly. Each hour of time difference between local mean solar time and Greenwich mean time represents a difference of 15 degrees of longitude. For that reason, the British government had offered a prize for a clock that would keep accurate time on board a ship. Setting such a clock to Greenwich time, one would then always be able to calculate longitude by comparing local solar time with the clock time. Such clocks were not easy to develop and were far from cheap and reliable. The cheap way of calculating longitude, once astronomy was sufficiently sophisticated to predict planetary motion with accuracy, was to use a big clock in the sky.

For instance, the moon undergoes changes of phase. If one could chart these phases accurately enough, it would only be necessary to look at the moon to know what time it is in Greenwich. Unfortunately, the moon's phases change too slowly to permit measuring those changes over the period of a few hours. When Galileo discovered the moons of Jupiter, he realized that their configurations, once worked out, could be a much better "universal clock" than moon-related phenomena such as phases or tides. They were actually used for this purpose in some surveying work. The most easily observable clock of this type, however, is a lunar eclipse (a solar eclipse is not visible simultaneously at widely separated places). This use of eclipses in calculating longitude was known from very early times. A lunar eclipse on 20 September 330 B. C. E. was observed at both Arbela (44° E, the city of Erbil in the territory of modern Iraq) and Carthage (10° E, on the northern coast of Africa), and these observations were used by Ptolemy to calculate the difference in longitude between the two places ([4], p. 668). The accurate mapping of the world was still a matter of pressing practical importance in the early nineteenth century, and editors of scientific journals were eager to have accurate observations of eclipses to compare with the predicted times. For that reason, one must disagree with Lindsay's assessment of this part of the curriculum.

As for the rest of the curriculum, it was not the latest in research mathematics. The calculus, already 150 years old, was not part of the curriculum; nor were the researches in mathematical physics due to the great eighteenth-century mathematicians Leonhard Euler (15 April 1707–18 September 1783), Pierre-Simon Laplace, Joseph-Louis (Giuseppe Lodovico) Lagrange (25 January 1736–10 April 1811), and others, much less the torrent of creativity emanating from the French *École Polytechnique* in the first half of the nineteenth century. This work had hardly reached the United States in 1804, and in particular had not reached Vermont. Laplace's *Mécanique céleste* had, however, reached Boston and, as mentioned above, soon inspired a translation by Nathaniel Bowditch that far excelled the original in clarity of expression.

1.1. Physical apparatus. Teaching at UVM was by lecture, since there was very little opportunity for laboratory work. What we now call laboratory equipment used for instruction was known in those days as "philosophical apparatus"

and described by UVM’s sixth president, John Wheeler (11 March 1798–12 April 1862), who served in that capacity from 1833 to 1849, in an address at UVM’s semicentennial celebration in 1852 ([9], p. 2):

Of astronomical and philosophical apparatus, there was a telescope, planetarium, quadrants, two sets of 24-inch Globes, and other necessary articles of value, besides seven hundred dollars’ worth of instruments purchased of the Rev. Dr. Prince of Salem, Mass., by individuals, and deposited for the use of the University, in the Philosophical Chamber. The apparatus was more complete, than in any of the Colleges in New England, except Harvard and Yale.

Lindsay ([3], p. 106) mentions a catalog from The Rev. Dr. Prince⁵ listing objects for sale, including glass plates ground so as to make an airtight joint, a flask beam for weighing air, a pipe of mephitic air (carbon dioxide), a long glass tube with plate and collar of leather for the Torricellian experiment [showing the decrease of atmospheric pressure with altitude], a model water pump of brass and glass to show the action of valves, an electric generator turned by winch, an electrical cannon for firing hydrogen gas, a battery consisting of nine jars, a microscope, and many other objects. Lindsay reports that only one of these objects remained in the early 1950s, a compound magnet encased in brass.

1.2. Textbooks. There does not seem to be any record of textbooks, if any, used for the instruction at the earliest period. The library was not a rich source of reading material. The minutes of the Board of Trustees’ meeting in January 1811 (Vol. 1, p. 154), lists the entire University library of the time. It consisted of thirty volumes, with a heavy emphasis on literature and divinity studies. The few science books available were all devoted to the applied parts of science, such as (Erasmus) Darwin’s⁶ *Zoonomia*, Priestley’s⁷ *Corruption*, Priestley’s *On Air* (5 volumes), and “Paine’s *Geography*.”⁸

There were altogether six professors/tutors of mathematics up to 1855, and we shall devote almost all our attention to the three most prominent of them, the first and the last two, saying rather little (since less is known) about the other three.

2. James Dean, 1807–1814 and 1822–1825

In 1807 Mr. James Dean was deemed “suitably qualified and respectable” to be a tutor of mathematics and astronomy, and in 1809 he became the first professor

⁵John Prince, 22 July 1751–7 June 1836.

⁶12 December 1731–18 April 1802, an English physician, grandfather of the famous Charles Darwin.

⁷Joseph Priestley, 24 March 1733–6 February 1804, a Separatist theologian and chemist, the discoverer of oxygen.

⁸Actually, John Payne (dates unknown). The British *Dictionary of National Biography*, Vol. XLIV (1895), p. 111, says he went into business with a man named Joseph Johnson (15 November 1738–20 December 1809) in the publishing firm of Johnson and Payne in Paternoster Row, London. This firm burned down in 1770, after which he began writing a large number of books. His book *A New and Complete System of Universal Geography* was published by John Low, New York, during the years 1798–1800. A copy of this book was sold at auction by Christie’s, New York, on 24 June 2009. It went for \$375, even though Christie’s had evaluated it in the range of \$800–\$1200. This may be the book referred to in the minutes. Or that book may be his two-volume *Universal Geography*, published by Johnson in 1791.

of mathematics and natural philosophy at UVM. No portraits of James Dean seem to have survived, but his physical appearance and character were described in President Wheeler’s semicentennial address ([9], p. 24):

He possessed a mathematical mind, distinguished for its clearness and accuracy, rather than its depth and scientific insight. He devoted himself to the life of a student, and acquired much, and various knowledge, rather than comprehension and profound principles. He was rigid in his discipline, the sharp lines of which were perhaps increased, by an occasional irritability of temper, which seemed to spring from his very peculiar physical constitution. He was inordinately fleshy, and in such way as to give the appearance rather of disease than of health. His influence in the University was marked by adherence to law and order, in the simple and earnest pursuit of its objects.

In other words, according to Wheeler, Dean was a dabbler and dilettante, one who preferred breadth to depth. These are precisely the qualities needed in a professor at an institution devoted solely to teaching, although Wheeler’s tone suggests that he thought otherwise. Despite Wheeler’s patronizing characterization of him, Dean became a scholar of some note, and his biography appears in the *National Cyclopaedia of American Biography*. This biographical sketch, however, is very brief, and for the rest of what is known about Dean, including many interesting activities unrelated to scholarship, we must turn to other sources, the most immediate one of which is a biographical article ([2]) by George Frederick Houghton (born in Guilford, VT on 31 May 1820, died in St. Albans, VT on 22 February 1870), a lawyer who graduated from UVM in 1839 and served in the Vermont legislature during the 1840s. He was one of the founders of the Vermont Historical Society and wrote many articles for its journal.

2.1. Early years. James Dean was born at Windsor, VT on 26 November 1776, to Willard and Parnell Dean. His older brother Noah had been born on 30 August 1772, and his sister Abigail was born on 8 March 1785. He had at least one other sister, Eleanor, who died in 1809, and two younger brothers, John and Nathaniel, both of whom were born in the late 1780s and died in the early 1790s. He received the A. B. degree from Dartmouth in 1800. He then became the first principal of the Montpelier Academy, which was founded on 7 November of that year. Little is known of this institution, as Montpelier was sparsely settled at the time, having only 839 inhabitants. In 1813, by act of the Vermont legislature, the Academy was superseded by the Washington County Grammar School, which has a more detailed written history. Dean received an honorary A. M. degree from the University of Vermont in 1806. After serving for two years as a tutor in mathematics, he was appointed the University’s first Professor of Mathematics and Natural Philosophy in 1809.

UVM’s first professor of mathematics was, by American standards of the time, intellectually respectable as a researcher, as will be seen below. Was he a good teacher? There is some evidence that he was an interesting and inspiring lecturer. When he became professor in 1809 (actually on 24 April 1810), he delivered an inaugural address in the manner of the German *Antrittsrede*, entitled *An Oration on Curiosity*. This 19-page summary history of natural philosophy is based on

what was then popularly believed about ancient Greek philosophy, especially about Pythagoras, and is very inaccurate in the light of later scholarship. But it served a useful purpose in its time and was printed and published by the Samuel Mills Press in Burlington in May 1810 at the request of the students. We may infer, then, that they found him to be an interesting lecturer. We mention in passing that, during this time, he lived in the Lucy Ann Abbot House, now known as Nicholson House, at 41 South Prospect Street, which was later inhabited by two other UVM professors of mathematics, then became the home of the Department of Mathematics for several decades, and was eventually named after a long-serving mathematician.



The Lucy Ann Abbot House at 41 South Prospect Street. Built in the first decade of the nineteenth century, it acquired its name from the person who owned it from 1871 to 1875. It was briefly the residence of James Dean during the second decade of the nineteenth century. In the final decade of that century it was for a time the residence of mathematics professor Arthur Dexter Butterfield and in the 1930s the residence of mathematics professor Myron Ellis Witham. In the twentieth century, the Department of Mathematics and Statistics was located in it for several decades, during which time it was renamed Nicholson House in honor of George Hubert Nicholson, who taught at UVM from 1923 through 1973.

James Dean left UVM in 1814 along with President Sanders, when the University closed and rented its buildings to the American government for use in the war against the British. In his years at UVM up to that point his salary, nominally \$400 per year when he was appointed in 1809, had not been regularly paid. The University accounts in January 1811 show that he was owed \$847.15. This was surely not a sum one could easily afford to spare at the time. The University, however, was not going to settle easily. In the discussion leading up to the closing of the University (Minutes of the meetings of the Board of Trustees, Vol. II, p. 55, meeting of 24 March 1814) we read:

Resolved, That the Treasurer in paying the debts due from the Corporation to the late President and Professors, pay to them in

proportion to their existing debts, provided Professor Dean withdraws his suit without Cost, at the same time having respect to what greater proportion anyone has already received. And if said Dean does not so withdraw his suit, pay said President and Professor Chamberlain first. . .

Jason Chamberlain (6 May 1783–31 July 1820) had been appointed Professor of the Learned Languages in 1811, and gave his inaugural oration—a discourse in praise of grammar—on 1 August that year, just as James Dean had done the year before. Like Dean’s oration, it was published by Samuel Mills Press. Before coming to UVM, he had been pastor of the Congregational Church in Guilford, VT. On 4 February 1814, Chamberlain wrote to ex-President Thomas Jefferson, sending him a sample of the Iroquois language and noting that many Iroquois were literate. Jefferson wrote back to him in July of that year. He in turn wrote back to Jefferson on 30 November, saying

Inter arma, Musæ silent. [In wartime, the Muses do not speak.] Our College Edifice is leased to the Government, for the accommodation of the Army; and our Collegiate exercises are suspended. Meanwhile, I have resorted to the practice of the Law, in order to obtain a reputable support. There are other situations, here, which would be more congenial to my feelings, but would not afford a good living. I receive a handsome income from my practice, and cheerfully submit to my destiny. Though anxious to obtain general information, and to visit other countries, I shall probably spend my days in this place.

Thus it appears that he had found a comfortable third profession and was prepared to practice it in Burlington for the rest of his life. He probably already knew that he was about to become a father. His daughter Eliza (8 May 1815–13 January 1895) was due to arrive in the spring of 1815. Before her arrival, however, an event occurred on the other side of the world that was to alter those plans two years later. In April 1815, Mount Tambora in Indonesia erupted, scattering ash worldwide and shutting out the sunlight. There was no summer in 1816, either in North America or in Europe. The effects on Vermont were devastating, as one can see from the population figures. Between 1790 and 1800, the population of Vermont increased by 70,000; between 1800 and 1810, by 60,000; between 1810 and 1820, by only 18,000; then, between 1820 and 1830, by 45,000 again. That drastic dip in the rate of growth over the decade from 1810 to 1820 in comparison with those that preceded and followed is a measure of what must have been major disruptions in the lives of Vermonters. Many of them headed west, hoping, no doubt, for a better life. (There were positive lures as well. This was the time when the Midwest was settled, and large amounts of very fertile land became available.) Among those who did so was the Rev. Prof. Chamberlain.⁹ After leaving UVM, he moved far west, to Jackson, MO,¹⁰ where he practiced law, with success, but not for long. On 12 August 1820, the *Arkansas Weekly Gazette* reported the following:

⁹See the article by Marius B. Péladeau, ([6], footnote on p. 29).

¹⁰Missouri and Arkansas were still territories at this time, not yet states. Missouri became a state in 1820, Arkansas in 1836.

Drowned about the 31st in attempting to ford Eleven Point in Lawrence County in this Territory, Jason Chamberlain Esq., a very respectable attorney at law of Jackson, Missouri. Mr. C was a native of Vermont but has resided in Missouri for the last few years.

2.2. Interregnum (1815–1821). Dean stayed away from UVM for seven years, during which time the duties of the presidency of UVM were carried out by the Rev. Samuel Austin, a strict Calvinist, in contrast to his predecessor, who, as noted, inclined to theological liberalism. Austin was born in New Haven, CT on 7 October 1760, graduated from Yale in 1783, and served as pastor of the First Congregational Church in Worcester, MA from 1790 until his appointment at UVM in 1815. (The *National Cyclopaedia of American Biography* asserts that he studied with “Dr. Jonathan Edwards” at Yale. It is not clear who that might be. It could not be the famous Boston-based, fire-and-brimstone preacher of that name, who died in 1758, two years before Austin was born, although he also was a graduate of Yale, in 1720.) He was in conflict with the trustees at some points, and the University’s financial position was quite precarious at this time. He left UVM on 21 March 1821 and served afterward as pastor of a church in Glastonbury, CT, where he died on 4 December 1830.

During the first part of this seven-year period, instruction in mathematics and astronomy was carried on by Ebenezer Burgess. The *Historical Catalogue of Brown University*, published in 1914, lists Burgess as a tutor at that institution in the period 1811–1813. Born in Wareham, Massachusetts on 1 April 1790, he was a preceptor at the University Grammar School in Providence during the years 1809–1811. He graduated from Andover Theological Seminary in 1815 and received a D.D. from Middlebury College in 1835. He taught at UVM from 1815 to 1817. After leaving UVM, he was an agent of the American Colonization Society for Africa in 1817–1818. In 1821, he was ordained a Congregationalist minister and was pastor of the First Church of Dedham, MA for fifty years, from 1820 until his death in 1870.

Burgess’s successor was the Rev. Gamaliel Smith Olds. Born in Granville, MA on 11 February 1777, he graduated from Williams College in 1801 and was tutor there until 1805, when he became its first professor of mathematics and natural philosophy. After serving at UVM in 1819 and 1820, he taught at Amherst College for a year and then for several years at the University of Georgia before moving to Circleville, OH, where he died on 13 June 1848. He wrote a pamphlet, now in the Wilbur Collection of the Bailey–Howe Library, bearing the title, “Statement of Facts Relative to the Appointment of the Author to the Office of Professor of Chemistry in Middlebury College and the Termination of his Connexion with that College,” published by Denio and Phelps, Greenfield, MA, 1818. As Rev. Olds tells the story, he was approached by Middlebury College in 1816 and asked to take the position of professor of chemistry. Not feeling quite qualified, he asked for a delay of one year in assuming the position, to which the president of Middlebury College assented orally. Olds was to be paid while preparing himself by listening to Benjamin Silliman’s course of lectures at Yale. When he wrote requesting his salary, however, the president of Middlebury College responded, “that our treasury is at present entirely empty, and is likely to remain so, I apprehend, for some time.”

Before his year of preparatory study was expired, Middlebury changed its mind and annulled the appointment, apparently claiming some impropriety on the part of Rev. Olds. It was the charges against him that provoked the pamphlet.¹¹ The minutes of the UVM Board of Trustees indicate that he was the fourth person to whom the position of professor of natural philosophy was offered, the first three chosen having declined the honor.

2.3. Tutor at Dartmouth, 1816–1819. In order to explain this phase of Dean’s career, we need an extensive digression into the history of Dartmouth College. The College has its origins in two schools founded in Lebanon, CT by the Rev. Eleazar Wheelock (born in Windham, CT on 22 April 1711—that is probably an old-style date, corresponding to 3 May on the Gregorian calendar, since Britain did not adopt the Gregorian calendar until 1752—and died in Hanover, NH on 24 April 1779). The first of these schools, founded in the 1730s, was termed a “Latin” school by Rev. Wheelock, and was a traditional liberal-arts institution of its time. The second school, which was founded two decades later in the 1750s, was a charity school for children of the aboriginal tribes in the colonies. The plan was to bring two boys from each tribe (so that they would retain their native language) and christianize them, turning them into missionaries to their own people. The colonists very much wanted to convert the native tribes, partly out of religious zeal, and partly because they hoped that, once the tribes were christianized, the devastating wars with them would come to an end. The Seven Years’ War (1757–1763), known in the United States as the French and Indian War, had shown how important it was to get peace with the aboriginal inhabitants of the region.

To this cause, in 1754, a prosperous farmer in Lebanon, CT named Joshua Moor(e) (1683–2 October 1756) donated two acres of land and two buildings that together had a value of approximately £500. For that reason, the school was named Moor’s Charity School. Wheelock was in contact with the Scottish Society for Propagating Christian Knowledge, with whose help he was able to procure financial support in Britain, in particular from Lord Dartmouth.¹²

By 1769, he had received an official charter from George III, which, following the usual tedious string of paragraphs beginning, “Whereas” and “Whereupon”, contains the following declaration:

We, considering the premises [the aforementioned string of whereases and whereupons] and being willing to encourage the laudable and charitable design of spreading Christian knowledge among the savages of our American wilderness, and also that the best means of education be established in our province of New Hampshire, for the benefit of said province, do, of our special grace, certain knowledge and mere motion, by and with the advice of our counsel for said

¹¹Whatever the merits of the charges laid against Professor Olds, the financial difficulties at Middlebury in that year are easy to understand in the light of the natural disaster of the “year without a summer” (1816, as noted above). The College had an ambitious plan to make education free of tuition charges and had procured pledges from the local landowners to provide the funds. But the absence of one summer led to widespread crop failure, and thence to financial disaster for Middlebury.

¹²William Legge, 2nd Earl of Dartmouth (20 June 1731–15 July 1801). From 1772 to 1775, he was Secretary of State for the Colonies, an office established in 1768 to deal with the unrest in the American colonies after the passing of the Townsend Acts.

province, by these presents, will, ordain, grant and constitute that there be a college erected in our said province of New Hampshire by the name of Dartmouth College, for the education and instruction of youth of the Indian tribes in this land in reading, writing, and all parts of learning which shall appear necessary and expedient for civilizing and christianizing children of pagans, as well as in all liberal arts and sciences, and also of English youth and any others. And the trustees of said college may and shall be one body corporate and politic, in deed, action, and name, and shall be called, named, and distinguished by the name of the Trustees of Dartmouth College.

Eleazar Wheelock was the first president of Dartmouth College. His son John Wheelock (28 January 1754–4 April 1817) was in the first (1771) graduating class of Dartmouth College and succeeded to its presidency after his father's death in 1779. In the meantime, of course, the American Revolution intervened, leading to eight years of war (1775–1783). John Wheelock fought on the American side. Although many Vermonters did also (notably Ethan Allen), Vermont was never an officially chartered colony of the crown and thus no Vermonters signed the Declaration of Independence.¹³

Many New Hampshire residents out on the western border of the colony felt estranged from the government in Portsmouth. Led by John Wheelock, twelve towns on the Connecticut River declared themselves to have seceded from New Hampshire and petitioned to be included in the Republic of Vermont. These towns, in the end, remained part of New Hampshire. The close cooperation between Vermont and western New Hampshire is attested by the support that the General Assembly of the Republic of Vermont gave to Dartmouth College. At its June 1785 session the Assembly passed the following resolution:

“An Act granting twenty-three thousand acres of Land to the Trustees of Dartmouth College, and the President of Moor's Charity School, to and for the use of the said College and School, for ever.”

The Legislature, having a high sense of the importance of the institution of Dartmouth College and Moor's Charity School, to mankind at large, and to this commonwealth in particular; its situation and connexions being most favourable to diffuse useful knowledge through the same. Be it therefore enacted, &c. that

¹³In fact, Vermont did not exist yet. At the time, Vermont was known as New Connecticut, and its territory was the subject of a dispute between New York and New Hampshire. Some residents of the territory gathered at Westminster on 15 January 1777 and wrote their own Declaration of Independence from the British crown. The name Vermont was adopted about six months later at Windsor on 8 July 1777, when the constitution of the Republic of Vermont was adopted. Most Vermonters held title to their land granted by Benning Wentworth, governor of New Hampshire. The colony of New York, however, claimed what is now Vermont as its territory. Vermonters with New Hampshire titles hired Ethan Allen and his cronies to defend their land and run off settlers from New York. In the end, Parliament ruled in favor of New York, but by then it was too late. Vermont had declared itself to be a republic. When the Continental Congress refused to recognize it, the Republic petitioned the British to be made a part of Canada. In order to settle the dispute, in 1790, New York agreed to the present border so that Vermont could enter the Union as the fourteenth state. The Vermont General Assembly voted to pay New York \$31,000 in compensation.

there be, and hereby is granted to the Trustees of Dartmouth College, and the President of Moor’s Charity School, and to their successors, twenty-three thousand acres of land within this State, to be ascertained and chartered upon the conditions hereafter provided in this act; to be to and for the use of said College and School, for ever.

And be it further enacted, that the surveyor-general for the time being, be and hereby is directed (as soon as the survey of the State is compleated, there being a sufficiency of ungranted lands remaining) to survey in one tract the twenty-three thousand acres, if that quantity of ungranted land, proper for cultivation, can be found in one parcel; or otherwise survey the like quantity in different parcels, under the direction, and to the approbation, of the President of the said institution.

And be it further enacted, that the Governor and Council of this State for the time being, be and hereby are requested to issue a charter of incorporation for the same, when so surveyed, to the Trustees of Dartmouth College, and the President of Moor’s Charity School, and to their successors, to be to and for the use and benefit of the said College and School, forever.

The Surveyor General mentioned would have been James Whitelaw, born on 11 February 1748 in Old Monkland, Scotland, died in Ryegate, VT on 29 April 1829. The office of Surveyor General was not regularized at the time, although it was recognized as such. In 1797, it was formalized as an office to which a candidate was elected at a joint meeting of the Governor, the Council, and the General Assembly.

