DEPARTMENT OF MATHEMATICS, UNIVERSITY OF VERMONT

Mathematics at UVM

The First Two Centuries

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This document sketches the people and activities that have characterized the Department of Mathematics (now the Department of Mathematics and Statistics) at the University of Vermont.

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By Roger Cooke

Introduction. In 1990, as the bicentennial of the founding of UVM approached, 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 following pages are the result of that proposal. Being a history of mathematics, this history appropriately has the form 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.

Sources. The following material was gleaned from a wide variety of sources. The most important source of documentary material was of course the University Archives. I am particularly indebted to David Blow, the University Archivist, 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 several retired colleagues (all unfortunately now deceased) for their personal reminiscences: Heath Riggs, Ivan Hershner, N. James Schoonmaker, Joseph Izzo, and most especially George Nicholson,[i] whose mathematical career spanned more than one-third of the history of mathematics at UVM.

Overview of the Subject. For the general history of UVM there are various secondary sources, for example, that of Lindsay (1954). For that reason the general history of UVM will be touched on only where it is necessary to the narrative, and no attempt will be made to render judgment on the many issues that arise. Also, before concentrating on the details of our own mathematical development, it may be well to expend a few words on the perspective within which this mathematics is to be judged. We might consider UVM in the context of its educational mission in Vermont and Northern New England, or as an example of an American University, or in the context of world mathematics. Each of these perspectives provides a special kind of insight into the mathematical activity at UVM.

Taking the local point of view, one is pleasantly surprised to find some rather well-educated mathematicians at UVM, even in the early nineteenth century, teaching mathematics in some depth to ordinary citizens aspiring to careers as lawyers, physicians, clergy, or farmers. As we shall see, some of these mathematicians even conducted a modest level of independent research. The national perspective reminds us that, although UVM is the twentieth oldest university in America, there was already in existence at the time of its founding in 1791 a sizable number of New England institutions. Indeed, these institutions provided the early UVM faculty. Harvard, which was founded before Newton was born, had already celebrated its sesquicentennial before UVM was conceived. The national point of view also brings an awareness of the expansion and democratization of education after the Civil War and suggests an investigation into the extent to which UVM shared in this phenomenon. Finally, 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, Gőttingen, Berlin, and London, universities such as Christiania (Oslo) in Norway (founded 1807) 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, who died in 1829 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, people of the stature of Sylow, Lie, and Bjerknes. Kazan, at its formation, already had the young Lobachevsky as an upper-level student. These mathematicians were geniuses, of course, but had they been in Vermont it is unlikely that any European now alive would have heard of them. All the Norwegians mentioned above traveled to the major centers of mathematical activity. The University of Kazan imported such teachers as Bartels (Gauss' teacher) to inspire Lobachevsky 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. No students from Vermont studied at the feet of the great German and French masters until late in the nineteenth century, and during the period of this narrative no mathematicians from Europe came to UVM to share their knowledge. Nevertheless, although the very latest mathematical research has never formed a substantial part of the curriculum at UVM, from the beginning a high standard of competence was expected of both students and faculty.

§1. The Early Years, 1801–1825

The Curriculum. The University of Vermont was chartered in 1791 by act of the State Legislature and given the right to collect rent from a large amount of very profitable land in Vermont. Perhaps because of the intellectual isolation of Burlington itself, no real 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. Thus spurred into action, Daniel Clarke Sanders, the first president of the University, 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. The minutes of the Board of Trustees' meeting of January 13, 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." Because of the year of tutoring, Sanders ruled that these students were ready to receive their degrees in 1804. Although no record of the earliest instruction has come down to the present, Lindsay (1954, 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 Evangelists in Greek.[ii] 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. Still, mathematics was not neglected. In fact, one may well ask who today has an intimate knowledge of all these particular mathematics courses, some of which have passed out of the standard curriculum or been absorbed into more comprehensive courses:

> *Second year.* 1st. Vulgar Arithmetick[iii]... 2d... Logarithms and Algebra... 3d... Geometry and Euclid's *Elements*. Plane Trigonometry. Mensuration of superfices 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...

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.[iv] Lindsay (1954, 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 a very important function in the mundane affairs of commerce, specifically in navigation: it can be used to determine terrestrial longitude. Latitude is easy to determine. 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 last statement is a slight oversimplification, of course, 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 number of revolutions a Foucault pendulum precesses in one sidereal day, and the direction of precession will distinguish northern latitude from southern.

Longitude, on the other hand, is more difficult to calculate. Any two points at the same latitude will observe the same elevation for each fixed star and planet. The problem, assuming you know that the origin of the longitude coordinate is Greenwich, 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 standard time and Greenwich mean time represents a difference of 15º 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 know longitude by comparing local (sun) 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 phases. 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 any 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 the 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 eclipses is not visible simultaneously at widely separated places). The use of eclipses in calculating longitude was known from very early times. A lunar eclipse on September 20, 330 B. C. E. was observed at both Arbela (47º E, in the territory of modern Iraq) and Carthage (10ºE, on the northern coast of Africa), and these observations were used by Ptolemy to calculate the difference in longitude between the two places (Neugebauer 1975, p. 668). The accurate mapping of the world was still a matter of pressing practical importance in the early nineteenth century, and 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, to be sure, not the latest in research mathematics. The calculus, already 150 years old, was not part of the curriculum, to say nothing of the researches in mathematical physics due to Euler, Laplace, Lagrange, and others. On the other hand, Laplace and Lagrange were still alive at this time; it is not surprising that their work had not reached Vermont. At least Laplace's *Mécanique céleste* had reached Boston and inspired a translation by Nathaniel Bowditch that far excelled the original in clarity of expression.