We note that 23,040 acres amounts to 36 square miles, exactly the size of a township, which normally consists of 36 square sections, each one mile on a side. A section equals 640 acres. Family farms in America have typically consisted of a quarter-section of land, or 160 acres. On 14 June 1785, the Governor issued a charter for a tract of land six miles square. That tract became Wheelock Township. It still exists under that name in the northwest corner of Caledonia County and had a population of 621 in the 2000 census. It is actually about 10% larger than the standard 36-square-mile township, occupying, as it does, 39.8 square miles. By offering homesteads rent-free for a number of years, Dartmouth was able to attract settlers to Wheelock, and within a decade was getting about \$1000 per year in rents from this land. In the end, though, this agreement was better for Vermont than for Dartmouth. Under an old contract, any full-time resident of Wheelock who is accepted at Dartmouth is able to attend tuition-free.

By 1807, however, Vermont had its own university, which had managed to graduate three classes of students; and meanwhile, it turned out that Dartmouth was no longer educating native missionaries. As a result, Chapter CXVIII of the 1807 *Legislative Acts of Vermont* reads as follows:

“An Act, directing a suit, for the purpose of ascertaining the validity of the charter of Wheelock”

§1. It is hereby enacted by the General Assembly of the State of Vermont, That Daniel Buck and Titus Hutchinson, Esqrs. be, and they hereby are authorized and directed, at the expense and on the behalf of this State, to institute a suit, before the Supreme Court,

pursuant to the mode pointed out in the act, entitled, “An act directing the mode of taking forfeitures of grants, and charters”—for the purpose of inquiring into the validity of that part of the grant and charter of the township of Wheelock, therein given and granted to John Wheelock, Esquire, President of Moor’s Charity School.

§2. And it is hereby further enacted, That the 7th of the act aforesaid, entitled, “An act directing the mode of taking forfeitures of grants and charters,” be, and the same is hereby repealed, so far, and so far only, that the same shall not in any way, affect the suit by this act directed to be brought.

Passed Nov. 10, 1807

Titus Hutchinson, who was born at Grafton, MA on 29 April 1771 and died in Woodstock VT on 24 August 1856, was a member of the General Assembly at this time. He served on the Vermont Supreme Court from 1825 to 1833, as Chief Judge the last two years. He later became a trustee of the University.

Daniel Buck, who was born at Hebron, CT on 9 November 1753 and died in Chelsea, VT on 16 August 1816, served as a Federalist representative in Congress from 1795 to 1797 and, as indicated here, later in the General Assembly.

Although it does not appear that the charter was revoked at that time, Dartmouth began to experience “growing pains,” when it acquired an endowed chair of theology, a bequest from trustee John Phillips, LL. D. (17 December 1719–21 April 1795) in 1789.¹⁴ As the College expanded, rivalries arose over the distribution of resources and over a philosophy of education. A pamphlet published in 1816 and bearing the title *Sketches of the History of Dartmouth College and Moor’s Charity School, with a Particular Account of Some Late Remarkable Proceedings of the Board of Trustees from the Year 1771 to the Year 1815* gives details of the evolution of the dispute. Without going into those details, we shall summarize a few aspects of the case.

In addition to the financial and philosophical disagreements, the case reflected two different political currents of the time, with the old Federalists (John Adams’s party), represented by the majority of the Board of Trustees, contesting control with the Democratic-Republicans (Thomas Jefferson’s party). The Democratic-Republican minority wanted the State of New Hampshire to take over the College on the grounds that the original charter came from George III, of whom the state government was the legal successor. On 27 June 1816, the legislature (1) renamed the corporation, which had been the Trustees of Dartmouth College; it was thenceforth to be the Trustees of Dartmouth University; (2) enlarged the membership in the Board from 13 to 21; (3) appointed a 25-man Board of Overseers; (4) put the ultimate power to decide the future of the institution in the hands of the Board of Overseers.

This was exactly what the minority among the trustees had wanted. The treasurer William H. Woodward (born in Virginia 17 September 1774, died in Hanover, NH, 8 August 1818), whom the majority had believed to be on its side, joined the

¹⁴Phillips had previously made gifts to Dartmouth, and one of the conditions of this gift was that his previous donations be earmarked for the use of the chair of theology; to his previous bequests he added 400 acres of land, which had at the time a value of £37, 10*d*, the pound sterling being still in use.

minority, which thereby became the majority, and was appointed Secretary of the Board of Trustees of Dartmouth University. The former Federalist majority of the trustees refused to accept this takeover, and demanded that Woodward turn over the books, seal, deeds, and other appurtenances of the corporation to them. He refused. They sued. The state superior court found for Woodward. The trustees appealed to the Supreme Court, of which the illustrious John Marshall was then Chief Justice. The case became famous as *Trustees of Dartmouth College v. Woodward*. The case for the trustees was argued successfully by none other than Daniel Webster, Dartmouth class of 1801 (and hence a contemporary at Dartmouth with James Dean).

2.4. Return to UVM, 1822–1824, and a year at Union College, 1825–1826. Marshall's decision for the plaintiffs became a landmark in corporate law. Dartmouth remained a private institution. But one of the casualties of the decision was the position that James Dean had as tutor, since he had been hired by the Trustees of Dartmouth University, not the Trustees of Dartmouth College. He left off teaching for a while and ultimately came back to UVM from 1822 through 1824, where UVM's third president, replacing Rev. Austin, was the Rev. Daniel Haskel. Haskel was born in Preston, CT in July 1784 and graduated from Yale in 1802. His degree, unlike his predecessor's, was A. M., not D. D. He was pastor of the First Calvinist Congregational Society of Burlington before becoming president of UVM. Haskel was a man of broad humanistic learning, well versed in geography and history, as he demonstrated in the quarter-century after he left UVM. Unfortunately, in addition to UVM's financial woes, with which he struggled heroically, there was a disastrous fire in May 1824, which destroyed the College Edifice, the University's only building, causing the loss of the library and laboratories as well, and driving President Haskel to a nervous breakdown. He spent the rest of his life in quiet academic pursuits.

Together with the geographer John Calvin Smith (born about 1809, died 11 June 1890), he was the author of a 732-page compendium entitled *A Complete Descriptive and Statistical Gazetteer of the United States of America* (Sherman and Smith, New York, 1848). In that same year (the year of his death, on 9 August), he published *A Chronological History of the World* (J. H. Colton, New York). Earlier (1833), he had published *Lessons in Astronomy* (publisher and place unknown).

After the fire, the duties of president were briefly assumed by James Dean. Unfortunately, a disagreement arose between Dean and the trustees that year over the fate of three students whom Dean believed unworthy of a degree. The trustees sided with the students, and Dean left to take up a position at Union College in Schenectady, NY, from which he received an honorary Doctor of Divinity degree in 1847.¹⁵ I have not been able to ascertain what Dean did during his year at Union College—there is a hiatus in the records at just that year—but it is certain that he returned to Burlington at the end of it.

At this point, we pause in the story of mathematics at UVM, leaving it without a president or a professor of mathematics, to finish our biography of the interesting character James Dean, after which we will resume our account of the two decades from 1805 to 1825.

¹⁵UVM awarded him the degree of Doctor of Law that same year.

2.5. Entrepreneurial activity: The Champlain Glass Company. What Dean was doing between 1826 and his death in 1849 was long buried in obscure documents. Only recently has one scholar unearthed his activity for the ten-year period from 1827 to 1837. I am indebted to L. Diana Carlisle, the author of an article ([1]) that fills in the details of Dean’s participation in this enterprise. Returning to Burlington in 1827, Dean formed a partnership with two men named John Peck (1 May 1785–24 July 1864) and John S. Foster (22 July 1773–6 January 1834) and founded The Champlain Glass Company, incorporated by act of the General Assembly of Vermont on 27 October 1827. Under three different names this company produced high-quality window panes and other glassware in Burlington from 1828 until 1840. Dean must have become prosperous from this enterprise, although the company overextended itself in 1831 by buying shares in the Redwood Glass Company near Plattsburgh, New York. It was induced to do so by a member of its Board, one Charles W. Corning,¹⁶ who proposed that the company borrow \$2400 from each of James Dean and John Peck for this venture. Obviously, if they were in a position to lend so much money, the two must have made a considerable fortune from the company. This hypothesis is confirmed in the case of Peck by the large house he inhabited and the fact that he owned the land along South Willard Street starting at Maple Street. (It was field and forest at the time, however.) John Foster left the enterprise at that time and moved across Lake Champlain to join another glass-manufacturing firm, from which he was dismissed in 1833. He tried to start yet another such firm, but died suddenly the following year.

Dean and Peck eventually had to sue to recover their money, and the company (or rather, its successor) was declared forfeit, so that they owned the company free and clear of all debt. Not until 1839 did Dean manage to liquidate his share of it. By that time, he was well past 60 and apparently able to retire with an independent income.

2.6. A missed opportunity: The American exploring expedition. An adventure that came near to Dean but passed him by is nevertheless worthy of our attention for the light it shows on American society then and now. This glimpse into Dean’s life in the year 1828 and again in 1836 is provided by the 1975 book ([8]) by William Ragan Stanton. The portion of the story that leads up to Dean’s near-connection with this expedition begins and ends in a way that is typically American. It begins with a theory that only the most radical UFOlogists could believe after the two poles had been reached by expeditions: That the earth is hollow, there being an empty core drilled out of it, so to speak, from one pole to the other. (The aforementioned fringe UFOlogists believed that “flying saucers” are built by creatures living inside and emerge through these holes.) This bizarre theory, which had nothing scientific to recommend it, even in the beginning, was the brainchild of one John Cleves Symmes, Jr. (5 November 1780–19 June 1829), who believed it mostly on theological grounds. Symmes even built models of his hollow earth. Despite the unpromising nature of this hypothesis, it could not be definitively refuted without sending an expedition to one of the poles, and that fact led Jeremiah N. Reynolds (1799–25 August 1858), a newspaper editor in Wilmington, OH in 1824, to attempt to organize such an expedition.

¹⁶It is coincidental that he had the name of another famous glass company. That company is named for the city of Corning, NY, with which this Corning has no known connection. Indeed, I have not been able to unearth any further information on him.

The idea was attractive even to intellectuals who rejected the hypothesis, since it offered a chance to go exploring, always an exciting prospect to those with a scientific curiosity. The expedition was getting well organized in 1828, with support from the Secretary of the Navy, and nearly succeeded. For a scientific expedition, real scientists would have to be taken aboard ships of the United States Navy, and they would do the essential work to complete the mission. In particular, an astronomer was needed, and apparently James Dean, professor and entrepreneur at the time, aged 52, was eager to join up. The project fell through, however, also in a typically American way. The year 1828 was an election year, in which the incumbent President John Quincy Adams was to be turned out of office by the western hero Andrew Jackson.

For reasons that I cannot fathom,¹⁷ historians have admired the latter, calling him a “masterful” President who helped to bring democracy down to the common people. In my view this Jacksonian democracy, more thoroughgoing than the Jeffersonian version, of which I am an adherent, has had pernicious effects throughout American history. It has led to the belief that ignorant people can decide scientific issues just as well as scientists. The result is the present backwardness of Americans, led by politicians and media commentators with no understanding of the relevant science who blithely declare themselves the equal of the Academy of Sciences in deciding, for example, the question of anthropogenic climate change. The consequences, not only to America, but to the entire world, are liable to be catastrophic.

In the context of James Dean’s career, this arrogance of the “common people” was forcefully expressed by South Carolina Senator Robert Young Hayne, who was chair of the Committee on Naval Affairs in 1828. Hayne declared that the scientists who were to be aboard the ships ought to be “mere agents and instruments of the officers,” but if the expedition was mounted, those odious scientists would reap “the glory of the enterprise, if any glory was to be acquired in it” ([8], p. 24). Thus, he played the role of the champion of the people against the elitist intellectuals for whom he had no use whatever. The expedition was scuttled.

Under Jackson’s successor, Martin Van Buren, the expedition was reorganized, and this time it would actually be launched, but without Vermont’s native son James Dean. According to Stanton ([8], p. 48),

Professor James Dean of the University of Vermont, who had been eager to join the expedition of eight years earlier, was now over sixty and felt himself too old to embark on so arduous a journey.

2.7. Dean’s best-remembered legacy. On 5 April 1832, Daniel Webster, who was a senator from Massachusetts at the time, read into the Senate record a “Report on the Subject of Apportionment of Representation, in the House of

¹⁷By all accounts, Jackson was an ignorant, arrogant man whose crimes against humanity would nowadays rank him with the great moral monsters of all time. I don’t mean merely that he kept slaves. Many people, trapped in their time, did that. But, to take just one example, he dispossessed the Cherokee tribe of its lands in Georgia, even though the Supreme Court of the United States had declared in *Worcester v. Georgia* that they held sovereignty over these lands. The resulting Trail of Tears as the Cherokees and four other tribes were relocated west of the Mississippi River, led to the cruel deaths from starvation and exposure of thousands of innocent people. I do not believe that any positive verdict can be rendered on this man’s life.

Representatives of the United States.” In his report, Webster included an appendix under the title “Extract of a Letter from Professor James Dean”:

I cannot express my rule so densely and perspicuously as I would wish; but the meaning is, that each State shall have such a number of Representatives, that the population for each shall be the nearest possible, whether over or under, to []. The number for each state may be ascertained thus: Divide the representative number by the number assumed to fill the blank, disregarding the remainder; the quotient, or the next greater number, will be the number of Representatives. In order to determine which is the proper one, divide the representative number of the State by the two numbers separately, then subtract the least quotient from the assumed number, and the assumed number from the other quotient; and that from which results the least remainder is the number of Representatives for the State.

This letter is not among those published in the multi-volume edition of Webster’s correspondence. That could mean two things: (1) Webster did not keep the letter after inserting its contents into the Senate record, or that the letter was subsequently lost; (2) the letter was actually sent to someone else, who showed it to Webster. In either case, the assertion sometimes made that Dean wrote to Webster on this issue cannot be confirmed, although it is plausible that he did so.

Dean truly did not express his rule as “perspicuously” as he might have. When he says, “Divide the representative number” he should have said “Divide the population of the state by the number chosen to go between the brackets.” The latter number is to be the number of constituents (including children) that each representative is to represent. In his day, this number was flexible, since the size of the House was not fixed. It had begun as the number 30,000, which in our day would require a House consisting of more than 10,000 representatives. It was early on realized that the House could rapidly become unwieldy this way, and after each census, it became a contentious political problem to decide on the size of the House.

The problem became particularly acute after the censuses of 1870 and 1880, where a seeming paradox appeared: A state might have fewer representatives in a larger house than it would get in a smaller one. The particular case that is best remembered is that of Alabama. After the 1880 census, it was determined that in a House of 299 representatives, Alabama would have 8, but if the number was increased to 300, then Alabama would get only 7, given the procedures then in effect. In our day, when the size of the House is permanently fixed at 435, the number that goes into the brackets in Dean’s proposal would be (as of 2015) $308745538/435$, that is, approximately 709,760 constituents (including children) per representative. (The numerator in this fraction is the official population of the country according to the census of 2010.) For California, for example, whose population was given in the 2010 census as 37,253,956, Dean’s instruction leads to a quotient of $37253956 \times 435/308745538$, which is 52.4881. Thus, the number of representatives due California should be either 52 or 53.

Dean’s instruction is to divide the population of California by these two numbers, getting quotients of 716,422 and 702,904. Then, since $716422 - 709760 = 6662$ and $709760 - 702904 = 6856$, the quotient upon division by 52 is closer, and California would get 52 representatives. (In the system actually used, it got 53.)

2.8. Political activity. Nothing is known about Dean’s political leanings up to the age of 60, which he attained in 1836. From that time on until a few months before his death in 1849, he is regularly mentioned in Vermont newspapers as a political activist. Andrew Jackson’s autocratic style and policies soon led to dissension in his party, and the result was the formation of a new political party in America, which adopted the name of the British liberal party and called itself the Whig Party. It leaned toward the liberal side, but advocated written constitutions, strictly adhered to, and protection of minorities against the tyranny of the majority. The party arose in the middle of Jackson’s second term in office, around 1834, under the leadership of Senator Henry Clay of Kentucky, who together with Senators Daniel Webster of Massachusetts and John Caldwell Calhoun of South Carolina managed to reconcile the conflicting interests of their very different regions of the country through diplomatic compromises that held the Union together until 1860.

The Whigs took a firm stand against Jackson’s Indian Removal policies, and generally opposed the extension of slavery into new territories. Their main quarrel with the Jacksonians was over protective tariffs, which the Whigs wanted and the Democrats didn’t, and over the existence of a national bank, which the Whigs favored, and which Jackson was determined to destroy. (He succeeded, and a severe depression ensued after he left office.) They managed to get two of their number elected President, namely William Henry Harrison in 1840 and Zachary Taylor in 1848, both of whom were war heroes and both of whom died in office, Harrison having served only one month and Taylor fifteen months. Their successors John Tyler and Millard Fillmore bring the number of Whig Presidents to four. There might have been five, but for a split in the Whig Party that caused Henry Clay to lose the 1844 election to James K. Polk by a very narrow margin.

The *Burlington Free Press*¹⁸ was a Whig newspaper from the outset, and in 1836 it helped to organize public opinion in Vermont against Jackson’s heir-apparent, the Democratic Party candidate Martin Van Buren. It proudly proclaimed itself the supporter of William Henry Harrison for the presidency. Dean was a Whig and attended the organizing convention that year. In preparation for it, a few local organizers met in Burlington on 24 February 1836. The following resolution calling for organization of this party was printed in the *Burlington Free Press* on 4 March 1836:

Resolved, that all freemen of this state present or who may be present at the convention who disapprove of the office holder’s nomination at Baltimore for the Presidency, and of the nominee, pledged to follow in the footsteps of the present incumbent, be invited to take part in this convention and to participate in its deliberations.

The *Free Press* goes on to say that a committee had been appointed to prepare the business of the statewide Whig convention, which was to be held in June of that year, and that James Dean was a member of this committee. On 24 June, the *Free Press* noted that “Mr. Dean” had been elected to draft the party’s platform, and that

¹⁸Properly, the *Burlington Weekly Free Press*, but for simplicity we shall always use this name, which is the name of its modern successor.

On motion of Mr. James Dean: Resolved, that the [Chittenden] county committee be requested to correspond with the committees of Franklin, Grand Isle, and Orleans Counties and make arrangements for holding a District Convention for the purpose of nominating a suitable candidate to represent this District in Congress.

At that time, Vermont had four congressional districts, of which the four above-named counties formed District Three. Dean himself stood for election in this district in 1844, albeit as a member of the Liberty Party (see below) rather than as a Whig. As is well-known, Van Buren won the election of 1836, but rapidly lost popularity due to the depression, which was blamed on Jackson's attack on the national bank. In 1840, Harrison was again the Whig candidate, and was elected. The editors of the *Free Press* were jubilant, proclaiming on 6 November that OK¹⁹ stood for Orful Konflagration.

As already mentioned, however, Harrison died only one month into his term and was succeeded by John Tyler. As often happens with reform parties, success leads to the need to govern, and that in turn leads to compromises with the opposition that displease the party faithful. By 1844, two groups had split off from the Whig Party. The first was the Liberty Party, which was more radical on the subject of slavery than the Whig Party. The other was the Locofocos, named after a cigar that, like a railroad flare, could be used to light itself. (The Italian word for fire is *fuoco*.) The latter was a working-class party, which took its name from the use of the abovementioned self-lighting cigars to light its meeting hall in New York after the Democratic Tammany machine politicians had turned off the gas lighting. As already mentioned, Dean was the Liberty Party candidate for Congress from Vermont's Third District that year; he was not elected, nor were any other Liberty Party candidates. Still, the party's role as a spoiler, which third parties often are, has some credibility. The party won about 16,000 votes in New York. Had Clay won 11,000 of them, he would have become President.

By 1848, the Liberty Party and the Locofocos had combined with disgruntled Whigs to form the Free Soil Party. Martin Van Buren moved far enough left to gain that party's nomination, but not nearly far enough to satisfy the abolitionists among them and those who had opposed the annexation of Texas and the Mexican War under President Polk. Knowing that an abolitionist candidate was a guaranteed loser, Van Buren had pledged that he would do nothing to end slavery in Washington, DC.

The *Free Press* had remained loyally Whig and wrote about the Free Soil Party with lofty condescension on 25 August 1848:

THE FREE SOIL CONVENTION TODAY

A formidable array of Locofocos and Liberty men with a slight sprinkling of dismayed Whigs, made up the Free Soil Convention, which assembled in Burlington Wednesday morning. It was our

¹⁹The now-universal expression OK seems to have originated in America. The Democrats made use of it in 1836 by forming Democratic OK Clubs to support Van Buren, who, being a native of Kinderhook, New York, was affectionately called Old Kinderhook. On some theories, that is in fact the origin of the phrase OK, but it is possible that the Democrats chose that name because the expression was already current.

happiness to attend the morning session and to witness an amusing example of “much ado about nothing” A man from Hinesburg, who was a Locofoco, proposed that a committee of nine, to consist of three Liberty men, three Locofocos, and three Whigs, nominate delegates to the convention. . . Prof. Dean of Burlington (Liberty) was not satisfied with this summary method of disposing of an important motion. He said he had carefully read the Buffalo platform, and was not at all satisfied with it. That platform (in tender consideration of the views of Martin Van Buren, doubtless) comprehended opposition to the *extension* of Slavery, but did not come up to the mark of hostility to its *continuance*. Prof. Dean was opposed not only to the *extension*, but to the *existence* of Slavery in this boasted Republic. The Buffalo platform might be broad enough for some, but did not come up to his standard! (This was the wettest and coldest blanket that had been thrown upon the rye-and-indian Convention, and Prof. Dean’s character and reputation contributed not a little to the damp and the cold!)

The *Free Press* cited Dean again a week after this meeting, on 1 September:

The Buffalo Platform, as intimated by Professor Dean to the late Van Buren Convention in this village, is just big enough for New York Barnburners and no bigger! It says not a word about Slavery in the District of Columbia and declares for a “Revenue Tariff” . . . The Locofocos who drew it up and who passed it are the very men who voted for Polk and Dallas and the Mexican War, and thereby involved the country in the enormous “national debt” spoken of. . .

The “Dallas” referred to here is George Mifflin Dallas (10 July 1792–31 December 1864), former mayor of Philadelphia and vice-president in the Polk administration from 1845 to 1849. It is possible, though not certain, that the city of Dallas, TX was named after him.