Instruction and Equipment. Teaching was by lecture and demonstrations given by the faculty, since there was very little opportunity for hands-on laboratory work by the students. What we now call laboratory equipment used for instruction was known in those days as "philosophical apparatus," and described by ex-President John Wheeler in an address at UVM's semicentennial celebration in 1852:

> 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, [Wheeler says in a footnote that the latter were Dr. John Pomeroy, David Russel Esq., and Col. W. C. Harrington—RLC] 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. (Wheeler, 1854, p. 2)

Lindsay (1954, p. 106) mentions a catalog from the Rev. Dr. Prince 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. Unfortunately it is not known which of these were purchased. Lindsay reports that only one of these objects remained in the early 1950's, a compound magnet encased in brass.

There does not seem to be any record of textbooks, if any, used for the instruction at this period. Certainly 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 (Erastus) Darwin's *Zoonomia*, Priestley's *Corruption*, Priestley's *On Air* (5 volumes), and Paine's *Geography*.

Personnel. 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 of mathematics and natural philosophy at UVM. Dean became a scholar of some note, and his biography appears in Appleton's *Cyclopedia of American Biography*. According to information contained in the University archives in a folder bearing his name, he was born at Windsor, Vermont on November 26, 1776 and received the A. B. degree from Dartmouth in 1800 and the A. M. degree, also from Dartmouth, in 1806. He left UVM in 1814, 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 forego 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 March 24, 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...

He went to Dartmouth as tutor, but because of the legal dispute that tore Dartmouth apart at this time (in which he backed the losing side) he came back to UVM as a professor from 1822 until 1824. He was President pro tempore of the University briefly in 1824, just before leaving to take up a position at Union College. From Union College he received an honorary Doctor of Divinity degree in 1847. He died in January 1849 and is buried in Elmwood Cemetery in Burlington.

No portraits of James Dean exist, but his physical appearance and character, as they appeared to President Wheeler, were described in considerable detail in President Wheeler's semicentennial address:

> 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. (Wheeler, 1854, p. 24)

In other words, Dean was rather a dabbler, one who preferred breadth to depth. These are precisely the qualities needed in an institution devoted more to teaching than to research, even though Wheeler's tone suggests that he thought otherwise. One suspects that Wheeler felt some antipathy toward Dean.

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 September 17, 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. 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 solar time is ahead of or behind clock time at any given moment.)

The most important of the four articles, however, 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 to 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.[v]

Besides the papers just discussed, Dean also published an observation of several meteors in *Silliman's Journal*[vi] 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, just four years before his death. His analysis is really 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 University of Vermont. Among the papers in his file in the University archives is a letter of November 27, 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.

UVM's first professor of mathematics was therefore, at least by American standards of the times, intellectually respectable. The remaining question is, how much of his knowledge did he impart to his students? There is some evidence that he was an interesting and inspiring lecturer. When he became professor in 1809, he delivered an inaugural speech (actually on April 24, 1810), in the manner of the German *Antrittsrede* entitled "An Oration on Curiosity." In my view, this 19-page summary history of natural philosophy is exceedingly inaccurate, even for its own time, and contains no memorable thoughts or sentences. It was, however, printed and published by the Samuel Mills Press in Burlington in May 1810 *at the request of the students*![vii] His most enduring contribution to American civilization, however, has been immortalized as "Dean's Method" of apportioning the House of Representatives. Those familiar with the paradoxes that can result from any system of proportional representation will appreciate the difficulty of framing general principles of representation that will be fair under all circumstances. The most notorious such paradox is the so-called Alabama paradox, which arose after the 1880 census. It was discovered that if the total number of representatives in Washington was increased, Alabama would actually be entitled to fewer representatives than it would get if the number was left unchanged. Dean's Method is explained in detail in the book *Fair Representation* by M. L. Balinski and Y. Peyton Young (Yale University Press, 1982).

As mentioned above, James Dean left UVM when the University closed down in 1814 and did not return until 1821. His place as professor of mathematics during this time was taken by the Rev. Ebenezer Burgess (1815–1817) and the Rev. Gamaliel Smith Olds (1819–1821). Neither of these men was particularly a mathematician or scientist. The *Historical Catalogue of Brown University*, published in 1914, lists Burgess as a tutor in the period 1811–1813. Born in Wareham, Massachusetts on April 1, 1790, he was Preceptor at the University Grammar School in Providence 1809–1811. He graduated from Andover Theological Seminary in 1815 and received a D. D. from Middlebury College in 1835. After leaving UVM he was an agent of the American Colonization Society for Africa in 1817–18. In 1821 he was ordained a Congregationalist minister and was pastor of the First Church of Dedham, Massachusetts for fifty years, from 1820 until his death in 1870.

Somewhat less is known about G. S. Olds (1777–1848). He wrote a pamphlet now in the Wilbur Collection of UVM 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, Massachusetts, 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 assented orally. Olds was to be paid while preparing himself by listening to Benjamin Silliman's course of lectures in New Haven, Connecticut. When he wrote requesting his salary, however, the President 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. 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.

At the time of James Dean's return to the University we find the first University Catalog, for the year 1822, 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 and five in the Medical School. Prof. Dean's companion in the Classical College was Lucas Hubbell, A. M., Professor of the Learned Languages. These two, and perhaps the President (Rev. Daniel Haskel) taught all 40 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 mathematical portion of the curriculum was based entirely on a famous series of textbooks by the British mathematician Charles Hutton (1737–1823), 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 (1988) 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 (1775–1843), an Irish immigrant 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 will be discussed in the next section. Although a thorough discussion of the contents of Hutton's textbooks would require far more time and space than the current project allows, certain points are of sufficient interest to be mentioned. Hutton's arithmetic goes far beyond mere computation and considers 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 (without its use in calculus and differential equations) really has no application to ordinary human life. 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 , and so on increasing 1 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 mostly approximate. As Hutton puts it,

> 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 (1501–1576) was an Italian mathematician who 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 imaginary numbers, occurs precisely when the equation has three real roots, even though this fact had been known since not long after Cardano's original work.

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. By cutting the Gordian knot of the parallel postulate 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 fifth postulate, which is not even stated.[viii]

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.) Even when an allowance is made for inflation, the cost per theorem has probably never been so low at any time since.

Students. According to the *General Catalogue of the University of Vermont, 1791–1890*, UVM had about 100 living alumni by the year 1820, 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 the others. The most noteworthy alumnus of the early period from the point of view of mathematics was George Palmer Williams 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 1863. He was president of the faculty at Michigan in 1845–46 and again in 1848–49. He died in 1881.

On May 27, 1824 UVM suffered one of the greatest calamities in its frequently precarious existence. The only university building, the "college edifice" (in its rebuilt form now known as the Old Mill), was destroyed by fire. President Haskel suffered a nervous breakdown from this blow and never fully recovered from it. James Dean was appointed President *pro tempore* to officiate at commencement in August of that year. However, Dean had decided that three of his students, due to insufficient scholarship, were not to be promoted with the rest of their class. The three students promised reform and appealed to the trustees not to be held back. The trustees agreed and thereby precipitated the resignation of Professor Dean. On this rather sour note, the first section of our narrative ends.

§ 2. The "Benedictine" Era, 1825–1854

Personnel. The University was fortunate in its recovery from the loss of its building and its senior professor. A successor to Prof. Dean was found almost immediately in the person of George Wyllys Benedict, whose biography can be found in the *Vermont Alumni Weekly* of February 17, 1926. 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, Connecticut on January 11, 1796, he graduated from Williams College in 1818, then served as principal of the Academy in Westfield, Massachusetts, tutor at Williams College, and principal of an academy in Newburgh, New York before accepting the position at UVM. Speaking of the appointment at the 50th anniversary of the first graduating class (1854), Prof. Benedict stated:

> 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 [Board of Trustees—RLC], 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.

G. W. Benedict's energy was sorely needed by the University. It is very largely thanks to his efforts that a great deal of money was raised to fill the shelves of a very respectable 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 April 14, 1826, published in *Silliman's Journal*, Vol. XI, (1826), p. 120. His first innovation was to add calculus to the curriculum, based on a textbook by Étienne Bézout (1730–1783). Lindsay (1954, pp. 195–200) recounts Benedict's construction of the first chemistry laboratory in any American university (contradicting 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 world of learning. 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, which was distributed in the name of the entire faculty. Although UVM revived rapidly largely because of his labors, those labors took their toll on him. He resigned in 1847 for health reasons and went to work for a company bringing a telegraph line from Troy, New York to Burlington. He soon 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*, which unfortunately is not in the University Library. Prof. Benedict died in 1871, and is buried in the Benedict family plot in Green Mount Cemetery.

G. W. Benedict taught mathematics at UVM only until 1829. In that year George Russell Huntington, a graduate of the class of 1826, 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.) I have been unable to discover any more information about Prof. Huntington, except that he died in 1872. He 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 a cousin of G. W. Benedict.

The biography of F. N. Benedict is given in more detail in an article by Prof. Evan Thomas in the *Vermont Alumni Quarterly*, but will be summarized here. He was born in Parsippany, New Jersey in 1803. Upon his graduation from Hamilton 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, was titled, "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, New Jersey, apparently for the sake of his wife's health. He was an ardent conservationist with a keen interest in the Adirondacks, where he purchased large 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 titled, "A Foot-Note to John Todd's Long Lake," Back Log Camp Press, Sobail, New York, 1957, part of a collection about Long Lake published by Howard I. Becker.[ix]

F. N. Benedict died in 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 this paper, he is my favorite, the one I would most like to have met. As Prof. Thomas points out, 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, a Rev. Parker. It 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...

Curriculum. The curriculum and entrance requirements at UVM changed slightly during the 1830's, 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, and the "summer vacation" was the months of January and February, for obvious climatic reasons. As the catalog shows, the 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. The textbooks used were Bonnycastle's *Algebra*, Legendre's *Geometry* in a translation by Charles Davies (1798–1876), Herschel's *Outline of Astronomy*, and the "Cambridge Course," (a series of textbooks used at Harvard), all of which were a vast improvement on the earlier ones. John Bonnycastle (ca. 1760–1821), like Hutton, a professor at the Royal Military Academy at Woolwich, was a much clearer writer who seemed to have real insight into his subject. As for Adrien-Marie Legendre (1752–1833), he is one of the greatest mathematicians of all time, and his textbook of geometry is pellucid. At the very least, he discussed the problem of parallels and stated the parallel postulate, which he made a futile effort to prove. John Herschel (1792–1871) was the son of the famous astronomer William Herschel.

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 Buckham, later president of UVM. The bulk of the course is 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, which were kept by McKendree Petty, the successor of F. N. Benedict as professor of mathematics, show clearly that the course was an elaboration of Newton's *Principia*, Book I, Sections II–III and XII (on the orbits of particles and the attraction of spherical bodies). No attempt is made to find simpler or clearer proofs of the propositions than Newton himself gave.

Students. Among the mathematical students of this period one should mention Joel Tyler Benedict (apparently a nephew of F. N. Benedict) of the class of 1843, who later became a professor of civil engineering and mathematics at the New York Free Academy. He wrote an algebra text in 1857 that conceals the true nature of algebra every bit as effectively as the books used earlier at UVM. The most distinguished was undoubtedly Selim Hobart Peabody, who graduated in 1852 and became a professor of mathematics and civil engineering at the Agricultural College of Pennsylvania in 1854 and obtained a Ph. D. in 1877 and an LL. D. in 1881 from the University of Iowa. He became professor of mechanical engineering at Illinois Industrial University in 1878 and president of the University of Illinois in 1880. Less well-known was Otis David Smith of the class of 1853, who became professor of English literature and mathematics (sic!) at the Agricultural and Mechanical College of Alabama in Auburn.