The United States national debt was retired exactly once in its history, in 1835, during the presidency of Andrew Jackson. As the *Free Press* says, the Mexican War unbalanced the budget again. The Whigs managed to get their candidate, Zachary Taylor, into the White House in 1848, but the country was becoming ungovernable, wracked by the dispute over slavery. The Free Soil Party was soon to become the Republican Party, which got its candidate, Abraham Lincoln, into office in 1860. What followed is well-known history.

2.9. Death and legacy. On that inspiring note, Dean’s recorded career comes to an end. His life came to an end less than five months later, in Burlington. He died on 20 January 1849, and is buried in the Elmwood Cemetery in Burlington. The inscription on his tombstone has been effaced by time, and we are indebted to George Frederick Houghton ([2]) for preserving it:

JAMES DEAN, LL. D., A. A. S.

Born at Windsor, Vt. November 26, 1776

Died at Burlington, Vt. January 20, 1849

A Friend of Peace,

Temperance, Knowledge and Freedom

“Nihil humani alienum”

The Latin phrase means “Nothing having to do with man is alien.” It is a shortening of the phrase due to the Stoic playwright Terence (Terentius), who lived in the second century B. C. E.: *Homo sum, nihil humani a me alienum puto.* (I am a man, and there is no aspect of humanity that I regard as alien to myself.)

In his will (Case 1394, Box 13 in the files of the Chittenden County Courthouse), Dean left his sister Abigail as first legatee her choice of \$100 worth of books from his personal library. Abigail died on 5 August 1858. His second legatee was his friend and 1800 classmate at Dartmouth, Caleb Butler of Groton, MA (13 September 1776–7 October 1854, he was the principal instructor at Groton Academy for many years), who was to have his choice of \$100 in books after Abigail chose the ones she wanted. His third legatee was the physicist Joseph Henry of Princeton, with whom he had corresponded about the aurora borealis; Prof. Henry received a piezometer, a forcing pump, and a compressing vessel. Dean also left bequests of \$100 in cash to each of the American Academy of Arts and Sciences and the Massachusetts Historical Society. The remainder of his estate was to be divided as follows: one-half to Abigail, one-sixth to his brother Noah (who died on 2 April 1856), and one-third to be divided among Noah’s children.

2.10. Scholarly works. The modest scholarly reputation that Dean attained was based on six articles by him listed in the *Royal Society Catalogue of Scientific Papers* (Vol. 2, p. 185). Four of these were published in 1815 in the *Memoirs of the American Academy of Arts and Letters*, Vol. 3, Pt. 2. One of the latter is a detailed report of an observation of the solar eclipse of 17 September 1811. Dean gives precise statements of the local solar time for the beginning and end of the eclipse as observed by himself and his companion. (See the remarks above on the significance of eclipses for geography.) The other three articles published in 1815 are connected with geometric astronomy. One is a description of a “cometarium.” Another is “A method of displaying at one view all the annual cycles of the equation of time in a complete revolution of the Sun’s apogee.” The misnamed “equation of time” is the amount by which mean solar time—on which clocks are based—differs from true solar time. The word *equation* refers to the process of *equalizing* (reconciling) true solar time with mean solar time. It is a periodic function of time, and Dean’s article provided a small elliptical piece of paper riveted to a chart. By turning the ellipse, one could determine the amount by which true solar time is ahead of or behind mean solar time at any given moment.

The most important of the four articles was a *tour de force* of spherical trigonometry, “An investigation of the apparent motion of the earth viewed from the Moon arising from the Moon’s librations.” The last word here is the key to this paper. It is a commonplace that the moon always turns the same face to the earth, but this commonplace is not strictly true. The moon rotates on its axis at a uniform rate, but its orbit about the earth is slightly elliptical. As a result, terrestrial astronomers get an occasional peek around the edge of the moon into its hidden side. This is one kind of libration. The other kind occurs because the moon’s axis of rotation is not perpendicular to the plane of its orbit around the earth, so that its northern and southern poles come alternately into view for an observer on the earth. Looking at these two kinds of libration from the perspective of the moon,

one finds that the earth does not remain in a fixed location in the sky, as would be the case if the commonly held view were accurate. Instead the earth describes a small but complicated closed curve in the sky over a long period of time. Dean gave a careful analysis of this curve and showed that it is the curve described by a pendulum bob at the bottom of a Y-shaped string, in which the vertical stroke of the Y is 40 times the distance from the fork in the Y to the line through its two tips. This article so intrigued the astronomer Bowditch that he was inspired to perform a detailed mathematical analysis of such a pendulum. Bowditch's article was published in the same issue of the *Memoirs of the American Academy* in which Dean's four articles appeared.²⁰

Besides the papers just discussed, Dean also published an observation of several meteors in Silliman's *American Journal of Science* in 1823, and an article "On the diameter of screws," in the *Boston Journal of Philosophy* in 1826, which he rewrote and expanded in the *Journal of the Franklin Institute* in 1845, when he was nearing 70 years of age. This paper is an analysis of the properties of a helix, combined with some frictional considerations, and therefore applies more properly to bolts than to screws. The problem is to find the diameter that enables the ratio of power (he seems to mean torque) to weight to be minimized. Besides these research papers, he was the author of a gazetteer of Vermont published in Montpelier in 1808, a copy of which can be found in the Wilbur Collection of the Bailey-Howe Library.

Among the papers in his file in the University archives is the letter mentioned above (written 27 November 1833) to the physicist Joseph Henry, reporting some meteor observations, and speculating on ways by which it could be proved that the aurora borealis is electrical in nature. At the time, Henry had only recently discovered the phenomenon we now call electromagnetic induction—naturally, his understanding of this phenomenon was very incomplete—and had just been named a professor at Princeton on the basis of his brilliant work.

Dean's most enduring contribution to American civilization, however, has been immortalized as "Dean's Method" of apportioning the House of Representatives, which was discussed above. Dean's Method is explained in detail in the book *Fair Representation* by M.L. Balinski and Y. Peyton Young (Yale University Press, 1982).

3. Mathematical Instruction

At the time of James Dean's return to the University we find the first university catalog, dated October 1823, from which we can form a picture of the course of study followed by the students and taught by the faculty. There were only two professors in the Classical College, five in the Medical College. Prof. Dean's companion in the Classical College was Lucas Hubbell,²¹ A. M., Professor of the Learned Languages. These two, and perhaps the president (Haskel) taught all 53 of the classical students. At the time, UVM adhered to a three-term school year, the autumnal term extending from September until December, the spring term from March through mid-May, and the summer term from mid-May through mid-August. The fact that there was no winter term and the University was closed down during the months

²⁰The late professor of physics at UVM Albert D. Crowell (12 February 1925–21 September 1985) once gave a detailed discussion of this paper of Dean's (see *The Burlington Free Press*, 11 March 1971).

²¹Born 30 October 1787 in Lanesboro, MA, died 4 November 1847 in Phelps, NY.

of January and February needs no explanation, given the harshness of the Vermont winter.

The mathematical portion of the curriculum was based on a famous series of textbooks by the British mathematician Charles Hutton (14 August 1737–27 January 1823), a professor at the Royal Military Academy at Woolwich. Hutton’s *Arithmetick* occupied the second semester of the Freshman year, Hutton’s *Algebra* the first term of the sophomore year, and Hutton’s *Geometry*, Hutton’s *Trigonometry*, and Hutton’s *Conick Sections* the third term of the sophomore year. That, except for a little astronomy in the last term of the junior year, was the extent of mathematics in the curriculum.

Pycior ([7]) points out that the American editions of these European works were often modified by their American editors. This is the case with Hutton’s work, which was edited by Robert Adrain, the Irish immigrant who was mentioned in the Preface and who taught at Queen’s College (Rutgers) and Columbia College. Adrain’s Hutton is bound in two volumes of about six hundred pages each. The material listed above is all in the first of these two volumes. The second volume covers spherical trigonometry and the “doctrine of fluxions,” that is, the calculus. Apparently, the second volume was not used in instruction at UVM at this time. (The volumes now in the stacks of the Bailey-Howe Library belonged to Professor G. W. Benedict, who arrived at UVM after Dean left for the second time and will be discussed in the next chapter.) Although a thorough discussion of the contents of Hutton’s textbooks would require more time and space than the current project allows, certain points are of sufficient interest to be mentioned.

Hutton’s arithmetic goes beyond mere computation to consider many topics that we now regard as algebra, such as compound interest problems, permutations and combinations, raising to power (called involution), extraction of roots (called evolution), logarithms, and mixture problems (called alligation problems and classified as alligation medial and alligation alternate).

Hutton’s algebra, written at a time when elementary algebra was not yet thoroughly elucidated through the use of complex numbers, betrays a lack of insight on the part of its author and a consequent lack of motivation for most of its methods. Algebra is defined as “the science of computing by symbols.” Some of the purported applications of algebra are curious, as they are bound to be, since algebra by itself (apart from its use in calculus and differential equations) has very little application to ordinary human life.

For example, under the heading APPLICATION OF ARITHMETICAL PROGRESSION TO MILITARY AFFAIRS, we find problems of the following sort:

A detachment having 12 successive days to march, with orders to advance the first day only two leagues, the second $3\frac{1}{2}$, and so on increasing $1\frac{1}{2}$ league each day’s march: What is the length of the whole march, and what is the last day’s march?

One wonders if students were any better fooled then by such fraudulent “applications” than they are today. Even the simplest topic of algebra, the solution of quadratic equations, gives the impression of rules laboriously and mindlessly memorized, to be passed on to students without any reflection whatever. Nowhere is the student told that solving a quadratic equation amounts to finding two numbers when one knows their sum and product. The rules for solving cubic equations are all approximate rules. As Hutton says:

There are many particular and prolix rules usually given for the solution of some of the above-mentioned powers or equations. But they may be all readily solved by the following easy rule of Double Position, sometimes called Trial-and-Error.

A formula for solving cubic equations is given, called “Carden’s formula.” Girolamo Cardano (24 September 1500–21 September 1576) was a sixteenth-century mathematician who either worked out or plagiarized this rule. Again, it is manifest that the author himself does not understand what he is doing. He gives the rule, but no proof of it, and never tells the reader that the irreducible case, in which the formula leads to complex numbers, occurs precisely when the equation has three real roots, though this fact was known not long after Cardano’s original work. Furthermore, students might have more confidence in the rule if they knew that it sometimes expresses a very simple integer as the difference of the cube roots of two other very complicated irrational expressions. For example, it gives the solution of the equation $x^3 + 6x = 20$ in the form $x = \sqrt[3]{\sqrt{108} + 10} - \sqrt[3]{\sqrt{108} - 10}$, and hardly anyone would recognize this as the statement that $x = 2$.

Hutton’s geometry escapes all the difficulty of the theory of parallels by simply defining parallel lines to be lines that lie at the same perpendicular distance from each other at all their points.²² (Two lines can be equidistant in this sense only in Euclidean geometry. Thus the definition of parallelism excludes what is now known as hyperbolic geometry.) By cutting the Gordian knot thus efficiently, he is able to prove a great deal in very little space, but of course the reader is deprived of any knowledge of one of the fundamental problems in geometry at the time, the role of Euclid’s parallel postulate, which is not even stated.

Such was the mathematical education available in Vermont in 1823 for the price of \$20.00 per year tuition, plus board at \$1.25 per week (rooms in the University commons were free). Whether or not inflation is taken into account, the cost per theorem has probably never been so low at any time since.

4. Students

According to the *General Catalogue of the University of Vermont, 1791–1890* (Free Press Association, 1890), by 1820 UVM had about 100 living alumni, of whom 51 were lawyers, 20 were (Protestant) clergymen, 5 were physicians, 5 were farmers, 3 were in the armed forces, 3 were merchants, 5 were teachers, 2 were professors, and 1 was a sea captain (no occupations were given for about four of them).

The most noteworthy alumnus of the early period, from the point of view of mathematics, was one who studied under James Dean, namely George Palmer Williams (13 April 1802–4 September 1881) of the class of 1825, who obtained an LL.D. from Kentucky College in 1849, became an Episcopal priest, and was professor of mathematics and physics at the University of Michigan from 1841 to

²²Another mathematician of even more naive views, J. J. Callahan (11 January 1878–11 October 1969), president of Duquesne University in the 1930s until he was sacked by popular demand, announced that he had proved the parallel postulate. His “proof,” published in a book bearing the title *Euclid or Einstein?*, cuts through the difficulty in exactly the same way. Apparently, Callahan never realized that Hutton had anticipated him. He also believed that he had proved that his definition of parallel lines was equivalent to Euclid’s. (It isn’t.) At another point in his notable career, he announced a ruler-and-compass angle trisection. One of his fellow priests said of him, “Father Callahan was the one man I knew who never had a doubt.” His book, by the way, contains a scurrilous personal attack on Einstein.

1863. He was president of the faculty at Michigan in 1845–1846 and again in 1848–1849.

CHAPTER 2

The Benedictine Era, 1825–1854

The University was fortunate in its recovery from the loss of its building and its senior professor. Over the next 30 years, it attracted two competent scholars, the first of whom also showed good business sense and helped to put the university's finances and physical plant back on a stable foundation.

1. George Wyllys Benedict

A successor to Prof. Dean was soon found in the person of George Wyllys Benedict. G. W. Benedict was a vigorous and resourceful man, just the person to put things back together again. It is his copy of Hutton's course of mathematics that is now in the stacks of the Bailey–Howe Library. Born in North Stamford, CT on 11 January 1796, he graduated from Williams College in 1818, then served as principal of the Academy in Westfield, MA, tutor at Williams College, and principal of an academy in Newburgh, NY, before accepting the position at UVM. At the 50th anniversary (1854) of the first graduating class, Prof. Benedict spoke of his appointment:

When I came here, I was an entire stranger to the Institution and to every person connected with it, to the region round about, and to all its inhabitants. Why I came, I can hardly tell. Certainly, the inducements held out to me were slight enough. The member of the Corporation, Hon. Titus Hutchinson, who called upon me, then a resident in another state, to ask if I would consent to be a candidate for the professorship of mathematics and natural philosophy, told me that the college building was burned down, that the Institution had met with many difficulties, and had poverty to contend with. Through the generosity of individuals, chiefly the inhabitants of Burlington, a partial rebuilding was to be commenced as soon as mild weather would justify such operations, but a slow growth was to be looked for, in his judgement. For salary, he could promise but \$600 per annum, and that not very regularly paid. There was, however, a freedom from discouragement in all that he said, and a confidence in the continued life and ultimate strength of the Institution, which won my sympathy, and gained my assent to his proposal.

This optimism was, in the long run, justified. Indeed, already on 28 June 1825, only 13 months after the fire, the cornerstone of the new College Edifice, henceforth

known as the Old Mill, was laid by none other than the Marquis de Lafayette, who was embarked on a farewell tour of the United States.¹

G. W. Benedict's energy was sorely needed by the University. It is very largely thanks to his efforts that a large sum of money was raised to fill the shelves of a respectable university library. While teaching mathematics at UVM, he sent off for publication the one scientific paper listed under his name in the *Royal Society Catalogue* (Vol. 1, p. 270), an observation of a meteor seen in Burlington on 14 April 1826, published in *Silliman's Journal*, Vol. XI, (1826), p. 120.

On the fiftieth anniversary of the founding of the American Republic (which, as is well known, was also the day on which both John Adams and Thomas Jefferson died), Benedict gave a beautifully patriotic oration in praise of the country, but nevertheless deplored the continued existence of slavery.

His first innovation was to add calculus to the curriculum, based on a textbook by Étienne Bézout (31 March 1730–27 September 1783), who is remembered for his work on solving equations by determinants and even more for his many textbooks. Lindsay ([3], pp. 195–200) recounts Benedict's construction of the first chemistry laboratory in any American university (despite contrary claims by the University of Michigan, where a chemistry laboratory was built in 1856). Benedict not only designed and financed this laboratory, he gave comprehensive lectures on electricity to the community. Although he taught mathematics for only four years—he continued to teach chemistry until 1847—he became treasurer of the University and one of its most articulate advocates in the academic world.

UVM was in need of such an advocate, since its curriculum was looked upon unfavorably by more traditional places. The classical language requirement for admission was applied only to those who planned to study the classics. Those who wished to study science or modern literature were exempt from it. G. W. Benedict wrote a pamphlet in defense of UVM's policy,² which was distributed in the name of the entire faculty. Explaining why students not specializing in classical studies did not have to exhibit competence in Greek and Latin, he wrote

It is certainly better for one to get a *part well* than to attempt all with the certainty of universal failure.

UVM revived rapidly in part due to his labors, which, however, became burdensome to him. He resigned in 1847 for health reasons and went to work for a company bringing a telegraph line from Troy, NY to Burlington. Soon afterward, he formed his own company to bring a telegraph from Boston to Burlington. In 1853, he and his son bought the *Burlington Free Press*. Both were outspoken abolitionists and defenders of the civil rights of freed slaves. Appointed historian of the University, he wrote a comprehensive history of its early days for Vol. XIII of the *American Quarterly Register*. He died in Burlington on 24 September 1871, and is buried in the Benedict family plot in Green Mount Cemetery. He is honored by one of the west windows in the John Dewey Lounge of Old Mill.

¹This visit to UVM is commemorated in the statue of Lafayette at the north end of the College Green.

²*An Exposition of the System of Instruction and Discipline Pursued in the University of Vermont*, Chauncey Goodrich, Burlington, 1831.



Window in the John Dewey Lounge of Old Mill honoring George Wyllys Benedict.

2. George Russell Huntington

As mentioned above, G. W. Benedict taught mathematics at UVM only until 1829. In that year, George Russell Huntington, a graduate of the class of 1826, who had been a tutor for the previous two years, was appointed professor of mathematics and civil engineering, the first mention of engineering at UVM as a separate discipline. (Rensselaer Polytechnic Institute was only five years old at the time. “Natural philosophy” has not been a subject of instruction at UVM since that time.) Prof. Huntington was born on 23 May 1800 in Woodbury, CT. The 1825 UVM catalog lists him as a senior from Onondaga, NY, but he is not listed among the students in 1823 or 1824. He left UVM in 1832, when Farrand Northrup Benedict was appointed to the position he had been occupying. He moved west and settled in Buffalo, NY, where he died on 7 January 1872.

3. Farrand Northrup Benedict

Huntington taught only until 1832, when the chair of mathematics and civil engineering was taken over by Farrand Northrup Benedict, an 1823 graduate of Hamilton College and apparently a cousin of G. W. Benedict. Both mathematically and personally, F. N. Benedict is as interesting as his (supposed) cousin G. W. Benedict. He was born in Parsippany, NJ on 11 March 1803. Upon his graduation from Hamilton College, he entered the law, but abandoned it after two years and began to practice as a civil engineer. The *Royal Society Catalogue* lists one paper under his name: “A method of determining the temperature of the mercury in a siphon barometer, from the observed upper and lower readings; and of testing the accuracy of the instrument,” published in *Silliman’s Journal*, Vol. XL (1841), pp. 250–263. An earlier publication, overlooked by the Royal Society, bore the title, “On the sections of a plane, with the solids formed by the revolution of the conic sections, about axes situated in their planes,” also in *Silliman’s Journal*, Vol. XXXI (1837), pp. 258–266.

F. N. Benedict retired rather early from UVM, in 1855, and returned to Parsippany, apparently for the sake of his wife’s health. He was an ardent conservationist with a keen interest in the Adirondack Mountains, where he purchased tracts of land to ensure their preservation. In 1874, he undertook an arduous survey of the

Hudson and Raquette Rivers, albeit for purposes of which modern environmentalists would not approve—he wanted to see what potential they had for damming. His environmental interests are discussed in an article by Warder H. Cadbury bearing the title, “A Foot-Note to John Todd’s Long Lake,” (Back Log Camp Press, Sobail, NY, 1957, part of a collection about Long Lake published by Howard I. Becker). F. N. Benedict is also believed to be the author of the article “The Wilds of Northern New York,” published in *Putnam’s Monthly*, Vol. IV, No. XXL, September 1854, and reprinted as a pamphlet by Purple Mountain Press, Fleischmanns, NY, 2001.

F. N. Benedict died on 26 July 1880. Historians are supposed to maintain a nonjudgmental aloofness from the characters they write about, but I cannot help revealing that of all the former professors I have encountered in doing the research for the present work, he is my favorite, the one I would most like to have met. He was not only a competent, if slightly eccentric, mathematician, he was also a man of warm human sympathies. In his file in the UVM archives there is a letter written a few months before his death, to the daughters of one of his former pupils.³ F. N. Benedict’s letter to Catherine and Laura begins as follows:

Although suffering from great weakness and loss of sight, I cannot refrain, without violence to my feelings, from assuring you of my deep sympathy in the loss of your dear father. . .

4. Curriculum

The curriculum and entrance requirements at UVM changed slightly during the 1830s, as already mentioned in connection with G. W. Benedict. The 1837 catalog reveals that UVM had gone from a three-term academic year to a two-term system, with semesters referred to as the “autumnal term” and the “summer term.” Commencement was on the first Wednesday in August. The idle period remained the months of January and February, for the same obvious climatic reasons as earlier. Students studied algebra during the autumnal term of the first year and geometry, including solid and spherical geometry, during the summer term of that year. In the second year they took up conic sections, plane and spherical trigonometry (autumnal term) and surveying, navigation, projections, differential and integral calculus, and civil engineering (summer term). Science in the third year was devoted to physics and chemistry, especially mechanics, optics, and crystallography. Finally, in the fourth year the study of algebra and calculus was resumed, and astronomy was added. This was quite a respectable curriculum.

4.1. Textbooks. The textbooks used were Bonnycastle’s *Algebra*, Legendre’s *Geometry* in a translation by Charles Davies (22 January 1798–17 September 1876, professor at the United States Military Academy), Herschel’s *Astronomy*, and the *Cambridge Course*, a series of textbooks used at Harvard. All of these texts were improvements on the earlier ones.

John Bonnycastle (born on 29 December 1751 in Hardwick, Buckinghamshire, died on 15 May 1821 in Woolich, Kent) became a professor at the Royal Military

³This student was evidently Charles Carroll Parker, who was born in Underhill, VT on 26 September 1814 and was listed as a first-year student in the 1837 UVM catalog. He was a clergyman and had two daughters (Catherine and Laura) and a son, Charles Parker, Jr. He died near F. N. Benedict in Parsippany on 15 February 1880.