The Mathematical Environment. During this period the University matured into an institution with an established and well-deserved reputation of competence, and even excellence in some respects. 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 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 Colson's translation of Donna Maria Agnesi's *Analytical Institutions* (London 1801), George Airy's *Mathematical Tracts on Physical Astronomy* (Cambridge 1826), Arbogast's *Du calcul des dérivations* (Strasbourg 1800), as well as works by Biot, the Bernoulli brothers, Lazare Carnot, Roger Cotes, Delambre, Euler, Gauss, La Croix, MacLaurin, Newton, Poisson, and Young. The chief deficiency that a modern researcher would notice is an absence of mathematical journals: no *Comptes rendus*, no *Liouville's Journal*, no *Crelle's Journal*. These were the lifeblood of researchers in out-of-the-way parts of Europe, 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.

Instruction was undoubtedly 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.

Part of the University's prosperity at this time was due to the generosity of one Azarias (or Azariah) Williams, a native of Sheffield, England, 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 in 1849 the University became full possessor of this land. At its meeting of May 10, 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.

Like so many good resolutions, these seem not to have been carried out. Instead, 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' name continues in the catalog to this day, even though the title of Williams Professor of Mathematics was vacant from the 1950s until the 1990s.[x]

§ 3. A Generation of Struggle, 1854–1885

Personnel. 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.) McKendree Petty was born in North Dorset on July 4, 1827, graduated from UVM in 1849, then taught in an academy in Castleton for one year, while preparing to study for the law. He journeyed to Louisiana and obtained his law degree from LSU in 1852. He became Williams Professor at UVM in 1854, and was ordained a Methodist minister in 1859.

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, of course, were conducive to depression. The diary entries from May 29, 1856 contain powerful emotional outbursts evoked by the burning of Lawrence, Kansas, 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 strongly abolitionist, as was most of Vermont. Petty's reflections on the state of the world mix with his own personal problems in an entry of December 30, 1862 (a very bleak time for the Union):

> 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...

It should be noted that Petty had six children at the time.

With Petty's religious vocation, it is not to be expected that he would make original contributions to mathematics. 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, which seems to have passed out of the curriculum at this time. Despite his having been a much-loved teacher, he sounds rather burned out in this diary entry from June 4 (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 in 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 of the Old Mill.[xi]

Curriculum. It is not surprising that, amid the general 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 (1811–1889), 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. Davies' version of Legendre, for example, gives the parallel postulate in Playfair's form: *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: *Two intersecting lines cannot both be parallel to the same line*. This formulation does not rule out the possibility that parallel lines do not exist, but that possibility is ruled out by the unspoken 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' text as anything written since. It would not do as preparation for engineers, however. Many subjects now covered, such as vector calculus, were not yet invented, and no scientist should nowadays attempt to get by without multivariable calculus.

The Mathematical Environment. The change of greatest moment 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. (As we have seen, however, engineering had been taught at UVM from the earliest days.) Norwich and Middlebury Colleges were offered the chance to unite with UVM in one large institution at this time, but declined the honor. To fulfill its part of the law the State of Vermont was to contribute $8,000 per year to the maintenance of the new institution. Vermont's Senator Morrill, 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, $20,000 from John N. Pomeroy, and $200,000 from Frederick Billings. However, the State was not inclined to hear him (Lindsay, 1954, p. 223). One result of this new structure, shown in the 1866–67 catalog, was the creation of the College of Agriculture, containing Sections of Engineering, Mining and Metallurgy, and Analytical and Agricultural Chemistry. The Agriculture College listed among its faculty McKendree Petty and Samuel Huntington, Jr., C. E. as Instructor in Civil Engineering. Huntington was succeeded in the 1869–70 catalog by Volney Giles Barbour, who left a considerable mark on engineering at UVM. (His portrait now hangs in the Votey Engineering Building.) 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 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. Another change, of great significance was proclaimed in the 1871–72 catalog:

> 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 A. Hamilton) were admitted—after some controversy—to ΦBK when they graduated in 1875. Their portraits now hang in the Memorial Lounge of Waterman Building, alongside that of George Washington Henderson of the class of 1877, who was born into slavery in Virginia, yet graduated at the top of his class. (The UVM chapter of ΦBK was chartered in 1848.)

Yet another innovation in this period was a sort of 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 1873–74 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.

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. Notice 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

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

ALGEBRA: Scientific Division

3. *Reduce* $\dfrac{1}{a - \dfrac{1}{1 - \dfrac{a-1}{1+a}}}$.

The goal of the mathematical curriculum was stated in the 1878–79 catalog:

> 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 [Applied] Mathematics during the first two years. More advanced practical courses are pursued in the Department of Science.

A Digression: Religion at UVM. Although mathematics is not directly affected by the religious character of the institution, it may suffer indirectly if the professors of mathematics are also clergymen, whose time outside of their teaching duties is likely to be spent on their religious duties rather than on the cultivation of mathematical research. Such was certainly the case with the Rev. Ebenezer Burgess, and with McKendree Petty, who taught an entire generation of UVM students. Mathematics also suffers if part of the population is excluded from the opportunity to study it on religious grounds, as was certainly the case throughout most of the history of UVM. The position of religion at UVM during the nineteenth century is bound to seem anomalous to the twentieth century. Although founded as a secular institution and granted public lands for its sustenance, the University was unabashedly sectarian in its administration. The by-laws of the University from 1885, Chapter III, Sect. 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.
>
> Sect. 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 were surely a deterrent to the enrollment of Catholics, for whom deliberate participation in Protestant worship was a mortal sin until the late 1960's. This 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. One cannot help wondering whether the people who made these rules ever gave any thought to the proposition that it might be unjust to take taxable land from the entire population and bestow it for the benefit of one particular religious group. The most likely explanation is that they were simply afflicted with the kind of cultural blindness that never really recognizes that reasonable people can differ radically from oneself in such matters. Such blindness persists even today; one frequently reads statements by public figures which take it for granted that everyone in America is Protestant, Catholic, or Jewish. The relaxing of these rigid rules came about piecemeal. The Faculty, in its wisdom, exempted itself from compulsory Chapel in 1892. Medical students, apparently being regarded as incorrigible, 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 (at last!) abolished in 1920.