Academy at Woolwich in 1782. In comparison with his predecessor Charles Hutton, he was a much clearer writer who seemed to have real insight into his subject. As for the Parisian Adrien-Marie Legendre (18 September 1752–10 January 1833), he is one of the greatest mathematicians of all time,⁴ and his textbook of geometry is pellucid. In particular he discusses the problem of parallels and states the parallel postulate. Likewise, Frederick William Herschel, born in Hannover, Germany on 15 November 1738, was a multi-talented musician, scientist, and mathematician. He moved to England after the Hannoverians were defeated by the French in 1757 and did his most famous work there. He is best known for having discovered the planet Uranus on 13 March 1781. He died in Slough, England on 25 August 1822.

Further indication of the content of these courses is fortunately available from two sets of notes that have been preserved. One is a set of notes on the course in analytic geometry from the autumnal term of 1848 kept by Matthew Henry Buckham (born in Hinckley, Leicestershire, England on 4 July 1832, died in Burlington 9 November 1910), valedictorian of the UVM class of 1851, who served half his life (1871–1910) as the eleventh president of UVM. (This was the longest presidential term in UVM's history.) Buckham's notes reveal that the bulk of the course was devoted to applications of coordinates to the study of conic sections, whose equations are given in rectangular, oblique, and polar coordinates. The second notebook is from the 1849 course in central forces. These notes were preserved by McKendree Petty, who became the successor to F.N. Benedict as professor of mathematics. They reveal that the course was an elaboration of Newton's *Principia*, Book I, §§ II–III and XII (on the orbits of particles and the attraction of spherical solids). No attempt is made to find simpler or clearer proofs of the propositions than Newton himself gave. Still, getting students to read and understand Newton directly from his text must have been no small achievement.

5. Students

Among the mathematical students of this period one should mention Joel Tyler Benedict (18 January 1821–15 January 1892) of the class of 1843, who later became a professor of civil engineering (1852) and mathematics (1857) at the New York Free Academy (founded in 1847, renamed the City College of New York in 1866). He wrote an algebra text in 1857 that, like the books by Charles Hutton used earlier at UVM, rather tends to obscure the subject.

The most distinguished alumnus was probably Selim Hobart Peabody, who was born in Rockingham, VT on 20 August 1829, graduated from UVM in 1852 and became a professor of mathematics and civil engineering at the Agricultural College of Pennsylvania in 1854. He obtained a Ph. D. in 1877 and an LL. D. in 1881, both from the University of Iowa. He was appointed professor of mechanical engineering at Illinois Industrial University in 1878 and president of the University of Illinois in 1880,⁵ where he served until 1891. In 1893, he headed the department of liberal arts at the World's Columbian Exposition in Chicago, then in 1899 was statistician

⁴A supposed portrait of Legendre, which made him look something like Mr. Pickwick and adorned hundreds of books for many decades, has recently been shown to be the portrait of another man, possibly Legendre's butcher. What he actually looked like is thus not known, except for a caricature portrait of him that can be found in various locations.

⁵These two institutions are one and the same. Illinois Industrial University was founded at Champaign–Urbana in 1867 and officially renamed the University of Illinois in 1885.

and editor for the United States commission at the Paris Exposition. In 1901, he was once again superintendent of the liberal arts division at the Pan-American Exposition in Buffalo, NY. He died in St. Louis, MO on 26 May 1903.

Less well-known was Otis David Smith (born in New Haven, VT on 27 June 1831, died at Auburn, AL on 7 May 1905) of the class of 1853, who became professor of English literature and mathematics at the Agricultural and Mechanical College of Alabama in Auburn.

Passing over a number of UVM graduates who became prominent politically, we shall conclude this list with two prominent businessmen who were not, as far as is known, mathematics majors. Frederick H. Billings (born in Royalton, VT on 27 September 1823, died in Woodstock, VT on 30 September 1890), a member of the class of 1844, became president of the Northern Pacific Railroad Company. Henry Oscar Houghton (no apparent relationship to George Frederick Houghton, who wrote the article on James Dean mentioned above), was born on 30 April 1823, graduated from UVM in 1846, and died on 25 August 1895. He was one of the founders of Houghton–Mifflin publishing company.

6. The Library

During this period the University matured into an institution with a well-deserved reputation of competence, indeed excellence. The 1843 catalog boasts that the library “. . . contains upwards of seven thousand volumes, chiefly selected. It is open to the Senior and Junior classes every Saturday—to the Sophomore and Freshman classes every Wednesday—at noon, during term time. . .” The acquisition of this library was a notable feat, made possible by the vision of three prominent figures of the time. Two of them were UVM’s sixth president, John Wheeler and Professor/Treasurer George Wyllys Benedict, who together raised \$30,000 to pay off some of the university’s debts and reserved \$12,000 of these funds to improve the library and laboratories. The third was Professor (Rev.) Joseph Torrey, who was born in Rowley, MA on 2 February 1797 and died in Burlington on 26 November 1867. He graduated from Dartmouth in 1816 and was appointed professor of Greek and Latin at UVM in 1827; he served as the ninth president of UVM during most of the Civil War, from 1862 to 1866. It was Professor Torrey who journeyed to Europe in 1835, spending the money very carefully and acquiring 7000 excellent volumes for about \$10,000.

A catalog of the library holdings from 1843 (University Press, Burlington, printed by Chauncey Goodrich) bears out this claim. Of the 7,000 books some 250 are on mathematics and physics, and these contain some impressive works, such as John Colson’s translation of Donna Maria Agnesi’s *Instituzioni analitiche* (Analytical Institutions) (London 1801), George Airy’s *Mathematical Tracts on Physical Astronomy* (Cambridge 1826), many works by John and Jacob Bernoulli, Roger Cotes, Leonhard Euler, Carl Friedrich Gauss, Colin Maclaurin, Isaac Newton, Thomas Young, Lazare Carnot, and the works of the many geniuses at the École Polytechnique, among which were Louis-François Arbogast’s *Du calcul des dérivations* (Strasbourg 1800), and works by Jean-Baptiste Biot, Jean-Baptiste Delambre, Sylvestre François La Croix, and Siméon-Denis Poisson.

Here is some information on the mathematicians named above:

- John Colson (1680–20 January 1760) was the fourth Lucasian professor at Cambridge (the second being Isaac Newton). He contributed greatly to

a full understanding of cubic equations. Unfortunately, he mistranslated Agnesi's name for the semicubical parabola, whose equation is $y^3 = ax^2$. Agnesi called it a *versiera* (twisted curve), which Colson conflated with *aversiera* (wife of the devil), and it is now known as the “witch of Agnesi”—a lamentable slur on the character of a very fine woman and mathematician.

- Maria Gaetana Agnesi (16 May 1718–9 January 1799) was a talented mathematician, but her charitable and religious instincts were strong, and she eventually devoted her time and her inheritance to assisting the poor.
- George Airy (27 July 1801–2 January 1892) was the Lucasian Professor at Cambridge after 1826. He is most famous for Airy's equation $y'' = xy$, and its solutions, known as Airy functions.
- John and Jacob Bernoulli (27 July 1667–1 January 1748 and 6 January 1655–16 August 1705, respectively) were two brothers from a distinguished Swiss family that produced a dozen outstanding scientists over a period of a century or more. These two were close disciples of Gottfried Wilhelm Leibniz (1 July 1646–14 November 1716), co-discoverer with Newton of the calculus.
- Roger Cotes (10 July 1682–5 June 1716) worked on an edition of Newton's *Principia* from 1709 to 1713 and had some correspondence with Newton about methods of approximating irrational numbers. The result is a method of approximation still known as Newton–Cotes.
- Leonhard Euler, who was mentioned above, was the most profound mathematician of the eighteenth century, and the most prolific one of all time.
- Carl Friedrich Gauss, also mentioned above, is regarded by most historians of the subject as the most profound mathematician of the nineteenth century, ranked alongside Archimedes and Newton, and just above Euler, as such things go. (He himself admired Euler above almost all others.)
- Colin Maclaurin (February 1698–14 June 1746) was a Scottish disciple of Newton, one of his defenders in the controversy over infinitesimals. He is remembered for the power-series expansion that bears his name.
- Isaac Newton (4 January 1643–31 March 1727)—these dates are Gregorian dates, even though in his day the British calendar was Julian—is sufficiently well known that no description is needed.
- Thomas Young (13 June 1773–10 May 1829) is best known for his interference experiments supporting a wave theory of light.
- Lazare Carnot (13 May 1753–2 August 1823) was a French engineer, noted for having written a calculus text.
- Louis François Arbogast (4 October 1759–18 April 1805) was a mathematical physicist and engineer.
- Jean-Baptiste Biot (21 April 1774–3 February 1862) is remembered for the Biot–Savart inverse-square law of magnetic induction around a current-bearing wire.
- Jean-Baptist Delambre (19 September 1749–19 August 1822) worked on measuring the length of a meridian of longitude on the earth. (The meter was to be defined so that the total length would be 40,000,000 meters.)
- Sylvestre François La Croix (28 April 1765–24 May 1843) occupied the chair of analysis at the École Polytechnique after 1799.

- Siméon-Denis Poisson (21 June 1781–25 April 1840) is remembered for the Poisson probability distribution. He was, according to one historian of mathematics “the greatest French mathematician of the first half of the nineteenth century.”

The chief deficiency that a modern researcher would notice is an absence of mathematical journals: no *Comptes rendus*, no *Liouville’s Journal*,⁶ no *Crelle’s Journal*.⁷ These were the lifeblood of researchers in out-of-the-way parts of Europe, but entirely missing at UVM. To be sure, the library did have many *back numbers* of the *Transactions of the Royal Society* in an abridgement due to Charles Hutton, but these dried specimens of mathematics were no substitute for the living plant of *current* research.

Instruction at this time was by lecture and textbook reading. There were apparently no quizzes or midterm examinations. According to the 1844 Catalog,

... the students are examined at the close of each study by the Faculty, and also annually by the Faculty and a committee, during the three weeks immediately preceding Commencement, in all the studies pursued under the direction of the Faculty. The examinations are intended to be exact and thorough, and the results in the case of each student are noted and recorded.

The University was apparently forced to retreat on some of its academic innovations, and the requirement of Greek for entrance was restored in 1839. The University also returned to a three-term academic year, with the eight-week vacation falling in December and January.

7. The Williams Professorship

Part of the University’s prosperity at this time was due to the generosity of one Azarias (or Azariah) Williams, born in Sheffield, England on 31 July 1765, who in 1839 gave the University land estimated in value at \$25,000 in return for an annuity during the remainder of his life. Upon his death on 18 February 1849 the University became the sole possessor of this land. At its meeting of 10 May 1849 the Trustees adopted the following resolutions:

Resolved, by the Corporation of the University of Vermont, that a suitable monument of durable material and imposing structure with an inscription commemorating the great liberality of the deceased to this Institution be erected on some conspicuous site at the expense of this Corporation.

Resolved, that if the consent of all persons authorized to grant it can be obtained, the mortal remains of the late Azarias Williams be removed from their present resting place and deposited under the proposed monument.

These resolutions seem not to have been carried out, as the remains of the Hon. Mr. Williams are to this day buried at the Pike Cemetery in Concord (Essex

⁶Founded in 1836 by Joseph Liouville (24 March 1809–8 September 1882), it is officially the *Journal de mathématiques pures et appliquées*.

⁷Founded in 1826 by August Leopold Crelle (29 April 1771–24 August 1856), it is still called *Crelle’s Journal*, although of course it has had many editors and its official name has always been *Journal für die reine und angewandte Mathematik*.

County), VT, where they were no doubt interred some months before this resolution was taken. In 1853, the Trustees substituted a more modest effort:

Resolved, that out of respect to the memory of Azariah Williams,
the largest donor as yet to this University, the Professorship of
Mathematics be styled the Williams Professorship of Mathematics.

And it was done: F. N. Benedict, in his last year of service, became the first Williams Professor of Mathematics. It was a chair having all the appearance of an endowed chair, but no funds were ever set aside to endow it. Mr. Williams's name continued in the catalog from that day on, although the position of Williams Professor of Mathematics was vacant for a generation, from the 1960s to the end of the twentieth century. The title was revived in the year 2000 and bestowed on Roger Cooke (author of the present work), after whose retirement in 2003 it was conferred on the late Kenneth I. Gross (14 October 1938–10 September 2017), then in 2008 on Kenneth I. Golden, and in 2013 on Jeffrey Dinitz.

CHAPTER 3

A Generation of Struggle, 1854–1885

The second Williams Professor of Mathematics, the Rev. McKendree Petty, was appointed at a time of gathering danger to America, as the Civil War drew near. The University Archives contain Rev. Petty’s diary, begun in 1844, when he was just 17. There are not many entries, however, until 1855. (The diaries are arranged as the days of a single year, but were used over many years, with the year being noted at the beginning of each entry.)

1. The Second Williams Professor

McKendree Petty was born in North Dorset, VT on 4 July 1827. A full-length biography of him ([10]) was written by his great-grandson, the late Dr. Edward H. Worthen (15 February 1930–28 December 2016), a specialist in Latin-American studies. From this biography, we learn that there were serious conflicts between McKendree Petty’s body and his ideals. He married in haste during his sophomore year at UVM (1847), only four months before the birth of his first son ([10], p. 53). At UVM, he was a member of Lambda Iota fraternity, the oldest fraternity in Vermont, founded in 1836 as a literary and smoking club to protest a university ban on the use of tobacco.¹ Petty’s obsessive, guilt-ridden personality is reflected in an entry in his diary from January of 1853 containing a bitter self-reproach for having allowed himself to become addicted to cigarettes ([10], p. 82).

Petty graduated from UVM in 1849, then taught in an academy in Castleton, VT for one year while preparing to study for the law. He journeyed to Louisiana and obtained his law degree from Louisiana State University in 1852. He became Williams Professor at UVM in 1854, and was ordained a Methodist minister in 1859. As one might expect, when reading the Petty diaries, one gets the impression of a rather melancholy man with an overly developed conscience. Many of the entries are full of self-reproach for his lack of achievement, for “evil thoughts,” and other faults. It may be, however, that the diaries were the safety valve for his gloomier side. Certainly, he was much loved by his students, who rained tributes on him after his death in 1887 and for years afterward.

The external conditions of the times were conducive to depression. The diary entries from 29 May 1856 contain powerful emotional outbursts evoked by the burning of Lawrence, KS, and the vicious attack on Senator Sumner by Preston Brooks. Petty, who had lived in the South, describes the horror of a slave auction. He was an abolitionist and a Republican, as was much of the population of Vermont. Petty’s reflections on the state of the world mix with his own personal problems

¹The club received a generous subsidy from Pierre Lorillard III (20 October 1796–23 December 1867), grandson of the founder of the Lorillard Tobacco Company, which manufactured six different brands of cigarettes ([10], p. 82). The Greek letters in the name of the fraternity are said to stand for *Lorillard Institute*.

in an entry of 30 December 1862 (a very bleak time for the Union and of course especially dark and bleak in Vermont, as it always is on that date):

The appointment received of the corporation of the University of Vermont in 1854 is still held. The anticipations then enjoyed have not been realized, and today the office is one of beggary rather than of ease and competence. Thus, the War, which desolates the South by the ravages of mighty Armies, disturbs the various relations of business at the North and changes posts of honorable independence into undesirable places of meager sustenance. . .

Petty had six children at the time.

Only a few diary entries relate to mathematics, and these are rather elementary parts of planned lectures. Unlike his three predecessors, he did not teach civil engineering. He sounds rather burned out in this diary entry from 4 June (no year given):

Engaged all morning in Differential Calculus. Find it very difficult to bring students to any desirable interest in the study. Some succeed, many are willing to fail and do so without any proper notion of the nature of their neglect. We are hampered by a class of students that are here they know not for what—idle, restless, mischief-making bodies—that bring more or less [illegible] into all College exercises. These dead limbs, in my opinion, as well for their own good as for our prosperity, should, after due trial, be “lopped off” and allowed to fall to their more appropriate spheres.

McKendree Petty was forced to retire in 1885 by a degenerative neural disease. He lingered on for another 18 months after retirement and died in Burlington on 23 September 1887. Tributes to him were many. The first volume (1888) of UVM’s yearbook, *The Ariel*, was dedicated to him. In 1910 his portrait was presented by grateful former students to Lambda Iota fraternity. This portrait now hangs in the John Dewey Lounge in Old Mill.



McKendree Petty (1827–1887), second Williams Professor of Mathematics.

2. Curriculum

Amid the poverty and disorganization created by the Civil War, the mathematics curriculum shrank from its previous dimensions. By 1867, mathematics was confined to the first two years of study in the classical course and its highest level was a two-month long study of calculus. The textbooks used during Petty's time were a series by Elias Loomis (7 August 1811–15 August 1889, professor at the City University of New York). They are competently written, though it is hard to see in what way they are an improvement over those used previously. The book by Legendre that had been used earlier, for example, gives the parallel postulate in the form given by the Scottish mathematician John Playfair (10 March 1748–20 July 1819): *Through a point not on a given line, there can be drawn one and only one line parallel to the given line.* Loomis adopts a slightly different wording that is not quite equivalent: *Two intersecting lines cannot both be parallel to the same line.* This formulation rules out the possibility that more than one line can be drawn through a given point and parallel to a given line, but it does not assure that there actually is one such line. The existence of such a line is guaranteed by the tacit assumption that a line is totally ordered and separates the plane into two disjoint half-planes. A person who wants to know only one-variable calculus might do just as well to study Loomis's text as anything written since. (Many subjects now taught, such as vector calculus, were not in Loomis's books because they had not yet been invented; and no physicist nowadays should attempt to get by without multivariable calculus.)

3. The University Environment

President Wheeler was succeeded by the Rev. Worthington Smith. Rev. Smith was born in Hadley, MA on 11 October 1795—he was the last UVM President born in the eighteenth century—and graduated from Williams College in 1816. He became pastor of the St. Albans Congregational Church on 4 June 1823. He served as president of UVM for six years, from 1849 to 1855, and during this time he attempted unsuccessfully to revive negotiations for a merger with Middlebury College. He died in St. Albans on 13 February 1856.

Rev. Smith was succeeded by Calvin Pease, the first UVM alumnus to serve in that role. He was born in Canaan, CT on 12 August 1813, and received the bachelor's degree at UVM in 1838 and a master's degree in 1841. From 1842 on, he was professor of classics at UVM. As a result of external economic forces beyond anyone's control, UVM's finances became precarious during the six years (1855–1861) leading up to the Civil War. The War itself, as Rev. Petty noted in his diary, made things even more difficult. In 1862, after resigning the presidency of UVM, Calvin Pease became Rev. Pease, pastor of a Presbyterian church in Rochester, NY. He spent only one year in Rochester, however, and returned to Vermont, where he died on 17 September 1863.

Rev. Pease's successor, the Rev. Joseph Torrey, who guided the University through the difficult years of the Civil War, was discussed above in connection with the university library. Rev. Torrey was the the last of the nine Congregational/Presbyterian pastors to occupy that office.

The postwar period was presided over by the most distinguished of all the first ten presidents, James B. Angell. He was born in Scituate, RI on 7 January 1829 and graduated from Brown University in 1849, where he remained (after a year traveling

around Europe) to teach modern languages. When he took office as president of UVM in 1866, there were only 30 students all told. He managed to increase this number to 60 and (more importantly) to firm up the university's financial position, so that professors were better paid. He left UVM in 1871 to become president of the University of Michigan, where he served until 1909 (!!). He died in Ann Arbor, MI on 1 April 1916. Angell's successor, Matthew Buckham, has been discussed above in connection with the lectures of F.N. Benedict. His presidency of UVM coincided exactly with his predecessor's presidency of the University of Michigan.

4. UVM Becomes a Land-grant Institution

One important change at UVM during this period was its incorporation as a land-grant institution in November 1865, when, under the terms of the Morrill Act, it became the University of Vermont and State Agricultural College, offering instruction in engineering and agriculture as well as the classical academic subjects. Norwich and Middlebury Colleges were once again offered the opportunity to unite with UVM in a single institution at this time, and once again, both turned it down.

To fulfill its part of the law, the State of Vermont was to contribute \$8,000 per year to the maintenance of the State Agricultural College. Justin Smith Morrill, one of Vermont's representatives in Congress and the author of the act that created the land-grant colleges, protested that this was a paltry investment, considering that the State received in return half the profits from various gifts to the University, including \$100,000 from John P. Howard,² \$20,000 from John N. Pomeroy,³ and \$200,000 from Frederick Billings of the class of 1844, whose presidency of the Northern Pacific Railroad was mentioned above. However, the State was not inclined to hear him (Lindsay, [3], p. 223).

One result of this new structure, shown in the 1866–1867 catalog, was the creation of the State Agricultural College, containing Sections of Engineering, Mining and Metallurgy, and Analytical and Agricultural Chemistry. The Agricultural College listed McKendree Petty among its faculty, along with Samuel Huntington, Jr.,⁴ C. E. as Instructor in Civil Engineering. Huntington was succeeded in the 1869–1870 catalog by Volney Giles Barbour,⁵ who left a considerable mark on engineering at UVM.

The entrance requirements for the new unit do not appear particularly onerous:

Applicants for admission to the Agricultural College must be at least 15 years of age, and must bring satisfactory testimonials of good character, and be able to sustain an examination in all the parts of a common school education, and particularly in English

²Born 27 July 1769 in Providence, RI, died in Burlington 24 February 1854. He owned a major hotel in Burlington and a large estate on the east side of Willard Street, at the top of what is now Howard Street.

³Born 29 September 1792 in Burlington and died there on 19 July 1881. He graduated from UVM in 1809 and eventually became a very successful lawyer, a profession from which he retired upon receiving a legacy from his father.

⁴Born in October 1842, he was an 1861 graduate of Union College. He taught at UVM from 1867 to 1869. By 1900, he was living in Maricopa County, in the Arizona Territory. Information on him appears to be rather sparse.

⁵Born on 2 June 1842 in Canton, CT and died in Minneapolis, MN on 4 June 1901, but buried in Burlington. He was a professor of civil engineering at UVM for 31 years.

Grammar, Geography, Arithmetic, and Algebra as far as quadratic equations. . .

The new sections had some influence on the curriculum, chiefly the addition of courses in mechanical drawing and projections. This adjunction of new academic units to the basic core of classical studies and medical studies brought with it the first “turf wars,” with traditional humanists fearing the degradation of academic standards and the public at large fearing that entrance requirements for the practical studies they cared about would be made too rigorous. These turf wars continue unabated between champions of STEM and champions of the humanities right down to the present day, although nowadays the struggle is purely over resources, not academic standards.

This change to the charter led to legal complications. The University of Vermont had been chartered by the legislature under that name in 1791, but was not subsidized through taxation. It relied on endowments, gifts, and tuition for its income. The newly-created State Agricultural College, however, was a state-subsidized institution. A further administrative complication arose when these two institutions were both immediately made subsidiary to a third legal entity called The University of Vermont and State Agricultural College, which was not subsidized by the legislature. This situation was bound to result in perceived inequities, which were not resolved until 1955.

5. Women and People of Color Come to UVM

In the 1871 catalog, we find the following:

By the recent action of the Trustees, the Academic and Scientific departments of the University are open to young women on and after the first day of the Spring Term of the present Academic year. Young women are admitted to all the courses of the department, subject to the same conditions as young men. They are required to board and room in private families approved by the Faculty.

The first women students turned out to be of very high caliber, and two of them, Lida A. Mason and Ellen Eliza Hamilton, were admitted—after some controversy—to Phi Beta Kappa (which had formed a chapter at UVM in 1849) when they graduated in 1875. They were the first women ever admitted to Phi Beta Kappa anywhere.

Lida Mason was born in Derby, CT on 7 September 1849 and raised in Jersey City, NJ. Thus, she was already of the normal age at graduation when she was finally allowed to enter UVM. Her presentations at the sophomore, junior, and senior exhibitions held at UVM every year, on “Luther and Loyola,” “The Puritans and Art,” and “True Excellence: Conformity to Principle” respectively, were reported and favorably commented on in the *Burlington Free Press*. After graduating, she was named assistant principal at the planned Vermont Academy in Saxton’s River, VT (founded by the Vermont Baptist Convention), which opened on 6 September 1876. The third catalog of Kappa Alpha Theta sorority from 1894 says she was a teacher there. However, it gives her address as Burlington. In fact, on 10 September 1877 she married the Burlington dentist Steven Dwight Hodge (2 February 1847–12 September 1934) and thereafter lived in Burlington. (The couple seem to have done the marriage ceremony again in Jersey City a month later, on 10 October. Both Vermont and New Jersey have records of it.) The 1880 US census lists her

occupation as “keeping house.” By that time, she had the given birth to twin daughters (Lydia and Helen). She attended the centennial commencement of UVM in July of 1904. She died on 4 July 1921 in Burlington, having suffered from arterial sclerosis for 12 years.

Ellen Hamilton was born in Brandon, VT on 14 January 1853. After graduation, she taught Latin and Greek in the high school in Claremont, NH from 1875 to 1879, then, in 1880–1881 at Ingham University in Leroy, NY, founded as a “female seminary” in 1835 and chartered as the first women’s university in the United States in 1852. (It was closed in 1892.) She then went traveling and, in Athens, Greece on 11 January 1883, married her UVM classmate, Congregational minister Frank Edward Woodruff (20 March 1855–19 November 1922). The couple had two sons and a daughter. Frank Woodruff eventually became a state legislator from Brunswick, ME, and after his death, Ellen ran unsuccessfully to fill out his term. (Women had been able to vote for only two years at that time!) She died in Brunswick on 28 November 1933. Her great-granddaughter Mary Woodruff inherited an extensive collection of letters between Ellen and Frank from 1870 to 1920, which she donated to Special Collections at the Bailey–Howe Library.

The first African-American member of Phi Beta Kappa was George Washington Henderson of UVM’s class of 1877. He was born into slavery in Clarke County, VA on 11 November 1850 and was illiterate 14 years later, when he attached himself to a Vermont military unit. He came to Vermont, learned to read, and after graduating first in his class in 1877, received a master’s degree from UVM in 1880. He later received a divinity degree from Yale and served in a number of distinguished positions, including a term as Dean of Fisk University in Nashville, TN (1904–1909). He later served at Wilberforce University in Ohio until his retirement in 1932. He died on 3 February 1936 and is buried at Xenia, OH.

Obviously, in the 140 years since those three students, there have been many women members of Phi Beta Kappa at UVM. African-Americans, however, were not among the student body in any considerable numbers until very recently. Both groups have certainly suffered discrimination, but it is noteworthy that Henderson was able to have a good career and the women were not. They could not even vote until they were well past normal retirement age. While George Washington Henderson’s career was mostly in “historically black” institutions, and he would, no doubt, have found it difficult to obtain comparable positions in public or private universities, it is very plausible that he would have freely chosen exactly the positions that he did occupy. The stories of these three after graduation provide an object lesson in the vast gulf between the career opportunities open to women and those open to men—even men who face intolerable discrimination. It would be an interesting project in Women’s Studies to see how these two women raised their daughters.

5.1. The variety of minorities. The number of ways human beings relate to one another is immense, and there are many groups besides women and African-Americans who were absent (or *apparently* absent) from UVM in its early days, notably Asians, Hispanics, Native Americans,⁶ people with disabilities, and members of the LGBT community. The reader will no doubt notice the absence of any

⁶I use this term reluctantly. It strikes me as patronizing to identify the descendants of the aboriginal inhabitants of the land with the name of the nation that disrupted their traditional ways of living. In addition, having been born in the United States, I find that this term applies

reference to people from these groups until the late twentieth century. For example, there were surely LGBT people at UVM from early days, but due to severe prejudice against them, they found it prudent to conceal their orientation.

People from all of these groups have had to struggle for acceptance, even though UVM, which is not a wealthy university, has made many attempts to integrate them into the University Community, by supporting organizations like ALANA (Asian-American, Latino, African-American, Native American), the Center for Cultural Pluralism, the LGBTQA Coalition, and Advocates for Exceptional Children, which reaches out to the wider community beyond the University to help learning-disabled children.

The single greatest obstacle to human progress is the fact that members of the dominant community everywhere have not fully overcome the tribalism that excludes people marked as “other.” (The “others” are also tribalistic, of course, but we are discussing this problem in the context of discrimination inflicted on powerless people.) Progress toward greater inclusiveness has always been painfully slow and interspersed with periods of reaction in which some gains are reversed. While most of the gains are made at the level of the University as a whole, or on the state or federal level, individual initiatives do make a difference. The Department of Mathematics and Statistics can be very proud of one of its members, Lecturer Holly Puterbaugh, who, together with her partner, established in court cases during the 1980s and 1990s that a qualified lesbian couple must be allowed to adopt a child and that same-sex married couples must have the same civil rights as heterosexual married couples. This action was taken at considerable personal risk, expense, and stress, and has yielded immeasurable benefits to the entire community, not merely to the LGBT community.

6. UVM Reaches Out to Vermont High Schools

Still another innovation in this period was the first High School contest sponsored by UVM, not only in mathematics, but also in other areas of science and in the classical languages. According to the 1873–1874 catalog (p. 23):

By the liberality of Mrs. M. C. Wheeler of Burlington, \$100 was offered last year in prizes to those who should best sustain the entrance examinations. This was evenly divided between the Classical and Scientific Departments, two prizes (\$30 and \$20) being offered in each. A competitive examination in writing resulted as follows: In the Classical Department, the first prize was awarded to Miss Ethel Persis Sherman of Montgomery, a graduate of the New London (N.H.) Institution; the second to Miss Lettie Estella Durant, of Montpelier, a graduate of the Montpelier High School. In the Scientific Department, the first prize was taken by Charles Wayland Drew, of Burlington, a graduate of Burlington High School; the second by William Thompson of Greenwich, N. Y., who was fitted for College at the High School in that place. The questions are reproduced here, as serving in some sort to indicate the kind and degree of preparation which is desired in candidates for admission.

exactly to myself; but if I applied it to myself, people would think I was claiming a heritage that is not my own.

Mrs. M. C. Wheeler was Mary Constance Wheeler, née Rignall, widow of President John Wheeler, born in England on 25 May 1818. She married the widower John Wheeler in West Roxbury, MA on 10 August 1852. She died on 18 March 1904. Three of the four student winners graduated from UVM. Ethel Persis Sherman was born 27 June 1851 and died 13 January 1933. She is listed as a teacher with a master's degree in the *General Catalogue of the University of Vermont, 1791–1890*. She studied in Oxford and Berlin between 1890 and 1892. In 1920, she was living in San Francisco. Lettie Estella Durant unfortunately died young. Born on 26 June 1854, she attended UVM from 1873 to 1875, but did not graduate. She became an insurance agent. She married civil engineer Augustus M. Torrey (21 November 1850–20 August 1902) on 18 June 1878 and died only one year later, on 20 June 1879. Charles Wayland Drew was born 18 January 1858 and died 25 November 1920 in Minneapolis, MN. He became a professor of chemistry at the University of Minnesota. William Andrew Thompson, born on 6 December 1854 in Easton, NY, became a civil engineer, having graduated from UVM with the class of 1878. The 1890 catalogue just mentioned gives his address as Rock Island, IL, but he also lived for a while in La Crosse, WI, being involved with control of the upper Mississippi River. He died on 27 March 1930.

The reference to “the desired preparation” reflects the fact that students no longer had to be examined by the UVM faculty in order to be admitted. The University was willing to accept the certification of a high school. Here are a few sample mathematical questions. We note that mathematical preparation was demanded of students in both classical and scientific divisions.

ALGEBRA: CLASSICAL DIVISION

5. Divide $a^2 + a^{-2} + 1$ by $a^{-2} + a^{-1} + 1$.
8. Solve the equation $a\left(1 - \frac{1-x}{2a^2}\right) = x\left(a + \frac{1-(1-a)}{3a}\right)$

ARITHMETIC: SCIENTIFIC DIVISION

6. Cube root of $30\frac{265}{512}$?

ALGEBRA: SCIENTIFIC DIVISION

3. Reduce the expression $\frac{1}{a} - \frac{1}{1 - \frac{a-1}{1+a}}$.

The purpose aimed at by the mathematical curriculum was stated in the catalogs, of which the 1878–1879 catalog is typical:

The high importance of thorough mathematical training, both as a logical gymnastic and as preparation for practical life, is constantly kept in view. Instruction is given by means of Recitations and Lectures in Pure and Mixed Mathematics during the first two years. More advanced practical courses are pursued in the Department of Science.

7. Religion at UVM

Although mathematics is not directly affected by the religious character of an institution, there are some points where official religious observances may affect instruction. Although the First Amendment to the Constitution forbids Congress

to establish an official national religion,⁷ the states themselves were subject to no such restriction, and Massachusetts was officially Congregationalist until 1828. It is very noticeable that nine of the first ten presidents of UVM were Congregationalist or Presbyterian ministers, and no one thought it unusual that the University should include Congregationalist worship in its official ceremonies. The position of religion at UVM during the nineteenth century now seems peculiar. Although founded for the purpose of secular education and granted public lands for its sustenance, the University was openly sectarian in its administration. The by-laws of the University from 1885, Chapter III, §2, p. 11, state

There shall be public prayer in the Chapel every week-day morning at such hour as the Faculty shall direct, preceded by the reading of a portion of the Scripture, and other devotional exercises at their discretion, which service it shall be the duty of the Faculty and students regularly to attend.

§3. Every student shall attend public worship on the Lord's day. During that day nothing shall be done which would disturb the quiet, or interfere with the religious observance of the day. All days devoted to religious purposes by the Government of the land shall be observed in such manner as may be prescribed by the Faculty.

These rules would seem to preclude the enrollment of devout Catholics, for whom deliberate participation in Protestant worship was officially a mortal sin until the late 1960s. This fact may account for the paucity of French surnames among the students and faculty at UVM, despite the fact that the French formed a significant portion of the population of Vermont. Almost anyone, of any religious persuasion or none at all, would nowadays regard it as unjust to take public resources belonging to the entire population and bestow them for the benefit of one particular religious group.

In the context of the time, however, one would say that the practice at UVM simply reflected the unconscious world-view of the Protestant majority. Acceptance of Catholics and Jews as an equal part of this national world-view took considerable time, and it is noteworthy that other religions have still not achieved full acceptance. The relaxing of these rules came about piecemeal. The Faculty exempted itself from compulsory Chapel in 1892. Medical students were exempted in 1912. Only in 1916 was the existence of non-Protestants rather grudgingly recognized, with a statement that, "Students who, because of their religious affiliation, object to attendance at Chapel, are excused by the President upon request being made to him." Compulsory Chapel was finally abolished in 1920, making UVM at last, fully secular.

Not only Catholics and Jews, but also racial minorities have had to struggle for acceptance at UVM. A summary of the experiences of all these groups can be found in the article by Older ([5]).

⁷Some lawyers argue even today that this amendment merely prevents the naming of any one Christian denomination as the official religion, in the sense of the national churches in England and Scandinavia and the various nations that once proclaimed the Catholic Church as official in their constitutions. These lawyers argue that it is still permissible to declare the United States an officially Christian nation.

CHAPTER 4

The Beginnings of Growth, 1885–1914

In the period from the end of the Civil War and up to the beginning of World War I, many young Americans went to Europe in pursuit of an education. The German universities, which were considered the finest in the world, were particularly hospitable to young Americans, and such mathematicians as Felix Klein (25 April 1849–22 June 1925, professor at Göttingen) and Carl Neumann (7 May 1832–27 March 1925, professor at several universities, eventually at Leipzig) had many American students. The long-term effect of this Germanization of American universities was a decreased emphasis on the British-style education for public service and an increased emphasis on original research as a duty of the professor, an effect that was reinforced a generation later by European scholars who were refugees from the Nazis.

All that was in the future, however. The first generation of European-educated Americans for the most part did very little research themselves. Instead they acquainted their students with the contemporary trends in the most advanced centers of mathematical research. New, high-quality American research universities were being founded all the time, with Johns Hopkins (1876), Clark University (1889), Bryn Mawr College (1885), and the University of Chicago (founded in 1856 as a Baptist university and reinstated by the American Baptist Education Society in 1890 with a large grant from John D. Rockefeller) being among the most prominent. Meanwhile, the faculty at the long-established places like Harvard, Yale, and Dartmouth were beginning to gain international reputations as well.

1. Personnel

Among the young Americans who obtained part of their education in Europe during this period was McKendree Petty's successor as the Williams Professor of Mathematics, Archibald Lamont Daniels. He was born in Hudson, MI on 19 June 1849 and obtained the A. B. degree at the University of Michigan in 1876. He then went to Göttingen and Berlin, where he took courses from such great mathematicians as Hermann Amandus Schwarz (25 January 1843–30 November 1921) and Karl Weierstrass (31 October 1815–19 February 1897). He returned to America in 1881 and worked on a fellowship at Johns Hopkins until 1883. Hopkins at the time was only slightly inferior to the great European universities. It had the best of the new generation of American research mathematicians, including Simon Newcomb (born in Nova Scotia on 12 March 1835, worked for the Naval Observatory in Washington, DC, died on 11 July 1909), William Edward Story (29 April 1850–10 April 1930, he was the chair of the mathematics department at Clark University from its founding until 1921), Fabian Franklin (born in Hungary 18 January 1853, died on 9 January 1939), and Thomas Craig (20 December 1855–8 May 1900) and had enjoyed the services of the great British algebraists James Joseph Sylvester (3

September 1814–15 March 1897) and Arthur Cayley (16 August 1821–26 January 1895).

In 1883, Daniels became instructor at Princeton University, taking over the teaching duties of Henry Burchard Fine,¹ who had gone on leave. Daniels received the D. Sc. degree from Princeton in 1885 and became instructor in mathematics at UVM that year. The following year, upon the retirement of McKendree Petty, he became the third Williams Professor of Mathematics.

Daniels’s research record resembles that of many other first-generation American scholars. It consists of three expository articles in the *American Journal of Mathematics*, Vols. VI and VII (1884–1885) explaining Weierstrass’s theory of elliptic functions for the benefit of Americans. Daniels has the distinction of being the only UVM faculty member ever listed in Poggendorff’s² *Biographisch-Literarisches Handwörterbuch zur Geschichte der exacten Wissenschaften*, Bd. 4 (1904), p. 295. Poggendorf—or rather, his successor—credits Daniels with four years of study in Göttingen, two in Berlin, and one at the Johns Hopkins University “[in] Cambridge, Mass.”

Daniels preserved the notes from Weierstrass’s 1881 course on analytic function theory, which were not published with Weierstrass’s collected works and are still of interest to historians of mathematics. These notes were inherited by his grandson, Robert V. (Bill) Daniels (4 January 1926–28 March 2010), who had a distinguished career at UVM as a specialist in Soviet history and a period of service as a state Senator from Chittenden County.

1.1. Expansion of the faculty. Daniels set about revamping the curriculum to suit his own background, using the textbooks of Simon Newcomb as the base. (Physics and mathematics were being taught out of the College of Agriculture at this time.) By the mid-1890s, he was offering courses in ordinary and partial differential equations, projective geometry, and “heat, magnetism, and electricity.” In 1895 and 1896, he offered a course in geometric function theory and elliptic functions. Sophisticated material indeed, for an American university of the time!

This being a time of expansion for the University, Daniels regularly had the assistance of an instructor in teaching the courses. The most interesting of these was Fred Merritt Corse, born in Bakersfield, VT on 7 September 1864, who received his A. B. at UVM in 1888, then became Curator of Buildings, Secretary of the Faculty, Registrar, Instructor in Mathematics, and Instructor in Political Economy over the period 1891–1894 while also obtaining a master’s degree from Columbia University. In 1894, he went on leave of absence. After leaving UVM he taught at Brooklyn Institute, then joined the Singer company in 1899, which he left in 1902 to join the New York Life Insurance Company. As manager of the Russian division of the company in Petersburg, he spent 16 years getting to know the Russians. He returned to America with his family after the Russian Revolution and, in two

¹Born 14 September 1858, died 22 December 1928. Until 1969, the mathematics department at Princeton was housed in a magnificently paneled building named Fine Hall. In that year, it moved into a section of a tall tower near the football stadium, dubbed “Finer Hall” by Professor Robert C. Gunning.

²Johann Poggendorff (29 December 1796–24 January 1877) was a German physicist who undertook an ambitious plan to compile a catalog of scientists—that is, all who were recognized in Europe. This *Handbuch* was the result.

long articles in the *New York Times* in 1918,³ urged intervention to overthrow the Bolsheviks. He appears among a group of social revolutionaries in a photograph opposite page 34 of George Kennan's book *Russia Leaves the War* (Atheneum, New York, 1967). He died in New Canaan, CT on 20 August 1927. In 1952, the Fred and Fanny Corse Professorship was established at UVM. There is also a Corse fellowship, awarded annually to a UVM graduate holding a Bachelor of Arts degree and planning to teach languages in a University.

Mr. Corse was followed by Allison Wing Slocum, who was actually a professor of physics but taught courses in the Department of Mathematics beginning in 1894, leaving Prof. Daniels free to teach more advanced mathematics courses. Slocum, who was born in Dartmouth, MA on 22 April 1866 and died in Boston on 15 December 1933, obtained a bachelor's and master's degree from Haverford, then went on to Harvard to obtain a second master's degree in 1891. He was Tyndal scholar at Harvard in 1890–1891 and Morgan scholar at the University of Berlin in 1891–1892. Physics was beginning to come into its own at UVM at this time, even though Slocum was its only professor. Williams Science Hall was built in 1895, named for the industrialist Edward H. Williams⁴ of the Baldwin Locomotive Company in Philadelphia, who donated \$30,000 to equip the building, an assignment that was carried out by A. W. Slocum.

Two other instructors in mathematics were hired during the 1890s: Warren Gardner Bullard and Arthur Dexter Butterfield. Bullard's contact with UVM was rather brief and superficial on both sides. He was born in Hinsdale, NY on 25 February 1867 and graduated from Brown University in 1892. After spending one year as an instructor at the Elmira (New York) Free Academy, he entered graduate school at Clark University, where he received the Ph.D. in 1896 for a dissertation "On the general classification of plane quartic curves," written under the direction of W. E. Story, who was mentioned above. He spent four years as an instructor at UVM, then left to become a faculty member at Syracuse University, where he rose to the rank of full professor by 1909. He eventually published his dissertation and was co-author of a textbook on college algebra, published in 1908. He died on 16 February 1927.

Arthur Dexter Butterfield had a long and varied career, intersecting with UVM over two periods. He was born on 13 October 1870 into an old and distinguished family in Dunstable, MA. (He was the 15th generation to live in his house.) He received the B.S. degree from Worcester Polytechnic Institute in 1893 and then, after serving there as an instructor in civil engineering, an M.S. from the same institution in 1898. In that year, he joined UVM's faculty as an instructor in civil engineering. He was named an assistant professor of mathematics in the Department of Engineering in 1900, so that apparently UVM now had two mathematics departments.

In this period of his career, he became the second UVM mathematician—the first, as noted above, was James Dean—to live in the Lucy Ann Abbot House at 41

³See "Fred Merrit Corse returns to New York after 16-year sojourn in Russia, describes conditions," (*New York Times*, 29 April 1918, p. 6, col. 4) and "Describes conditions in Russia and urges intervention against the Bolsheviks," (*New York Times*, 23 June 1918, Sect. III, p. 4, col. 1).

⁴He was born in Woodstock, VT on 1 June 1824 and graduated from the UVM College of Medicine. He eventually abandoned medicine to work in the railroad industry. He died in Santa Barbara, CA on 21 December 1899.

South Prospect Street, now Nicholson House, named after UVM Professor George Nicholson (discussed below). He went on leave from UVM in 1904 to obtain an A.M. from Columbia.

He left UVM in 1908 to be assistant professor of mathematics and geodesy at Worcester Polytechnic Institute, which made him a full professor in 1914. During this time, he showed considerable skill in fundraising and alumni relations. In 1917, during America's participation as a belligerent in World War I, he joined the Aviation Corps as a captain and was attached to General Pershing's staff. He returned after the Armistice as a lieutenant colonel, having been awarded the prestigious French *Légion d'honneur*. He resigned from Worcester Polytechnic in 1920 to become director of education at the Norton company.

Returning to UVM in 1938, he became professor of mathematics and geodesy and head of the mathematics department, a position he resigned in 1942. He seems to have been a popular teacher, and his students referred to him affectionately as "Butt." After World War II, he became director of Veterans' Education at UVM, having obtained a Doctor of Engineering degree from Worcester Polytechnic in 1945. He resigned as director of Veterans' Education in 1948 because of a desire to engage in other work. He was an acquaintance of Atwater Kent, from whom he requested money to build an observatory at UVM.⁵ His vaunted fund-raising ability seems to have failed in this case. The money was not forthcoming, and the observatory was not built. He died of arteriosclerosis complicated by nephrosclerosis in Burlington on 22 August 1955.

A. D. Butterfield had broad intellectual interests, and his two publications reflect an intense interest in the history of science. The first was perhaps his master's thesis, a 57-page pamphlet bearing the title *History and Development of Triangulation in Massachusetts*, published in 1898. The other is a 168-page work entitled *A History of the Determination of the Figure of the Earth from ARC Measurements*, published by the Davis Press in Worcester, MA in 1906. It is thus not surprising that he eventually was named professor of mathematics and geodesy.