§ 4. The Beginnings of Growth, 1885–1914

Personnel. On a national scale, one of the more interesting phenomena in the period from the end of the Civil War until World War I was an exodus of well-to-do young Americans to France and Germany 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 and Carl Neumann 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 research as a duty of the professor, an effect that was reinforced later by the large number of scholars who were refugees from the Nazis. The full effect was felt in the last half of the twentieth century. 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.

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, Michigan in 1849 and obtained the A. B. degree at the University of Michigan in 1876. He then went to Gőttingen and Berlin, where he took courses from such great mathematicians as Schwarz and Weierstrass. 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 early American research mathematicians: Simon Newcomb (actually a Canadian), W. E. Story, Fabian Franklin, and Thomas Craig; and it had enjoyed the services of the great British mathematicians J. J. Sylvester and Arthur Cayley. In 1883 Daniels became instructor at Princeton University, taking over the teaching duties of Henry Burchard Fine, who had gone on leave. He received the D. Sc. degree from Princeton in 1885. He became instructor in mathematics at UVM that year, and the following year, upon the retirement of McKendree Petty, he became the third Williams Professor of Mathematics.

Daniels' research record is consistent with that of other "first-generation" American scholars. It consists of three expository articles in the *American Journal of Mathematics*, Vols. VI and VII (1884–85) explaining Weierstrass' theory of elliptic functions for the benefit of Americans. Daniels has the distinction of being the only UVM nineteenth-century faculty member at UVM listed in Poggendorf's *Biographisch-Literarisches Handwőrterbuch zur Geschichte der exacten Wissenschaften* (Bd. 4, 1904, p. 295). Poggendorf credits him with 4 years of study in Gőttingen, 2 in Berlin, and 1 at the Johns Hopkins University, "Cambridge, Mass." A. L. Daniels preserved the notes from Weierstrass' course on analytic function theory, which were not published with Weierstrass' collected works and are still of great interest to historians of mathematics. These notes passed to his grandson, R. V. (Bill) Daniels, who recently retired from UVM after a career of distinction as a specialist in Soviet history and a period of service as a state Senator from Chittenden County. (Bill Daniels died in March 2010. I do not know the present whereabouts of these notes.)

Daniels lost no time in revamping the curriculum to suit his own background, using the textbooks of Simon Newcomb (1835–1909) as the base. This period 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 Frederick Merritt Corse, 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. In his file in the UVM archives there is an undated clipping from an unidentified publication, which I have ascertained dates to mid-July 1893 and is not from any Burlington newspaper of the time. This clipping is a vicious attack on his character, accusing him of spreading false and libelous rumors, refusing to see his impoverished mother when she came to visit him, and scheming to have his unqualified sister (Lillian Estelle Corse, '93) admitted to ΦΒΚ. One cannot judge the truth of such attacks at a distance of nearly a century, of course, but Mr. Corse's subsequent career seems to be a sufficient contradiction of them. 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. Working for New York Life as its representative in Petersburg, Russia, he spent 16 years getting to know the Russians. He returned to America with his family after the Russian Revolution and, in two long articles in the New York Times in 1918, urged intervention to overthrow the Bolsheviks. In 1952 he endowed the Frederick M. and Fannie Corse Professorship at UVM. He also left money for the 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 two other instructors, one of whom, Allison Wing Slocum, was actually a professor of physics, but taught courses in the Mathematics Department as well, leaving A. L. Daniels free to teach more advanced courses. A. W. Slocum (1866–1933) was born in Dartmouth, Massachusetts, obtained a bachelor's and master's degree from Haverford, then went on to Harvard to obtain a second master's degree. He was Tyndal scholar at Harvard in 1890–1891 and Morgan scholar at the University of Berlin in 1891–92.

There are two other instructors in mathematics during the 1890's, Warren Gardiner Bullard (1896–97) and Arthur Dexter Butterfield (1897–1900). I have not found any information on W. G. Bullard. A. D. Butterfield became an assistant professor of mathematics in the Engineering Department in 1900, the first official indication that UVM now had two mathematics departments, which were bound to be rivals for personnel and resources. Those resources had increased during the 1890's. The minutes of the Board of Trustees' meeting of December 1, 1891 (Vol. IV, p. 224) note

> 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.

The first Flint Professor of Mechanics and Bridge Engineering was Volney Giles Barbour. Only once has this professorship been held by a mathematician (Percy Fraleigh, during the 1950's).

A. D. Butterfield was a hydraulic engineer, born at Dunstable, Massachusetts in 1870. He received a B. S. degree from Worcester Polytechnic Institute in 1893, and an M. S. (also from WPI) in 1898. He went on leave from UVM in 1904 to obtain an A. M. from Columbia. He finally obtained a Doctor of Engineering degree from WPI in 1945, after retiring from UVM in 1942. In 1945 he became director of Veteran's Education at UVM, a post he resigned 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. (Apparently, the money was not forthcoming, since the observatory was not built.)