The resources mentioned above had increased during the 1890s, as shown by the construction of the Williams Science Hall. The minutes of the Board of Trustees' meeting of 1 December 1891 (Vol. IV, p. 224) note that

the bequest of fifty thousand dollars to the University to found a Professorship of Mathematical, Natural, or Technic Science, by the will of the late Hon. Edwin Flint of Mason City, Iowa, and alumnus of the class of 1836, was announced by the President.

Flint, born in Braintree, VT on 25 May 1814, was a lawyer and judge in Wisconsin and Iowa. He died in Iowa on 15 October 1891. The first Flint Professor of Mechanics and Bridge Engineering was Volney Giles Barbour, who was mentioned above. Only once has this professorship been held by a mathematician (Percy Fraleigh, during the 1950s).

⁵Arthur Atwater Kent, Sr. was born in Burlington on 3 December 1873. He was a first-year student at Worcester Polytechnic in 1895, which is probably where he met Butterfield. He patented the Unisparker automobile ignition coil, which was an industry standard for about 50 years. He is most famous for the Atwater Kent radios, which were wildly popular, despite being expensive. He died in Hollywood, CA on 4 March 1949.

2. Curriculum

Daniels's course on analytic function theory was supplemented with readings from Durège's book on Riemann's theory of complex variables.⁶ This course, however, was offered irregularly. Really, the best mathematics offered during this period was taught in the Department of Physics department. In 1899, Slocum offered a course in mathematical physics using as texts Riemann's⁷ *Partielle Differentialgleichungen*—would we dare to use a textbook in a foreign language nowadays?—and Fourier's⁸ *Analytical Theory of Heat*. He also used Maxwell's *Heat* and Duhem's⁹ *Potential thermodynamique*. As mentioned above, Daniels reciprocated by offering a course in “Heat, Magnetism, and Electricity.”

For unknown reasons, Prof. Daniels ceased to teach the more advanced courses after 1904. The academic students (exclusive of medical students) numbered about 350 at this time, of whom 164 were first-year students. These figures suggest a high dropout rate. Whether mathematics students contributed to this high failure rate is unclear. Certainly, the admission standard for the University (as distinct from the Agricultural College) in 1905 was rigorous enough, consisting of

(1) Arithmetic, including the metric system; (2) Algebra, including the four species, factoring, largest common divisor and lowest common multiple, fractions, theory of exponents, involution, elementary forms of binomial theorem, evolution, surds, simple [linear] equations with one, two and three unknown quantities, simple quadratic equations. In the instruction the aim should be the formation of the habit of clear and concise expression, and to this end the class room work should be largely oral.

II. Solid and Spherical Geometry.

The word *species* has been used in different senses in algebra. In the writings of Diophantus, it means what we call the unknown in an equation. In those of al-Khwarizmi, there are species of equations, since only positive coefficients were considered. Thus, one could have quadratic equations of the form $ax^2 = bx + c$, $ax^2 = c$, $ax^2 + bx = c$, $ax^2 + c = bx$, each of which required a separate diagram to illustrate its solution geometrically. Cases where $a = 0$ are linear equations, and those with $c = 0$ have 0 as a root and become linear when divided by x .

The following year these requirements were expanded to include trigonometry, simple permutations and combinations, determinants, linear equations, graphical

⁶Heinrich Durège (born in Poland on 13 July 1821, died in 1893) was a professor at the University of Prague. His book went through at least four German editions before being translated into English. Although the notation has changed considerably by using the language of manifolds, the classical examples upon which an intuitive understanding of Riemann surfaces must be based are discussed with great clarity in this book.

⁷Georg Friedrich Bernhard Riemann (17 September 1826–20 July 1866), one of the greatest geometers and analysts of the nineteenth century.

⁸Jean-Baptiste Joseph Fourier (21 March 1768–16 May 1830), famous chiefly for this work, which introduced Fourier series and integrals.

⁹Pierre Duhem (10 June 1861–14 September 1916), best known for precisely this work.

treatment of equations, Descartes'¹⁰ rule of signs, and Horner's¹¹ Method “but not Sturm's¹² functions or multiple roots.” Descartes' rule of signs gives an upper bound on the number of positive and negative roots a polynomial with real coefficients can have. Sturm's functions, modifications of the remainders that arise in finding the greatest common divisor of a polynomial and its derivative, can be used to find the exact number of real roots in a given interval, provided the polynomial has no repeated roots.

Admission by high school certification was supplemented by the College Board Examination sometime during the first decade of the twentieth century.

3. New Personnel

The engineering mathematics department began to grow in 1905, adding assistant professor George Monroe Brett to the faculty. He was born in Auburn, ME on 4 November 1875 and graduated from Bowdoin College in 1897. He came to Burlington in 1903 as an assistant principal at Burlington High School. Local newspapers reported in July 1910 that he and Prof. Butterfield were surveying the Winooski River. He must have gone abroad soon afterward, as he was listed as a passenger on the *Lusitania*, which arrived in New York on 13 September 1912. Two years later, now a professor at City College, he married Agnes Baldwin, a noted numismatist. He served in the army during World War I. His academic specialty was accounting, and he is the author of *Fundamental Accounting* in the CCNY series, published by Lancaster Publishing Company in 1928 (541 pages). He continued as professor at City College until his death on 7 November 1941. He is buried at St. Paul's Episcopal Church in Newark, NJ.

In 1908, the engineering mathematics faculty gained professor Evan Thomas, who is the author of many biographies and reminiscences of UVM mathematicians. He was born on 25 August 1853 in Wales, as one would probably guess from his names. In fact, he was born in the Rhondda Valley, made famous in the 1939 novel *How Green Was My Valley* by Richard Llewellyn, which in turn was made into a movie in 1941 starring Maureen O'Hara and Walter Pidgeon. In 1867, at the age of 14, he was apprenticed to a firm of clothiers, and his parents emigrated to Ohio. While visiting his parents at the age of 18, he decided to enroll in Dennison University, where he obtained the B.S. degree in 1876. He became a Congregationalist minister at Vershire, VT in 1880, then spent 3 years as a pastor in the Ludlow/Plymouth area, where he also managed the local newspaper. He came to Essex Junction as pastor in 1886. In 1892 he taught a semester of mathematics at UVM. Eventually, he became head of engineering mathematics and mechanics at UVM, retiring in 1928, although he came back to teach for one semester in 1930.

He was the author of several articles on pedagogy, as well as Chapters XVII and XVIII in the second edition of Walter Hill Crockett's *History of Lake Champlain* (McAuliffe Paper Company, Burlington, 1936). Prof. Thomas's two chapters tell of the raising of two of Benedict Arnold's ships, which were sunk by the British

¹⁰René Descartes (31 March 1596–11 February 1650), one of the inventors of analytic geometry and calculus.

¹¹William Horner (1786–22 September 1837), inventor of a method of approximating roots of an equation, although his claim to this honor is controversial. Besides the fact that there were contemporaries who worked in this area, a method very like his was known to the ancient Chinese.

¹²Jacques Charles François Sturm (29 September 1803–18 December 1855), famous for his work on series expansions of solutions of second-order linear differential equations.

in October of 1776, and of the construction of the bridges across Lake Champlain. After he retired, he traveled in Europe and was horrified by *Kristallnacht* in Germany, which shattered many illusions about the superior civilization of Germany. He wrote back to the United States that he was sure this was not typical of the Germans and that the aberration would soon be corrected. He died in Burlington on 3 September 1947.

Growth continued in the Department of Engineering Mathematics in 1914. There seems to have been some general reorganization of UVM around this time. After 1911 the catalogs refer to the “College of Arts and Sciences” and the “College of Engineering,” where previously these units had been referred to as the “Departments of Arts and Sciences” and the “Department of Engineering.” In 1914, A. L. Daniels retired from the Academic Mathematics Department, bringing an end to the first phase of what can be seen in retrospect to be UVM’s first move to join the worldwide mathematical community.

Another Generation of Struggle, 1915–1954

A. L. Daniels's successor, the fourth Williams Professor of Mathematics, was Elijah Swift, like Daniels a part of the generation of young Americans who obtained their education in Europe. Having obtained his European education a quarter-century later than Daniels, however, he became a more prominent mathematician. He was born in Buffalo, NY on 23 October 1882 and graduated from Harvard in 1903. In that year, he presented a paper before the American Mathematical Society (which had been founded as the New York Mathematical Society in 1888), "On the condition that a point transformation of the plane be a projective transformation." This paper was published in the 1904 *Bulletin of the American Mathematical Society*. He then went to Göttingen, where he studied under the world-famous mathematician David Hilbert (23 January 1862–14 February 1943). His notes from Hilbert's 1905–1906 course in integral equations, in which the now-standard concept of a Hilbert space was introduced, were left in the mathematics department and were turned over to the library's Special Collections in 1990. He received the Ph. D. degree *magna cum laude* in 1907 for a dissertation, "Über die Form und Stabilität gewisser Flüssigkeitstropfen," (On the shape and stability of drops of certain liquids). Then, like A. L. Daniels, he took up a position at Princeton, from which he was hired by UVM.

Although he published a number of papers, we note here just two that are typical:

- "Note on the second variation in an isoperimetric problem," *Bulletin of the American Mathematical Society*, **XIV** (1908).
- "Canonical forms for ordinary homogeneous linear differential equations of the second order with periodic coefficients," *American Journal of Mathematics*, **L** (1928).

In Elijah Swift, UVM had found one of the best American mathematicians available at the time. In 1931, he became Dean of the College of Arts and Sciences, retiring from that position in 1948. He died on 21 July 1957. (In a 1990 interview, Professor Nicholson said that Swift suffered from dementia for some time before he died.)

Despite Swift's outstanding qualifications, the department was to be hard-pressed to sustain the advances made under A. L. Daniels, mostly because of financial constraints, which at one point threatened the very existence of the university. The curriculum declined over this period to a very elementary level, especially after Elijah Swift left off teaching to become a dean.

1. New Personnel

During the period of "Coolidge prosperity" of the 1920s, UVM added a large number of new faculty members, and was able to add even one more during the

Great Depression. The explanation for this seeming paradox will be given in Sect. 3 below. Right now, we merely note the additions.

Along with Prof. Swift, the Mathematics Department of the College of Arts and Sciences hired James Edward Donahue, and these two were the core of the Mathematics Department for the next 17 years. J. E. Donahue was born in Fairfield, VT on 25 April 1880. He graduated from Burlington High School in 1897 and from UVM in 1902. He obtained the M. A. degree from Harvard in 1910 and remained there until 1912, when he became an instructor at Washington University in St. Louis. After three years at UVM he joined the Navy for the duration of America's participation in World War I, then returned to the Department of Mathematics. In 1930 he went on leave from UVM and obtained a doctoral degree from Columbia University in 1931 for a dissertation "Concerning the geometry of the second derivative of a polygenic function," written under the direction of Edward Kasner (2 April 1878–7 January 1955). Tragically, he lived only one year after obtaining this degree, dying of a cerebral hemorrhage while on vacation in Maine on 15 August 1932.

Swift and Donahue were joined by a succession of instructors, and gradually more and more professors were added. Instructors Howard Guy Millington and Fred Walter Householder were hired in 1920–1921; both of them later became assistant professors. Millington's appointment was in the Department of Engineering Mathematics.

H. G. Millington was born 28 August 1887 and received the B. S. degree from Rensselaer Polytechnic Institute. He became Assistant Coordinator of Civilian Pilot Training at UVM in 1942. He retired from UVM in 1954 and died on 25 February 1965.

F. W. Householder, who had served in the Army Engineering Corps during the last six months of World War I, was born in Jackson, TN on 7 April 1884. He received the B. A., M. A., and LL. B. degrees at the University of Texas. He was actually an historian who happened to know some mathematics. In those post-War years, mathematicians were hard to find. Householder seems to have worked out well at first, but suffered from "burn-out" in the 1930s. (Heath Riggs, who took courses from him, confirmed in a 1990 interview that this judgment, made by Elijah Swift himself, is accurate.) Householder went to California to work in the shipbuilding industry at the beginning of World War II, and Swift took advantage of this situation, together with the University's precarious financial position (all salaries had just been reduced by 25%) to urge him to resign. He died in Johnston, RI on 3 June 1950.

Householder had been replaced by Instructor Douglas Tillman McClay in 1941. McClay was born in Boston on 20 December 1915, graduated from Harvard in 1936, and obtained a Ph. D. at Harvard in 1940. He remained at UVM until 1949 and died in Burlington on 12 July 1982. Dean Swift expressed the opinion that McClay was superior to Householder as an instructor.

The year 1923 saw the addition of the longest-serving member of the UVM faculty. George Hubert Nicholson was born on Prince Edward Island on 12 March 1898 and attended Mount Allison University in New Brunswick, where he received the A. B. in 1922. When the Canadian scholarship he had been hoping for was preferentially awarded to a veteran of the war, he went to Harvard to obtain a master's degree. He taught at UVM, in some periods as much as 12 hours per

week, for fifty years, rising to the rank of associate professor, despite not having a Ph.D. Although he officially retired in 1963, as required by UVM statutes, he continued to teach as an adjunct until 1973.

Despite the sometimes-heavy teaching load, he found time to write a brochure on mathematical instruments that is still in his file in the UVM Archives. Shortly after he came to UVM, some students asked him to coach a hockey team. He did so, spending \$300 of his own money to flood a field near the site of what is now the Bailey–Howe Library, and thus became the founder of the UVM Hockey Team. As mentioned above, when he retired permanently in 1973, the Lucy Ann Abbott House, which was the home of the Mathematics Department at the time, was renamed Nicholson House in his honor. He died in Burlington on 24 January 1995.



Ceremony in 1974 honoring George Nicholson's 50 years of service to the University by renaming the Lucy Ann Abbot House as Nicholson House. At left is N. James Schoonmaker, chair of the Department. At right is Joseph Izzo, acting dean of the College of Engineering Mathematics and Business Administration. The woman in the photo is Margaret Essery (Peggy) Nicholson (1 February 1911–29 September 1994), wife of George Nicholson and, like him, a native of Prince Edward Island.

Another instructor, added in 1924, was Horace Alpheus Giddings, who was born in Farnworth, NH on 6 January 1902 and obtained the B.S. degree at the University of New Hampshire in 1923. He remained at UVM until 1930, when he entered graduate school at the Massachusetts Institute of Technology. He became an instructor in mathematics there in 1933, while still working on a Ph.D. He obtained the Ph.D. at MIT in 1937 and became an assistant professor at the Armour Institute of Technology in Chicago, which became the Illinois Institute of Technology in 1940 after merging with Lewis Institute. He died in Volusia, FL on 11 December 1984 and is buried in Tamworth, NH.



The Arts and Sciences Mathematics Department in 1925. Back row, left to right: Nicholson, Householder, Donahue. Front row, left to right: Swift, Giddings.

In 1928, Percy Austin Fraleigh became an assistant professor, bringing the total faculty to 7 (four professors and three instructors). Fraleigh was born in Hyde Park, NY on 12 April 1895 and received the degrees of A. B. (1917), A. M. (1918), and Ph. D. (1927) at Cornell. He remained at UVM until 1963. As mentioned above, during his last thirteen years at UVM he was the Flint Professor of Mathematics, the only mathematician to occupy this endowed chair. He died in Burlington on 27 December 1980.

The next new professor, James Atkins Bullard, was appointed in both the Arts and Sciences and Engineering Mathematics Departments, replacing Evan Thomas in the latter. He was born in Parsippany, NJ on 3 February 1887 and received the Ph. D. from Clark University in 1914,¹ as his namesake Warren Gardner Bullard had done 18 years earlier. He was an instructor at Worcester Polytechnic Institute until coming to UVM in 1928. He published his doctoral dissertation as the article “On the structure of finite continuous groups” in *The American Journal of Mathematics*, **XXXIX**, No. 4 (October 1917). He was co-author of a textbook on plane and spherical trigonometry, published by D. C. Heath, Boston, in 1922 (revised edition 1930). He remained at UVM until 1953, becoming the fifth Williams Professor of Mathematics in 1944 upon the resignation of Dean Elijah Swift from the Mathematics Department. He was the last person on whom this title was conferred until it came to the present author in the year 2000. He came out of retirement for two years in the mid-1950s to teach again. He died in Parsippany, NJ on 10 April 1959.

¹His thesis adviser was Henry Taber, born at Staten Island, New York on 10 June 1860. Taber was a student of W. E. Story at Johns Hopkins, receiving the Ph. D. in 1888. He then joined Story to form the core of the mathematics department at the newly founded Clark University. He died on 6 January 1936.

The last of the new faculty, Myron Ellis Witham, a civil engineer, was hired in 1932. He was born in Rockport, MA on 29 October 1880. He was a prominent football player at Dartmouth, the hero of its 1903 team. In addition to teaching mathematics at UVM through 1972, he also coached the UVM football team² and taught physical education. He lived for a time in the late 1930s in what is now Nicholson House. He died in Burlington on 7 March 1973.

The extended “Coolidge prosperity,” which had lasted all through the 1930s at UVM, came to an abrupt end in 1941, for two reasons, one of which will be discussed in the next section but one. The other reason was the attack on Pearl Harbor on 7 December 1941. During the years of American participation in World War II (1942–1945), when enrollment had shrunk to half of its normal level as students enlisted in the armed services in large numbers, the faculty members just listed barely managed to keep mathematics going at the University of Vermont.

2. Curriculum

Despite the large number of new faculty, there was little, if any, innovation in curriculum during this time and essentially no research. Indeed, only ten courses were offered in the department at this time, and they were all elementary, with the single exception of theory of functions. They were, however, heavily enrolled, so that the five faculty members were kept quite busy teaching them. Although the curriculum was revised when Swift and Donahue took over, it remained rudimentary. Calculus was followed by Synthetic Geometry and Theory of Functions. That was the entire curriculum. The Engineering Mathematics Department continued to teach mechanics and differential equations and duplicated the teaching of analytic geometry and calculus. (There was a great deal of duplication at this time; the Engineering College even had its own English Department.)

The large growth in faculty during the 1930s discussed above reflects the growth in the size of the student body rather than any growth in curriculum. The courses that were added during this time, while of practical value to the students, no doubt, were not by any means advanced mathematics courses. Mathematics of finance was added in 1932, and a course in the teaching of algebra and geometry in 1934. The admission requirements of 30 years earlier remained in the catalog unchanged. The impression of stagnation created by this curriculum is confirmed by a person who actually took the courses. Heath Riggs, who graduated from UVM in 1940, stated in a 1990 interview that he took mostly physics courses, since there wasn’t much of interest in the Mathematics Department. He described Fraleigh and Nicholson as excellent teachers and competent mathematicians, but confirmed what other sources suggest, that Householder was an incoherent lecturer.

In summary, this was a period when the University was overworking the teaching faculty in order to serve a large number of students, leaving the faculty little time to develop new courses and no time for research. It was only near the end of World War II that some real updating of the curriculum began, and then very slowly. Courses in advanced calculus, differential equations, complex variables, and infinite series were added in 1944. A course covering Lebesgue integration appears for the first time in 1946. The first tentative step into graduate education appears in 1947, with the addition of a master’s thesis course.

²Football was abolished at UVM in 1974.

3. The Financial Situation

Despite the dismal economic situation in the United States during the Great Depression of the 1930s, UVM's thirteenth president, Guy Bailey,³ seemed to be a miracle-worker, prolonging the "Coolidge prosperity" of the 1920s, keeping salaries up, and expanding the physical plant and the faculty. Only after his death was it discovered that he had in fact been running huge deficits, and that the University was half a million dollars in debt. An emergency bailout of \$260,000 was provided by the legislature, with the stipulation that a certain amount of money (set at precisely \$68,880) was to be held in reserve each year to pay the interest on the debt. This bailout came in early November 1941, just before Bailey's successor, John Schoff Millis,⁴ took office.

These events all took place less than a month before the attack on Pearl Harbor took the United States into World War II. (I cannot resist pointing out that when the legislature voted the bailout, it also voted a declaration of war on Germany by the State of Vermont! That was a month ahead of the rest of the country.) UVM students flocked to enlist in the armed services, and by 1944, the enrollment of 1300 students in 1942 had fallen by more than half. For an institution highly dependent on tuition, this inevitably led to further deficits. Millis, however, proved to be a very capable president and managed to reduce the debt by nearly half a million dollars before leaving office in 1949. This effort was no doubt facilitated by an influx of returning veterans after the war.

4. The Mathematical Environment

Mathematics at UVM was a service discipline at this time. The department in Arts and Sciences was merged with the Engineering Mathematics Department to form a single Department of Mathematics and Mechanics in the College of Technology in 1946. There were persistent rumors that this move was made because of the terms of the Wilbur Fund, established by UVM trustee James Benjamin Wilbur.⁵ It was asserted that this fund, which provided money for the College of Arts and Sciences, specified that the College not grow beyond a fixed number of students. With mathematics majors being counted as engineers, the College had some room to grow in other areas. This scenario sounds plausible, but some details need to be added.

Wilbur left the money to the University of Vermont, not to the College of Arts and Sciences. But, recall that when the institution known as the University of Vermont and State Agricultural College was established, the portion of it that bore the name *University of Vermont* was essentially only the College of Arts and Sciences, together with the Medical School. According to his bequest,⁶

³Born in Hardwick, VT on 7 May 1876, died on 22 October 1940, he became president of UVM in 1920 and remained in that office until shortly before his death.

⁴Born in Palo Alto, CA on 22 November 1903, died in Cleveland Heights, OH on 1 January 1988.

⁵Born in Cleveland on 11 November 1856, he apparently made his considerable fortune at the Royal Trust Company in Chicago, which he founded in 1891. He gave money to UVM to build the Ira Allen Chapel in 1925, and set up a trust for the money that is now in the fund. He died on 28 August 1929.

⁶Wilbur also specified that certain of his heirs were to have a lifetime claim on the money, one of them being his son James Jr., who died in 1933. The widow and son of the latter sued the University seeking to recover the money. Apparently UVM's title to this money is now secure and

The University of Vermont Trust, hereinabove referred to shall not be created unless the Legislature of Vermont pass a law limiting the number of students attending the University of Vermont in any one year to one thousand, and no students from outside the State to be admitted until after native born Vermont students, who apply and qualify, are admitted, or the Trustees of the University of Vermont, if they have the authority to do so, pass a similar resolution. This number of one thousand may be added to at the rate of two hundred and fifty for every one hundred thousand increase in the number of inhabitants of the State over the United States census taken in 1920, as determined by the best available information obtainable in the State of Vermont. As soon as this provision is carried out by the Legislature of Vermont or the Trustees of the University, the Trustee shall constitute and set up the trust to be known as the "UNIVERSITY OF VERMONT TRUST" for the purposes and in the manner and on the conditions set forth in this indenture.

The Wilbur Fund played a role in a charter change made in 1955. At that time, UVM's fifteenth president, Carl Borgmann,⁷ asked the legislature to stipulate that the umbrella entity known as The University of Vermont and State Agricultural College was an instrumentality of the State of Vermont and therefore eligible for financial support from the legislature. He had been disturbed by the fact that students in the branch known as the University of Vermont had to pay \$625 per year in tuition, while students in the legislatively subsidized State Agricultural College paid only \$225. The five academic units of the combined entity (Arts and Sciences, Medicine, Agriculture, Education and Nursing, and Technology) were left just as they had been created under President Millis ten years earlier, so as to protect the endowments, particularly the Wilbur Fund.

By 1946, the faculty in mathematics consisted of professors Bullard and Fraleigh and assistant professors McClay, Millington, Nicholson, Witham, and Larrivee.⁸

there are no more Wilbur heirs claiming it. The enrollment limit of 1,000 amounted to a little less than one-third of one percent of the Vermont population of 353,000 in 1920. If that proportion had been maintained, the allowable enrollment at UVM would now be slightly less than 2,000. In fact, in-state enrollment alone at UVM is now about 4,000 and total enrollment is 13,000, which is more than 2% of the population of the state. The conditions of the Trust are complicated, however, and subject to varying interpretations, depending on how one defines the entity named as *The University of Vermont*. By excluding the professional and graduate schools, one might be able to argue that those conditions are being met. But it is also possible that the entire Trust has been legally amended so that these conditions no longer apply at all. Moreover, the reference in the trust to "native born Vermont students" appears to be of questionable legality. There are various ways of establishing one's eligibility for the Vermont-resident tuition rate at UVM, but one that always works is having graduated from a Vermont high school. The fact that a student may happen to have been born elsewhere is not an issue.

⁷Born in Mount Washington, MO on 3 June 1905, he received a Ph.D. at Cambridge in 1934. He served as UVM's sixteenth president from 1952 to 1958. He died in Livermore, CO on 29 November 1998.

⁸Jules Alphonse Larrivee was born in Fall River, MA on 5 August 1909. His father, a carpenter, had been brought there from Québec in 1883 at the age of 2. J. A. Larrivee received the S. B. degree at MIT in 1930, an M. A. at George Washington University in 1935, and a Ph. D. from the Catholic University of America in 1942. He is listed in the 1933 Washington, DC directory as an astronomer, but in the 1950 census, where his address is again Fall River, his occupation

5. The Kenney Award

It becomes increasingly difficult to trace the present whereabouts of UVM alumni in the twentieth century, partly because of their large numbers, and partly because the University has not published a general catalog of them since 1902. One who absolutely must be mentioned, however, is John Francis Kenney (21 January 1897–4 May 1985) of the class of 1920, who was a professor at Northwestern and the University of Wisconsin. He was a mathematical statistician who published many articles in this area and wrote a two-volume textbook, *The Mathematics of Statistics*, published by Van Nostrand, which went through three editions. After retiring from the University of Wisconsin, he came to Brandon to live. In 1967, he gave the University \$5,000 to establish an annual prize in memory of his parents for the best graduate work in mathematics.⁹ The Kenney prize has been awarded annually ever since.

is given as professor. In a 1990 telephone interview, Professor Fishback said that Larrivee left UVM in 1953 to look for work on the west coast, having attained the rank of associate professor at UVM. He is listed on the voting rolls in Los Angeles in 1960. He died in Benton, OR on 27 September 1974.

⁹The careless use of the word “mathematics” to stand for “mathematics and statistics” must now be guarded against, since the present title of the department contains both names. In the mid-1980s, one mathematician objected to awarding the Kenney prize to a statistician, citing the language of the bequest. At that time, it had been forgotten that Kenney was, in fact, a statistician!

CHAPTER 6

Into the Mainstream: 1955–1975

In the years after World War II, the University expanded rapidly and has continued to do so ever since. Because of the increase in the number of personnel and the proliferation of courses and programs, we are forced to make rather drastic selections in our discussion of this period. By no means all the people hired into the department will be discussed, only those who remained for some time.

1. Personnel

The first woman to teach mathematics at UVM arrived a few years after the war. She was Ruth Gertrude Simond, who was born on 7 March 1904. She received the B. A. and M. A. degrees from Boston University and the Ph. D. from the University of Michigan. She then taught at Hampton Institute (a historically black college in Hampton, VA), Berea College (Berea, KY), Heidelberg College (Tiffin, OH), and Morningside College (Sioux City, IA) and served as a cryptanalyst for the Navy during the war before coming to UVM as assistant professor of mathematics in 1948. She died on 15 September 1958, having apparently resigned her position because of ill health the previous June. She is buried in Franklin, NH.

In 1951, the University hired an assistant professor, William Thompson Fishback (born in Milwaukee, WI on 28 January 1922, received the Ph. D. at Harvard in 1952, died in Richmond, IN on 9 March 2014), and an associate professor, William Scribner Kimball (born in Plainfield, NJ on 26 August 1886, died in Burlington on 7 March 1963). I was able to contact Prof. Fishback through my colleague Prof. Dan Archdeacon, who had been his student at Earlham College in Richmond, IN. Prof. Fishback had moved there after leaving UVM. Although he was at UVM for only two years, he was able to provide me with a few details about other figures in the department.

Kimball was a Lieutenant Commander in the United States Navy who had published about two dozen papers on physical chemistry, mechanics, and calculus of variations from 1929 through 1947. He also wrote a textbook on the calculus of variations, published in Britain. Already near the then-mandatory retirement age of 65 when he arrived at UVM, he eloquently defended the rights of the older worker, insisting on his right to be considered for tenure just like anyone else. (This statement is based on correspondence found in Kimball's file in the UVM archives.) He retired from UVM in 1954.

The year 1954 saw the retirement of J. A. Bullard and H. G. Millington, along with Prof. Kimball. It was also the last year for Assistant Professor Larrivee. It was thus an opportune time for both expansion and renewal. From this point on, the number of personnel in the department increases rapidly, and, as noted above, we shall not be able to discuss any of them in any detail. We shall omit the instructors entirely, although we will devote some space to the lecturers.

The renewal of the faculty had begun with the hiring of Heath Kenyon Riggs¹ and Ivan Raymond Hershner, Jr.² in 1953. From this point on, mathematics courses became both more numerous and more sophisticated. The following year, Julius Solomon Dwork³ was hired as associate professor. In 1955, Harry Lighthall, Jr.⁴ was hired as an instructor, and in 1956, Joseph Anthony Izzo, Jr.⁵ was hired as an assistant professor.

In a telephone interview in 1990, Professor Hershner recalled that the major task facing the Department was to rebuild the curriculum. Prof. Riggs was particularly interested in expanding the algebra offerings. A course in groups, rings, and fields was taught for the first time in 1955. The following year, a senior problems course was added, along with courses in computers and numerical analysis. At that point, Prof. Hershner left to work at the Pentagon. His replacement as head of the Mathematics Department was N. James Schoonmaker.⁶ In 1959, Lighthall became assistant professor, and Donald Eugene Moser⁷ joined the Department as associate professor. When Professor Fraleigh retired in 1963, Erling William Chamberlain, a

¹Born 28 October 1918, he was a 1940 graduate of UVM. He spent two years as a research assistant in the Department of Mathematics, then served as Director of Admissions before departing for graduate study at the University of Chicago, where he received the Ph.D. in 1948. He retired from UVM in 1985 and died on 20 April 2011, in Richmond, VT, the town where he was born and lived his entire life.

²Born 24 August 1916 in Lincoln, NE, he received the Ph.D. at Harvard in 1947. He died on 31 January 2005 in Fairfax, VA. In a 1990 interview, Prof. Fishback, who also had a Ph.D. from Harvard (1952) told me that he left UVM because he had heard that Hershner was coming. Perhaps Hershner had a dubious reputation at Harvard. He went to work at the Pentagon when he left UVM and retired from military service in 1980 at the rank of Colonel, after which he taught at George Mason University until 1985. From speaking with him on the telephone in August of 1990, I had the impression of a very vigorous man; he was about to leave for a vacation in Moscow.

³Born 19 October 1916. His listing in the Graduate College catalog asserts that he received the Ph.D. at New York University, but calls to NYU made by the present author in preparing a memorial resolution after his death revealed that they have no record of this degree. His file at UVM indicates that he was hired with a recommendation from the outstanding mathematician Martin Davis (b. 1928), who had contributed to the solution of Hilbert's Tenth Problem (which asks whether an algorithm exists for determining whether a given polynomial equation in several variables with integer coefficients has integer solutions—the answer is, “No”) and was at the Institute for Advanced Study in Princeton at the time. While Prof. Dwork's knowledge of mathematics was impressive, he refused to do any research or serve on any committees at UVM and was never promoted to full professor. His most memorable academic contribution was writing discretized differential equations that could be solved by electronic computers for weather prediction. He retired in 1981 and died on 20 February 2002.

⁴Born 7 January 1924 in New York, he served in the armed forces during World War II and lost his left arm in that service. He went on leave from UVM to get a Ph.D. at Brown University in 1959. He was an enthusiastic champion of Affirmative Action and diversity at UVM. He achieved the rank of full professor, but died soon afterward, on 11 January 1975.

⁵Born on 7 February 1917 in New York, he received a Ph.D. from Columbia University. He served for one year as acting dean of the College of Engineering, Mathematics, and Business Administration. He retired in 1981, but continued to teach at UVM until his death on 3 March 1996.

⁶Norman James Schoonmaker was born on 24 December 1918 in Pennsylvania. He received the Ph.D. in 1954 from the University of Pittsburgh for a dissertation on summability methods. He died in Escondido, CA on 7 November 2008.

⁷Born 22 June 1925, like Prof. Schoonmaker, he received the Ph.D. from the University of Pittsburgh in 1956 for a dissertation on summability methods. (They had the same adviser.) He died on 10 November 2001.

1962 Ph. D. at Columbia, was hired as an assistant professor. He is the first mathematics professor hired at UVM who is still alive as of this writing (2018). The following year, Bruce Meserve,⁸ a specialist in mathematics education, was hired as full professor. Mathematics education thereby became an important component of the Department's mission and was greatly strengthened a decade after Prof. Meserve's retirement, during the 1990s, by several initiatives undertaken by the chair of the department, Kenneth Gross. Thus, UVM made extraordinary efforts to connect the University with elementary and secondary education in Vermont.

All of these professors had been educated at excellent graduate schools. They began the task of moving UVM into the mainstream of contemporary mathematics, a process that faltered during the 1970s, but resumed very strongly in the 1980s. They began this effort by increasing the number of professors. In the year 1966, seven new assistant professors were hired, among them David Luther Sylwester,⁹ who was a specialist in statistics. Over the next three years, four more professors were to be hired, three of whom remained at UVM for several decades. The first of these three was Robert K. Wright, a 1966 Ph. D. at Columbia University (hired in 1966), followed by Roger L. Cooke (the present author), a 1966 Ph. D. at Princeton (hired in 1968), and James A. Burgmeier, a 1969 Ph. D. at the University of New Mexico (hired in 1969). The fourth and last who will be mentioned here was Paul Brock (29 March 1923–2 February 1977, hired in 1970). Prof. Brock was intended to be the senior research leader in a proposed Ph. D. program, as will be discussed below.

When the University was reorganized in 1973, the faculty of the Department resisted a proposal that Mathematics be moved into the College of Arts and Sciences, preferring to remain part of the College of Technology, which was renamed the College of Engineering, Mathematics and Business Administration. Since various departments all over campus had found need of statistics and were hiring their own statisticians to teach this subject, a program in statistics was organized, to run in parallel with a program in computer science. In 1984, in an administrative reorganization of the College, computer science was merged with electrical engineering and statistics with mathematics, forming the Department of Electrical and Computer Engineering and the Department of Mathematics and Statistics.

1.1. Computing at UVM. The story of computing at UVM deserves more space and more prominent attention than it can get in the present narrative.

In brief, here is what happened: In 1955, IBM announced plans to build its 704 computer at MIT and share the time with other New England Colleges. One-third of the time was reserved for IBM, one-third for MIT, and the remaining third was apportioned among the other New England Colleges. Prof. Riggs spent some time in Cambridge learning about computing in general and the 704 in particular. This was in the days before FORTRAN, and programming had to be done in symbolic

⁸Born 2 February 1917, he received the Ph. D. at Duke University and was the author of many elementary textbooks on mathematics and the teaching of mathematics and also served as President of the National Council of Teachers of Mathematics. He retired from UVM in 1981 and died 14 November 2008.

⁹Born in Roseburg, OR on 17 March 1936, he obtained the Ph. D. at Stanford in 1966. He left UVM in 1984, dissatisfied that no Department of Statistics was to be created. He moved to the University of Tennessee in Knoxville, where there actually is a Department of Statistics. He died of Parkinson's Disease on 26 April 2013.

language, very close to machine language. Later, Prof. Dwork wrote a discretized version of the differential equations that describe the movement of weather patterns, and Prof. Riggs and the head of the Weather Service at Burlington took these programs to MIT to run, thus carrying out some of the first attempts at computerized weather forecasting.

In 1960, UVM's seventeenth president, John Theodore Fey,¹⁰ offered to buy an IBM 1620 for the University, provided he could be assured the faculty would use it. Prof. Riggs obtained statements from 35 faculty members asserting their intention to use the proposed machine, which was accordingly bought. Prof. Riggs then gave an Evening Division course in computing to a broad group of engineers, teachers, and government workers from all over Vermont and thereby launched Vermont into the computer era. From this beginning, the explosion of computer miniaturization, the availability of affordable individual computers, and the Internet, have combined to flood UVM with computers, just as in every other major educational institution and business in the world.

Prof. Riggs spent a leave of absence studying computational mathematics at the University of California at Berkeley in 1965–1966, afterwards creating a course in numerical analysis that was for a long time one of the core elements of the computational part of the curriculum. That curriculum expanded enormously during the early 1960s, with courses being added on group theory, Galois theory, probability, topology, differential geometry, number theory, foundations of geometry, computers, and numerical analysis.

2. Research. Graduate Degrees

Along with the modernization of the curriculum, UVM began to demand research as a duty of the faculty. This movement was slow to develop, since research had never been an important component of UVM's educational mission. The Graduate College at UVM was formed only in 1953. (It had previously been the Graduate Council.) At that time, only the Medical College offered a doctoral degree. When Prof. Hershner arrived in 1953, there was only one master's degree student in mathematics. When he left in 1956, there were several. UVM began adding Ph.D. programs in 1957 with biochemistry, and opened one new program each year through 1960. By the time the program in mathematics and statistics was opened in 1970, there were 13 others already in existence. The first Ph.D. at UVM was awarded in 1962, and the Graduate College began to publish its own catalog in 1964. Master's programs in mathematics continued to expand throughout the 1950s and 1960s, and planning was begun for a Ph.D. in applied mathematics and statistics, a program that ultimately failed.

Part of the reason for this failure of the first attempt at a Ph.D. program was naïveté on the part of both faculty and administrators. They had never had to administer such a program and did not understand what was involved in taking on Ph.D. students. I write this not to criticize them. After all, UVM's teaching mission was a very useful and respectable enterprise. But it was not a propitious time to begin such a program. Of the senior faculty members at the time, only Bruce

¹⁰Born in Hopewell, VA on 10 March 1917, he served as president of UVM from 1958 to 1964 and returned as a member of the Board of Trustees from 1982 to 1985. He died on 29 April 2015.

Meserve had more than one publication,¹¹ and his area was mathematics education, which was not intended to be part of the Ph. D. program. Schoonmaker and Moser had both published their doctoral dissertations, but had not gone beyond that. Riggs had published one paper, a one-page review of work in computing. Lighthall, Dwork, and Izzo had published nothing at all. The other faculty members, who eventually did publish in some volume, were at the time all untenured assistant professors. It would take more than one senior research leader to make such a program viable, and even that one leader was not present.

In 1969, the sought-after research leader was found in the person of Paul Brock. Prof. Brock received the Ph. D. from New York University in 1951. Most of his career was spent working in private industry in California, at Electro Data Corporation, the Hughes Aircraft Corporation, and General Electric. Nine of his publications are listed in *Mathematical Reviews*, and undoubtedly there were others, in outlets outside the scope of *Mathematical Reviews*. He appeared to be just the kind of sophisticated researcher who could head up a Ph. D. program in applied mathematics and numerical analysis. Unfortunately, he was not in good health and had lost much of the vigor he surely must have had when younger. Although he was extremely good at solving tricky mathematical problems, such as those on the Putnam Examination, he was no longer doing original research. Moreover, he had no experience of working inside a university administration, and was rather naive as to what is needed to procure grant support. For all these reasons, the Ph. D. program that was opened in 1970 was closed down around the time of his death in 1977. The six Ph. D. students produced during the few years it was open were all supervised by younger faculty members (Burgmeier, Cooke, Wright, and Chamberlain).

Despite all these considerations, research, which had not previously been an issue in tenure and promotion cases, was strongly weighted by Clinton Dana Cook,¹² the Vice-President for Academic Affairs (now called the Provost) during the 1960s. It has assumed increasing importance with every change of administration since. Much of the impetus to this post-war expansion was due to the exceptional prosperity of the country during the 1950s and 1960s. The launching of Sputnik in October of 1957 by the Soviet Union stimulated government support for education and scientific research, and many mathematicians benefited from the available largesse, including the present author, who attended graduate school on a generous National Science Foundation fellowship from 1963 to 1966. Seeing the readily available funds, administrators simply made the receiving of grants essentially the only criterion for getting tenure and promotion. A number of assistant professors fell afoul of this policy, which was all but openly proclaimed.¹³ It was hidden behind a

¹¹This statement is based on a search in *Mathematical Reviews*. Since not every mathematics journal was reviewed, it is possible that UVM faculty published more than appears here.

¹²Born in St. Johnsbury, VT on 20 February 1921, he received the Ph. D. in chemistry from New York University. He died of heart disease on 25 June 1969. The Cook Physical Sciences Building is named in his honor.

¹³When the present author interviewed for a position in 1968, Prof. Schoonmaker opened the conversation on the way from the airport to the hotel by asking about my experience in getting grants. When the position was offered, he stated that the teaching load would be "six hours, which is half time," and that I would be expected to apply for grant support for half of my salary. Not that the salary would not have been paid otherwise, but the point was that applying for (and, by implication, receiving) grants was a serious obligation on my part, a *sine qua non* in getting tenure.

requirement of “significant research,” but as Graduate College Dean Macmillan¹⁴ frankly said,¹⁵ the real test of significance was whether the research was funded or not. One professor, being told by the Dean of the College of Technology¹⁶ that he was being denied tenure because he had not done significant research, asked the dean to justify that claim and was told that “the procedures of the Dean’s Office are not available for your inspection.”

At first sight, this policy seems to make sense. After all, major universities are able to offer a much richer curriculum with the funds they generate from industrial and government grants, and in the early 1960s, the portion of UVM’s budget provided by federal grants expanded from 16% to 26%. Most of that increase was in the Medical College, however. In terms of grant-funding credibility, most departments at UVM were not on a level with the major universities, and mathematics certainly was not. The mathematics Ph.D. was not the money-maker that had probably been envisioned. The administrators involved did not sufficiently take account of the fact that the ability of a faculty member to obtain grants was very much dependent on the reputation of the university itself, and that, in this time before the information superhighway, professors at isolated universities like UVM were liable to find that their research had been anticipated elsewhere. In addition, the University did not quite live up to its obligation to provide “matching funds” for the research grants actually received. (The present author was supposed to have “released time” for research while on NSF grants from 1970 to 1974. But in 1973, faced with a need to cover the courses of Prof. Lighthall, who was ill, and unwilling to ask any of the non-publishing faculty to teach 12 hours, the chair increased the teaching load for the researcher in question from six hours to nine, that is, the same teaching load given to professors who were not expected to engage in research.)

For all these reasons, the program was formally closed in 1976, the last candidate in the pipeline receiving the degree in 1978. Over the six years that it was open, it produced six Ph.D.’s. (Prof. Burgmeier directed two of these, Prof. Cooke another two, and Profs. Wright and Chamberlain each directed one.) A carefully prepared plan for a renewed Ph.D. program was approved at all levels except the Board of Trustees in 1990, but President Davis (1990–1991), engaged in planning for fiscal austerity, refused to present it to the Board. The program was resurrected with great success two years later, but that portion of the story is reserved for discussion in our final chapter.

To end this chapter on a cheerier note, we remark that tuition at UVM in 1970 was \$750 per year for Vermont residents and \$2200 for non-residents. The Good Old Days! In 2017, tuition for a normal course load of 12 to 18 hours per semester was just under \$16,000 for Vermont residents and just over \$40,000 for non-residents, roughly 20 times the 1970 level.

¹⁴William Hooper Macmillan, born in Boston on 23 October 1923, received the Ph.D. in pharmacology from Yale. He died on 4 April 2004 in Burlington.

¹⁵And perhaps even believed. The deans of the College of Technology and the Graduate College were both very nice men, and both very naive. A graduate-school classmate of the present author, whom the mathematics department was hoping to recruit in 1972, was so disgusted after his interview with Dean Macmillan that he immediately ruled out any position at UVM.

¹⁶Warren Orvel Essler. He was born in Davenport, IA on 22 April 1924 and received the Ph.D. in engineering from the University of Iowa. He left UVM in 1972 and took up a position at Tennessee Technological University in Cookeville. He died in Sparta, TN on 23 June 2005.



Mansfield House, the former residence of UVM presidents, is across Colchester Avenue from the main office in Lord House. It provides very elegant offices to many members of the faculty.

CHAPTER 7

Statistics Comes to UVM

At first glance a statistics textbook appears to be filled with numbers and formulas, just like a mathematics textbook, and indeed statistics has a strong mathematical component. It is not, however, merely an area of mathematics. Its origins are independent of mathematics, although of course numbers are involved. As the name itself implies, it comes from the information collected by governments (states) to be used in regulating their economies and social structure. Its basic problem is to find ways of making plausible inferences from large data sets. The part of mathematics that grew alongside it is probability theory, which in turn arose in the sixteenth and seventeenth centuries in connection with the analysis of games of chance. Faced with a large data set, one can imagine selecting one piece of data and asking how likely it is to have various properties. Statistical methods of testing and revising hypotheses have made the subject an indispensable tool for economists, scientists, and engineers.