Curriculum. Despite the turnover in personnel, one has a sense of stagnation in the curriculum during the 1890's. As mentioned above, the elementary mathematics courses were taught by Prof. A. W. Slocum of the physics Department, leaving Prof. Daniels free to offer advanced courses in geometric function theory with a sketch of the theory of elliptic functions and integrals. He also offered a course in ordinary and partial differential equations and one in projective geometry, taught from the textbook of Cremona. At this point the UVM curriculum seemed to be acquiring real sophistication. Daniels' course on analytic function theory was supplemented with readings from Durège's book on Riemann's theory of complex variables. Heinrich Durège (1821–1893) 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 and is now couched in terms of manifolds, the classical examples upon which an intuitive understanding of Riemann surfaces must be based are discussed with great clarity in this book. This course, however, was offered irregularly. The best mathematics offered during this period was taught in the Physics Department. Slocum offered a course in mathematical physics using as texts Riemann's *Partielle Differentialgleichungen*—would we dare to use a textbook in a foreign language nowadays?—and Fourier's *Analytical Theory of Heat*. He also used Maxwell's *Heat* and Duhem's *Potentiel thermodynamique*. In fairness, however, it must be said that 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, 164 of whom 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 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 following year these requirements were expanded to include trigonometry, simple permutations and combinations, determinants, linear equations, graphical treatment of equations, Descartes' rule of signs, and Horner's method "but not Sturm's 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 is now supplemented by the College Board Examinations.

The engineering mathematics department began to grow in 1905, adding assistant professor George Monroe Brett to the faculty. (I have not been able to obtain any information on Brett.) In 1908 the engineering mathematics faculty gained professor Evan Thomas, whose articles in the *Vermont Alumni Magazine* are my main source for the biographies I have sketched here. As one might guess from his names, he was born in Wales, in the Rhondda Valley made famous in the novel *How Green was my Valley*. In 1867, at the age of 14, he was apprenticed to a firm of clothiers, and his parents emigrated to Ohio. 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, Vermont 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. 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*, published by McAuliffe Paper Company, Burlington, 1936. Prof. Thomas' chapters tell of the raising of two of Benedict Arnold's ships, which were sunk by the British in October of 1776, and of the construction of the bridges across Lake Champlain. He died in 1947.

Growth continued in the Engineering Mathematics Department until 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 UVM's hesitant steps toward membership in the worldwide mathematical research community.

§ 5. Another Generation of Struggle, 1915–1954

Personnel. A. L. Daniels' 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. Being about twenty years later than Daniels, however, his mathematical career was correspondingly more prominent. He was born October 23, 1882 in Buffalo, New York, and graduated from Harvard (A. B.) in 1903. In that year he presented a paper before the American Mathematical Society, "On the condition that a point transformation of the plane be a projective transformation," published in the 1904 *Bulletin of the American Mathematical Society*. He then went to Gőttingen, where he studied under Hilbert. (His notes from Hilbert's 1905–1906 course in Integral Equations are now kept in the Mathematics Department.)[xii] He received the Ph. D. degree Magna cum Laude from Gőttingen University in 1907 for a dissertation, Über die Form und Stabilität gewisser Flűssigkeitstropfen," (On the form 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 I have not searched exhaustively for his publications, it is clear that he has several, in various areas of mathematics. In the *Bulletin of the American Mathematical Society*, Vol. XIV (1908), he published a "Note on the second variation in an isoperimetric problem," and in the *American Journal of Mathematics*, Vol. L (1928), he published, "Canonical forms for ordinary homogeneous linear differential equations of the second order with periodic coefficients." Clearly, 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 July 21, 1957.

Along with Prof. Swift, the Mathematics Department of the College of Arts and Sciences hired James Edward Donahue. These two were the core of the Mathematics Department for the next 17 years. J. E. Donahue was born in Fairfield, Vermont on April 25, 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, after which he returned to the Mathematics Department. 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. Tragically, he lived only one year after obtaining this degree, dying of a cerebral hemorrhage while on vacation in Maine in August 1932.

Swift and Donahue were joined by a succession of instructors, and gradually more and more professors were added. In 1920–21, Instructors Howard Guy Millington and Fred Walter Householder were added, both of whom later became assistant professors. Millington also had an appointment in the Engineering Mathematics Department. H. G. Millington was born August 28, 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 February 25, 1965. F. W. Householder was born in Jackson, Tennessee, April 7, 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, as Swift later explained in a letter to President Millis, mathematicians were hard to find. Householder seems to have worked out well at first, but suffered from “burn-out” in the 30’s. (Heath Riggs, who took courses from him, confirmed that this judgment of Swift’s 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. Householder had been replaced by Douglas T. McClay, a Harvard graduate, about whom I have not been able to learn anything. I do not know the date of Householder’s death.

The year 1923 saw the addition of the longest-serving member of the UVM faculty. George Hubert Nicholson, who was born on Prince Edward Island, 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. At UVM he taught a heavy load (12 hours per week) for fifty years. (Although he officially retired in 1963, he continued to teach part time until 1973.) With such a heavy teaching load, he had no time for research, although in 1940 he did write a brochure on mathematical instruments, which 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 the present library, and thus became the founder of the UVM Hockey Team. When he retired for good in 1973, the old Lucy Ann Abbott house, then the home of the Mathematics Department, was renamed the Nicholson Building in his honor.

Another instructor, added in 1924, was Horace Alpheus Giddings, who was born in Farnworth, New Hampshire in 1902. He had obtained the B. S. degree at the University of New Hampshire in 1923. He remained at UVM until 1930.

In 1928 Percy Austin Fraleigh became an assistant professor, bringing the total faculty to 7 (four professors and three instructors). Fraleigh was born April 12, 1895 at Hyde Park, New York and received the degrees of A. B. (1917), A. M. (1918), and Ph. D. (1927) at Cornell. He remained at UVM until 1963. 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 the early 1980’s (I am uncertain of the exact date). The next new professor, James Atkins Bullard, like Millington, was appointed in both the Arts and Sciences and Engineering Mathematics Department, replacing Evan Thomas in the latter. He was born in Parsippany, New Jersey on February 3, 1887 and received the Ph. D. from Clark University in 1914. He was an instructor at Worcester Polytechnic Institute until coming to UVM in 1928. Sometime during the twenties he was co-author (with Arthur Kiernan) of a trigonometry text. He remained at UVM until 1953, becoming the fifth and last Williams Professor of Mathematics in 1944 upon the resignation of Dean Elijah Swift from the Mathematics Department. He came out of retirement for two years in the mid-50’s. He died in Parsippany, New Jersey on April 10, 1959.

The last of the new faculty, Myron Ellis Witham, a civil engineer, was hired in 1932. He was born October 29, 1880 in Rockport, Massachusetts. He was a prominent football player at Dartmouth, indeed the hero of its 1903 team. In addition to teaching mathematics, he also coached the UVM football team and taught physical education. He died in Burlington in 1972.

Throughout the economically lean years of the 30’s and the war years the faculty members just listed kept mathematics going at the University of Vermont. There was little, if any, innovation in curriculum during this time and essentially no research. Not until the postwar years did the faculty begin to increase again. In the new expansion of the department we find the first woman to teach mathematics at UVM. She was Ruth Gertrude Simond, who was born March 7, 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, Berea College, Heidelberg College (Tiffin, Ohio), and Morningside College (Sioux City, Iowa) and served as a cryptoanalyst for the Navy during the war before coming to UVM as assistant professor of mathematics in 1948. She died September 15, 1958, having apparently resigned her position because of ill health the previous June. She is buried in Franklin, New Hampshire.

The University hired an assistant professor, William Thompson Fishback, and an associate professor, William Scribner Kimball, in 1951. I was able to contact Professor Fishback through my colleague Professor Dan Archdeacon, who had been his student at Earlham College in Richmond, Indiana. Fishback seems to be the author of a book on Euclidean and projective geometry, published in 1980. 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 in Butterworth's Scientific Series. He was born in Plainfield, New Jersey on August 28, 1887. Already near retirement age when he arrived, 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 between Kimball and Dean McKee found in Kimball's file in the UVM archives. Retirement at age 65 was mandatory at UVM until the mid 1980's.) I do not know what became of him after he retired in 1954.

Curriculum. The curriculum was revised when Swift and Donahue took over, but still remained quite 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 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 remain 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, told me that he took mostly physics courses, since there wasn't much of interest in the Mathematics Department. He describes Fraleigh and Nicholson as excellent teachers and competent mathematicians, but confirms what other sources suggest, that Bullard and Householder were incoherent lecturers.

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. Not until the end of World War II did some real updating of the curriculum begin, and then only 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 step into graduate education appears in 1947, with the addition of a Master's thesis course.

The Mathematical Environment. As already noted, teaching loads were too heavy to allow mathematical research. Mathematics was solely a service discipline at this time. In fact, the entire department was merged with the Engineering Mathematics Department to form a single Department of

Mathematics and Mechanics in the College of Technology in 1946. (An oral tradition that I have not verified asserts that this move was made partly because of the terms of the Wilbur Fund. This fund, which provided money for the College of Arts and Sciences, specified that that 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.) The new department consisted of professors Bullard and Fraleigh and assistant professors McClay, Millington, Nicholson, and Larivee. (Jules Alphonse Larivee is the only professor of apparent French or French-Canadian descent ever to belong to the Mathematics Faculty. I have not been able to learn much more about him. Professor Fishback told me that Larivee came from Massachusetts, and that he went to work in private industry on the West Coast after leaving UVM.)

Students. 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 of the class of 1920. He became a professor at Northwestern and the University of Wisconsin. He was a mathematical statistician who published many articles in this area and wrote a definitive two-volume textbook *The Mathematics of Statistics*, published by Van Nostrand, which went through at least two editions. The second edition was published in 1947. Volume two (1951) was written jointly with E. S. Keeping. After retiring from the University of Wisconsin, he came back 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. The Kenney prize has been awarded annually ever since.

§ 6. UVM Moves Toward the Mainstream, 1955–1965

Personnel. Universities grow like arthropods, taking in more students until the shell bursts, then shedding the old exoskeleton and growing a new one. The year 1954 saw the retirement of J. A. Bullard and G. H. Millington. It was also the last year for Assistant Professor Larivee and Associate Professor W. S. Kimball. It was time for both expansion and renewal. The new faculty was begun with the hiring of Heath Kenyon Riggs (d. 2011) and Ivan Raymond Hershner, Jr. (d. 2005) in 1953. Riggs, a 1940 graduate of UVM, had spent a year as Research Assistant in the Department of Mathematics, then served as Director of Admissions before departing for graduate study at the University of Chicago. They soon set out renovating the curriculum. The following year Julius Solomon Dwork (d. 2002) was hired as associate professor and Roland Frederick Smith as assistant professor. In 1955 Harry Lighthall, Jr. (d. 1975) was hired as an instructor, and in 1956, when Prof. Smith left, Joseph Anthony Izzo, Jr. (d. 1999) was hired as assistant professor. At that point Professor Hershner left to work for the Pentagon. (He retired in 1980 at the rank of Colonel and taught at George Mason University until 1985, when he retired irrevocably. 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.) Professor Hershner's replacement as head of the Mathematics Department was N. James Schoonmaker (d. 2009). In 1959 Lighthall became assistant professor, and Donald E. Moser (d. 2003) joined the Department as associate professor. When Professor Fraleigh retired in 1963, Erling William Chamberlain was hired as an assistant professor.[xiii] The following year Bruce Meserve (d. 2008), a specialist in mathematical education, was hired as full professor. All these professors had been educated at excellent graduate schools. They began the rather formidable task of moving UVM into the mainstream of contemporary mathematics, a process that continues down to the present day.