The first major works applying statistics to the real world were published in the early eighteenth century. In 1710, Queen Anne's physician John Arbuthnott (1667–1735) published a note in the *Transactions of the Royal Society*, pointing out what appeared to him to be an anomalous fact: Baptismal records for each of the 82 years between 1629 and 1710 revealed that more boys than girls were baptized in every single one of the years. This peculiar fact, he thought, required an explanation. About the same time (1705), Jacob Bernoulli (mentioned above) published the first work on this subject, the *Ars conjectandi* (Art of Prediction), which was published in 1713, after his death. He intended it to “apply to society, morals, and economics.”

The subject of statistics was neglected by most mathematicians for a long time, even though economists and engineers needed it. Courses in statistics at UVM were for many decades taught in other departments, such as economics and the Medical College. It was not until 1945 that the Department of Mathematics first offered a course in statistics. Before that, in 1942, the Department of Home Economics in the College of Agriculture had appointed an Assistant in Statistics, Margaret Mary Eliza Openshaw.¹ Thus, the mathematics department got into the business of teaching statistics rather late, the first course in mathematical statistics appearing in the catalog of 1945–1946. Courses in statistics continued to sprout all over campus, in dental hygiene, nursing, psychology, economics, agronomy, engineering,

¹Born in Newport, RI on 4 December 1911 and graduated from the University of Rhode Island in 1933, having been captain of the basketball team and manager of the hockey team there. Except for a hiatus from 1943 to 1945, she served as Assistant in Statistics from 1942 to 1947, then left to pursue other employment opportunities around Burlington. Eventually, she became a vice-president at the Howard Bank, the position from which she retired. She died in Burlington on 22 February 1992.

and many other places. The word *statistics* appears about a dozen times in catalogs from 1945, but about four dozen times in catalogs from the 1960s and over 100 times in catalogs from the 1980s.

Eventually, a core of statisticians was assembled into a program in statistics, which was announced in the catalog of 1973–1974, when the university underwent a major reorganization.

The statistics program was in the newly-formed College of Engineering, Mathematics, and Business Administration. (Business Administration was moved from the College of Arts and Sciences. In 1981, it became a school.) Chemistry and Physics were moved from the now-defunct College of Technology into Arts and Sciences, but strong preferences expressed by the mathematics faculty kept the department under the same roof with the engineers. Eventually, the statistics program was merged with mathematics, forming the Department of Mathematics and Statistics that now exists.

A similar program in computer science was also announced in the 1973–1974 catalog. Like statistics, computer science has a strong mathematical component, but is not mathematics. The computer science program was finally merged with electrical engineering, to form the Department of Electrical and Computer Engineering. For some time afterwards, the catalog did not actually specify academic departments, but only indicated that B.S degrees were available in mathematics, statistics, and computer science. The first two of these degrees were labeled B.S. in Mathematics, the third B.S. in Computer Science.

In the present-day College, called the College of Engineering and Mathematical Sciences, there are now two departments called the Department of Computer Science and the Department of Electrical and Biomedical Engineering.

CHAPTER 8

UVM in the Worldwide Community: 1975–2000

In his magisterial 1893–1895 lectures on Russian history from the earliest time down to his own day, the historian Vladimir Osipovich Klyuchevskii (16/28 January 1841–13/26 May 1911) broke the history of his country into periods, the fourth of which he dated from 1613, which was the beginning of the Romanov Dynasty, to 1856, the year Aleksandr II came to the throne after the Crimean War. In that connection, he wrote the following:

I repeat that this is not merely one period of our history. It is our entire recent history. . . In studying the phenomena of this time, one gets the feeling that, the farther one goes, the deeper one gets into autobiography, that one is passing to the study of his own self, his own spiritual content, to the extent that it is connected to the past of our country. And all this concentrates one's attention and guards one's thoughts from distraction.

Those words come to mind as I approach this final chapter in the story. My own career extends over this entire span of time, so that I find it easy to assimilate the facts but at the same time difficult to be sure I am evaluating them objectively. As I retired in 2003, I shall make no attempt to describe what has transpired after that date, and I shall increasingly neglect detail as that date is approached. Still, certain trends seem obvious to me. The Department of Mathematics and Statistics matured through many difficulties during the 1980s and emerged stronger and confident of its position as a respectable center of teaching and research excellence on the national and international scale. I shall break this story into two pieces to illustrate how both teaching and research were shaped into thriving enterprises in the last two decades of the twentieth century.

1. Reorganization: Lecturers

With the Ph.D. program shut down, the Department needed to decide on the best use of the faculty hired to staff the program. The entry into the world of publication and grantswinging was a trap door, and there was not any graceful way to exit, even if there had been a desire to do so. (There was no such desire.) It was necessary to move forward, even if research professors had to be paid out of tuition-generated funds. How were the students who paid the tuition to be adequately taught by faculty with two-course teaching loads? The answer was found by an ingenious adaptation. Until 1972, the probationary period for faculty was four years. Those at professorial rank were either given tenure (and sometimes promoted) after that much time, or they were terminated. For those at the rank of instructor, who did the heaviest teaching, only the second option was available. Many talented teachers were lost to the University through this policy. The way

to solve both problems was found in the creation of the rank of lecturer, carefully defined in the handbook as a non-tenured position whose duties involved only teaching, but did not have any term limits. Among the people hired as instructors in the 1973–1974 academic year were Larry Kost (9 January 1943–26 December 2015) and David Morency (11 September 1938–27 June 2015). In the 1974–1975 year, they were joined by John Lawlor. Holly Puterbaugh, who had been in the department for several years at that time, was made a lecturer in 1976. In the following year, Lawlor, Kost, and Morency were moved into the position of lecturer, and a former instructor, Jan Johansson also assumed that position.

These five lecturers were the teaching backbone of the mathematics side of the department for the next 30 years and more. Despite the wording in the handbook, they did an immense variety of work that was not direct instruction, serving on committees, organizing the high school mathematics competition, participating in seminars, and engaging in many other activities essential to the smooth functioning of the department. They were later joined by a number of other lecturers, of whom we mention Karin Larson, who served from 1980 to 1997, Joanne Chandler Brown (9 February 1939–14 November 1998), who served from 1983 to 1997, and four others who are still serving as of 2018: Karla Karstens, Helen Read, Tony Julianelle, and Joan Rosebush. Statistician John Aleong, who had obtained the Ph.D. at Iowa State University in 1975, was also appointed as a lecturer in 1976, but soon became a research professor, and in 1996 a professor of statistics. Other lecturers have been added in the 21st century, but these fall outside the scope of the present essay.

In statistics also, a large number of lecturers were hired, among whom were Brian MacPherson (1980, retired 2009), Elizabeth Low (1985, retired 2004, originally appointed in School of Business Administration in 1982), and Sheila O’Leary Weaver (1985).

2. Reorganization: Research Groups, 1975–1988

Meanwhile, to keep researchers active, it was realized that a critical mass of at least two or three professors would be needed in whatever areas were chosen as specializations. As a general disclaimer, we state at the outset that the following description of the researchers in these areas is incomplete, mostly because this essay is confined to the twentieth century. All of the research areas below have added talented people since the twenty-first century began. (And, it is now more than one-sixth gone! It is well that none of these research areas has chosen to rest on its reputation.)

In statistics, which had close connections with many other units in the University, especially the Medical College, a number of new people were hired during the period in question. The first of these, hired in 1973, was Takamaru Ashikaga, a 1973 Ph.D. at UCLA. He was followed in 1975 by Larry Haugh, a 1972 Ph.D. at the University of Wisconsin, and then in 1976 by John Aleong, mentioned above, in 1983 by Ruth Mickey, a 1984 Ph.D. at UCLA, and Mun Son, also a 1984 Ph.D., at Oklahoma State University. Thus a substantial staff of statisticians was assembled for both teaching and research.

As for the mathematicians, in the mid-1960s, Professors Chamberlain and Wright, both graduates of Columbia, collaborated in work on the asymptotic theory of differential equations. The two hires from the late 1960s, Cooke and Burgmeier

specialized in areas that had a common point of contact in what is called functional analysis, so that collaborative research would have been possible. In the end, however, Burgmeier's interests turned to computational and numerical methods, and Wright joined him in that area. Chamberlain also turned toward numerical methods, supervising a Ph. D. dissertation in this area in the mid-1970s. The areas that eventually defined the department's research interest turned out to be algebra/number theory, combinatorics, analysis, and numerical analysis. To form these groups, a sizeable contingent of young faculty was assembled during the early 1980s.

In combinatorics, Jeffrey Dinitz was hired, fresh from his Ph. D. at Ohio State University, in 1980. In 1982, he was joined by his classmate Dan Steven Archdeacon (11 May 1954–16 February 2015), also a 1980 Ph. D. These two brought in many visiting professors, conducted a lively seminar every semester, and published an impressive number of papers.

Algebra/number theory was built up beginning in 1981 with the hiring of Richard Foote, a 1976 Ph. D. at Cambridge (UK) University. In 1984, he was joined by David Dummit, who had received the Ph. D. at Princeton in 1980. This group was filled out in 1986 by the addition of Jonathan Sands, a 1982 Ph. D. at the University of California at San Diego. The group was expanded enormously by outreach to nearby Middlebury College, St. Michael's College, and McGill University in Montréal, forming a group known as the Vermont–Québec Number Theory Seminar, which issued its own proceedings in the form of a periodic journal.

In 1986, analysis, the area in which Cooke had been the sole researcher, acquired James Michael Wilson, who had received the Ph. D. at UCLA in 1981. These two conducted several seminars in orthogonal series expansions during the 1990s and supervised the doctoral dissertations of two students, both of whom graduated in 1999.

Numerical methods, as already remarked, were the province of Professors Burgmeier and Wright and various of their associates. In addition, Prof. Burgmeier specializes in mathematical software and had a long collaboration with lecturer Larry Kost in this area. While these four groups had active research programs, conducted regular seminars, and published papers that attracted notice from a wide audience, the absence of a Ph. D. program would have limited what they could achieve in terms of recognition in the academic world. These researchers were all rather young, most of them in their 30's and only two or three in their 40's. Especially after the death of Prof. Brock, there was no experienced "elder statesman" to organize a coherent research program that would involve the whole department. A search was therefore begun for such a person, and we now turn the page to explore the final episode of this history.

3. The Ph. D. Program: the Rocky Road to Renewal

Professor Schoonmaker announced his retirement from the position of department chair in 1977 and was succeeded by Prof. Moser. While the latter was a superb administrator, he was not well-versed in research, as he himself realized. A search for a senior research leader to chair the department was begun in 1983, and appeared to have turned up a suitable person, namely James C. Becker, a topologist with a Ph. D. from the University of Michigan, currently teaching at Purdue University. He was offered the position and accepted, subject to the condition that he would postpone his arrival for a year due to family commitments in West Lafayette.

The University found this arrangement acceptable, Professor Moser went on leave for the academic year 1984–1985, and the present author was named acting chair for that year.

Candor compels me to admit that I have no administrative skills whatever. I can carry out assignments with great zeal, but I have no ability to make a cogent argument for a policy, and I loathe having to refuse requests. Worst of all, I am hopeless when it comes to resolving interpersonal conflicts between two other parties. The result was that, by the time Professor Becker arrived to take up his position in the fall of 1985, morale in the department was low.¹ Nevertheless, everyone was hopeful that a new day had arrived along with Prof. Becker. That hope was dashed very quickly. Having dipped his toe into the waters at UVM, Professor Becker decided he did not wish to take the plunge. After only one semester in place, he submitted his resignation, effective as of May 1986. The department was once again without a leader.

Fortunately, Professor Moser was willing to return and set matters on an even keel once again, serving as chair through 1988. The search for a research leader resumed and this time was crowned with stunning success. The University was able to hire Kenneth I. Gross, a 1966 Ph.D. from Washington University in St. Louis, who had taught at the University of North Carolina, served as chair of the department at the University of Wyoming, and had travelled to many countries to collaborate with others. He was working at the National Science Foundation at the time. He had the experience, the contacts, the creative ideas, and the interpersonal skills to forge a superb Department of Mathematics and Statistics when he assumed the role of chair in January 1989.



Recent chairs of the Department. Jeff Dinitz (1999–2004), James Burgmeier (2004–2014), John Lawlor (Spring 2008), Kenneth Gross (1988–1992), Roger Cooke (1984–1985).

Professor Gross took several immediate and dramatic steps toward resurrecting the Ph.D. program. First, he hired another senior research leader, William D.

¹Lest you think me capable of learning from experience, I will say that I was once again drawn into administration in the years 1994–1998, and the effect on department morale was no better than it had been a decade earlier. My excuse, such as it is, is that my daughter was a student at Bryn Mawr during those years, and I needed the extra pay.

Lakin, a 1968 Ph.D. at the University of Chicago, to assist him in building a research group in applied mathematics. A group of excellent applied mathematicians, both junior and senior faculty, was assembled. The task was facilitated by giving joint appointments to four of the engineering faculty: George Pinder, a 1968 Ph.D. from the University of Illinois, dean of the college, and formerly chair of civil engineering at Princeton University; electrical engineer Kenneth Golden, who earned the Ph.D. at the University of Paris in 1964; electrical engineer Kurt Oughstun, a 1978 Ph.D. from the University of Rochester; and computer scientist Robert Snapp, whose 1987 Ph.D. is from the University of Texas. All that took place in 1990. Promising young people were then hired, beginning in 1992 with Jun Yu, a 1988 Ph.D. from the University of Washington; in 1994, Jianke Yang, who received the Ph.D. at MIT in that year; and finally, in 1995, Daniel Bentil, a 1990 Ph.D. from Oxford (UK) University.

In 1993, the statisticians added one more young person, namely Jeff Buzas, a 1993 Ph.D. at North Carolina State University and the present chair of the Department of Mathematics and Statistics.

As already stated, in 1990, President Davis had refused to submit the proposal for a renewed Ph.D. to the board of Trustees. But the department persisted, and the program was approved by the Board of Trustees in 1992. It has been flourishing ever since and has produced, as of 2018, 20 Ph.D.'s, starting in 1997.

An indication of the new, livelier intellectual atmosphere was provided in 1990, when the combinatorics and algebra/number theory research groups collaborated to organize an international conference on coding theory and combinatorial design to take place 13–18 September. This conference was proposed and organized with superhuman energy by Professors Dinitz and Foote, and had been planned to celebrate the 80th birthday of Professor Marshall Hall on 17 September. Unfortunately, Prof. Hall died on 4 July that year, and the conference was consequently dedicated to his memory.



Participants in the 1990 Marshall Hall Conference, photographed in front of the Waterman Building.

Not satisfied merely to add applied mathematics to the department's areas of specialization, Prof. Gross also took an interest in mathematics education at the kindergarten-to-high-school level. He developed contacts with the Vermont Department of Education and founded the Vermont State Mathematics Coalition in 1989, the Vermont High School Summer Mathematics Institute in 1993, and the Vermont Mathematics Initiative in 1999. He procured funding for all these programs from the National Science Foundation, the US Department of Education, and the Vermont Department of Education. Thus, mathematics education became a

strong sixth area of concentration for the Department. In fact, at least ten members of the current department list mathematics or statistics or computer education as areas of expertise.

Prof. Gross had named Prof. Dinitz associate chair in 1992, and the following year, he relinquished the chair of the department, being replaced by Prof. Lakin, who (as related above) took on the present author as associate chair. In 1999, Prof. Lakin relinquished the chair to Prof. Dinitz, who took Prof. Burgmeier² as associate chair.

4. The Year 2000 and Beyond

The large footprint that the Department of Mathematics and Statistics has in the University and in Vermont is well described in a snapshot of the mathematics portion of the department written in 2000 by then-chair Dinitz. This portion of the faculty consisted of twelve full professors, two associate professors, one assistant professor, five senior lecturers, five additional full-time lecturers, four part-time lecturers, and three graduate teaching fellows. Collectively, they taught 4668 students, a total of 14,608 credit hours. Unlike the majority of mathematics and statistics departments, the UVM department does not use the large lecture/recitation section method. All courses are taught as independent sections, and even in the very crowded calculus sequence, section sizes are normally held down to 35 students each. The seriousness of the approach to teaching is reflected in the fact that two members of the department up to that time had won the George V. Kidder Outstanding Faculty award (one more has won since 2000), and five others had won the Kroepsch–Maurice award for outstanding teaching. Although service courses are a large portion of the teaching mission, with a variety of courses being offered to meet the various needs of students in Engineering, Physical Sciences, and Social Sciences and Humanities, the Department nevertheless offers majors leading to the Bachelor of Science degree in the College of Engineering and Mathematical Sciences (21 majors in the year 2000) and the Bachelor of Arts in the College of Arts and Sciences (24 majors in the year 2000). In addition, it offers three master's degrees (Master of Science, Master of Science in Teaching, Master of Arts in Teaching) and the Ph. D. The impact of these programs in Vermont is considerable. Norwich University, for example, has two UVM Ph. D's on its staff, as well as several faculty members with master's degrees from UVM.

As for research, the quality of the Department's faculty is shown by the fact that a professor with an appointment in the Department of Mathematics and Statistics was named one of the three University Scholars every year from 1994 to 2000.

In service to the State of Vermont and the nation as a whole, the Department provides a number of programs, several of which were mentioned above as creations of Prof. Gross. In addition, the Department conducts the annual High School Mathematics Contest every year during Mathematics Awareness Month (March) and gives a luncheon and awards ceremony with a mathematics lecture to the winners. Faculty members also give frequent lectures at other institutions in the state. On the national level, the Department participates in the NASA Space Grant,

²Prof. Burgmeier became chair of the department in 2004, when Prof. Dinitz resigned the position, and continued through 2014, with John Lawlor serving as interim chair during Prof. Burgmeier's leave of absence in the spring semester of 2008.

which was administered by Prof. Lakin until his retirement. On the university level, mathematics faculty served on 40 committees in 2000–2001.

It is now, I hope, clear that the Department of Mathematics and Statistics has a large, talented, and hard-working faculty, who would under any circumstances have produced outstanding work. In that sense, one cannot name any one person or factor that has led to this rapid development. Still, it must be said that Prof. Gross was at least the catalyst, if not the main ingredient in the progress the Department has made over the past generation. He worked tirelessly to give the department a higher profile, constantly nominating faculty members for academic honors (and incidentally, winning a number of prestigious awards himself). All this took a terrible toll on his health, yet he continued to cope for nearly three decades before retiring in 2016. His death on 10 September 2017 was widely mourned, and he will always be remembered as an outstanding teacher and scholar and a kind and generous human being.

While Prof. Gross's contributions were enormous—I think greater than those of any other mathematician in UVM's history—he would be the first to minimize their effect and give the credit to the talented and energetic researchers and teachers who have made the Department of Mathematics and Statistics into the shining jewel in the crown of UVM that it now is. After all, he would say truly, they all contributed creative ideas and worked efficiently to implement those ideas. And on that note of optimism, our narrative comes to an end.



Faculty of the Department of Mathematics and Statistics, April 1994, in front of the Lord House. Standing in front, left to right: J. Michael Wilson, William Lakin, John Lawlor, Jeffrey Dinitz, Jozef Siran, Jan Johansson, Erling Chamberlain, Dan Zwick, John Aleong, Takamaru Ashikaga, Mun Son. First step, left to right: David Morency, Holly Puterbaugh. Second step, left to right: Janet Ferguson, Helen Read, David Dummit. Third step, left to right: Joseph Izzo, James Burgmeier, Dan Archdeacon. Fourth step: Larry Haugh. Standing on porch, left to right: Larry Kost, Mary Betty Burnard, Robert Wright, Joanne Brown, Jun Yu, Karin Larson, Richard Foote, Roger Cooke, Peter Rodney, Jonathan Sands.

UVM Mathematics and Statistics Faculty, 1800–2000

In the two charts that follow, the solid line indicates the period of full-time service. The dashed lines indicate the portion of the person's life before and/or after service at UVM. If there is no dashed line, the person was still alive as of March 2018.

The first chart below gives the time of service for faculty hired before 1970 whose service ended before the year 2000. It should be possible, for example, by holding a straight edge at right angles to the text, passing through the heading corresponding to a given year, to determine who was in the department that year.

The second chart shows the time of service for faculty who were either hired after 1970 or continued beyond the year 2000 or both. This chart is far from complete. It omits about a dozen faculty members who were in the department for a period of one to several years between 1970 and 2000, and it omits all the faculty hired after the year 2000. The latter now constitute about half of the present faculty. I regret the incompleteness and I hope no one feels slighted by being omitted; but, since I have not been present in the department since 2003 and am a *classical* analyst, I thought this story should be told by a more *modern* annalist.

	1800	1850	1900	1950	2000
James Dean				
Ebenezer Burgess			
Gamaliel Olds				
George Huntington			
George Benedict			
Farrand Benedict			
McKendree Petty			
Archibald Daniels			
Fred Corse			
Allison Slocum			
Warren Bullard			
Arthur Butterfield			
George Brett			
Evan Thomas		
Elijah Swift			
James Donahue			
Fred Householder			
Howard Millington			
George Nicholson			
Douglas McClay			
Horace Giddings			
Percy Fraleigh			
James Bullard			
Myron Witham			
Jules Larrivee			
William Fishback			
Ruth Simond			
William Kimball			
Ivan Hershner			
Heath Riggs			
Julius Dwork			
Harry Lighthall			
Joseph Izzo			
James Schoonmaker			
Donald Moser			
Bruce Meserve			
Erling Chamberlain				
David Sylwester				
Paul Brock				

	1900	1950	2000	2050
Robert Wright			_____	_____
Roger Cooke			_____	_____
James Burgmeier			_____	_____
Larry Kost		-----	_____	_____
David Morency		-----	_____	_____
John Lawlor			_____	_____
Holly Puterbaugh			_____	_____
Takamaru Ashikaga			_____	_____
Larry Haugh			_____	_____
Ruth Mickey			_____	_____
Mun Son			_____	_____
Jeffrey Dinitz			_____	_____
Dan Archdeacon		-----	_____	_____
Richard Foote			_____	_____
David Dummit			_____	_____
Jonathan Sands			_____	_____
J. Michael Wilson			_____	_____
Jun Yu			_____	_____
Jianke Yang			_____	_____
Daniel Bentil			_____	_____
William Lakin			_____	_____
George Pinder			_____	_____
Kurt Oughstun			_____	_____
Kenneth Golden			_____	_____
Kenneth Gross		-----	_____	_____
Jeff Buzas			_____	_____
John Aleong			_____	_____
Brian MacPherson			_____	_____
Sheila Weaver			_____	_____
Elizabeth Low			_____	_____
Karla Karstens			_____	_____
Helen Read			_____	_____
Joan Rosebush			_____	_____
Tony Julianelle			_____	_____
Jan Johansson			_____	_____
Karin Larson			_____	_____
Joanne Brown		-----	_____	_____

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