At this point we leave the story of the UVM personnel. The first step toward the mainstream, as it turned out, was an enormous expansion in the faculty. In the year 1966 no fewer than seven new assistant professors were hired, including the first specialists in statistics and computer science. Since that story is still being written by people at work at UVM today, it must wait for a future historian. In very brief summary, 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. Five years later, in an administrative reorganization of the College, Computer Science was merged with Electrical Engineering and Statistics with Mathematics, forming the present Department of Mathematics and Statistics. As of the present writing it seems possible that the next reorganization will once again divide the two areas and create a Department of Statistics, though this change may not come for several years.[xiv]

Curriculum. Professor Hershner recalled that the major task facing the Department was to rebuild the curriculum. Riggs, who obtained a Ph. D. degree from the University of Chicago, where he studied under Marshall Stone, Irving Kaplansky, and Antoni Zygmund, 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. Computers and numerical analysis, of course, go hand in hand. Professor Riggs spent a leave of absence studying computational mathematics at the University of California at Berkeley in 1965–66, afterwards introducing the course in numerical analysis that is one of the core elements of the computational part of the curriculum.[xv] The curriculum expanded enormously during the early 1960's, with courses being added on group theory, Galois theory, probability, topology, differential geometry, number theory, foundations of geometry, computers, and numerical analysis.

Research. While the curriculum was being modernized it was logical to bring UVM into the mainstream of mathematical research. This movement was slower, since research had never been an important component of UVM's educational mission in general. The Graduate College at UVM was formed only in 1953; at that time only the Medical College offered a doctoral degree. Prof. Hershner told me that there was only one master's degree student in mathematics when he came in 1953. When he left in 1956 there were several. The master's programs continued to expand throughout the 50's and 60's, and planning was begun for a Ph. D. in applied mathematics and statistics.[xvi] At any rate, research, which had not previously been an issue in tenure and promotion cases, was strongly weighted by Clint Cook (d. 1969), the Vice-President for Academic Affairs[xvii] during the 1960's. It has assumed increasing importance with every change of administration since.

Conclusion

Strictly speaking, one cannot come to the conclusion of a story that is not yet over. The heading of this section indicates only that the narration has reached a conclusion. To anyone who is disappointed that I have not carried the story down to the present day, I offer the triple excuse that (1) the story is still being written by people who would probably disagree about its meaning if asked, (2) the story is enormously more complicated from 1965 on because of the increase in personnel and activity, and (3) I am myself a participant in that activity, hence unqualified to judge it. The most I will say is that UVM has followed the vast majority of American universities in moving away from an academic model of organization and in the direction of a corporate model. Along with that change has come an increased emphasis on obtaining funding from external sources for faculty research as an obligation of tenure-track faculty. Indeed, many faculty feel that this obligation trumps everything else in tenure, promotion, and salary decisions. Along with it comes a movement away from the traditional academic ideal of a community of knowledge, to be shared with all, and toward the concept of knowledge as a commodity in which the University has a proprietary interest.

References

LINDSAY, JULIAN IRA

1954 *Tradition Looks Forward. The University of Vermont: A History 1791–1904*, published by the University of Vermont.

NEUGEBAUER, OTTO

1975 *History of Ancient Mathematical Astronomy*, 3 Vols., Springer, New York.

PYCIOR, HELENA

1988 "British Synthetic vs. French Analytic Styles of Algebra in the Early American Republic," in: *The History of Modern Mathematics*. Vol. I: *Ideas and their Reception*, Edited by David E. Rowe and John McCleary, Academic Press, Boston, pp. 125–156.

WHEELER, JOHN

1854 *Historical Discourse*, Free Press Print, Burlington.

[i] (Note added in October 2007) Prof. Nicholson died at the age of 97 in 1995.

[ii] A student who could meet these requirements nowadays would be considered as already having completed a good portion of a classics major!

[iii] *Vulgar arithmetic* means the arithmetic of common fractions, as opposed to decimal fractions.

[iv] Speaking only for myself, I have found that the chief difficulty in coming to an appreciation of Milton's *Paradise Lost* was occasioned by the numerous allusions to rivers and mountains from ancient mythology, geography that was familiar to educated people in Milton's day but meant nothing to me.

[v] My late colleague from the Physics Department, Professor Al Crowell, gave a detailed discussion of this paper of Dean's in 1971 (see the *Burlington Free Press*, March 11, 1971).

[vi] Benjamin Silliman (1779–1864) founded this journal, officially known as the *American Journal of Science*, in 1818. Silliman's son assisted him in the editing after 1838.

[vii] Perhaps the explanation is the paucity of reading material available to students in those days.

[viii] Another mathematician of even more naive views, J. J. Callahan, President of Duquesne University in the 1930's, announced that he had proved the parallel postulate. His "proof," published in a book titled *Euclid or Einstein*, cuts through the difficulty in exactly the same way. Apparently Callahan never realized that Hutton had anticipated

him. He of course failed to show that his definition of parallel lines was equivalent to Euclid's. His book, by the way, is mostly a scurrilous personal attack on Einstein.

[ix] (Note added in October 2007) F. N. Benedict is believed by most authorities to be the author of an anonymous article "The Wilds of Northern New York," published in *Putnam's Monthly: A Magazine of Literature, Science, and Art*, Vol. IV, No. XXI, September 1854. That article was reprinted by Purple Mountain Press, Fleischmanns, New York in 2001, with a preface by Sandra Weber.

[x] (Note added in October 2007) In the year 2000, through an amusing error, the present author was honored with this august title. The error was only recently discovered by my friend Jeff Dinitz. The position of Williams Professor was *not* vacant at the time. It had been bestowed some years earlier on my close friend and colleague Ken Gross, who richly deserved it. The final irony is that the illegal transfer of that honor to me was championed by none other than Ken Gross himself, who, like the rest of the Department, had forgotten that he held the title. The Williams Chair has now been properly and legally and deservedly presented to our colleague Ken Golden.

[xi] (Note added in October 2007) In 2004, Rev. Petty's great-grandson Edward H. Worthen wrote and published a beautiful and detailed biography of McKendree Petty, including a very complete genealogy of the Petty family, under the title *McKendree*, a copy of which he kindly presented to me.

[xii] (Note added in October 2007) I presented those notes to the Rare Books Room at the library in 2003. At the moment, they do not seem to be in the library's catalog, however.

[xiii] (Note added in October 2007) Professor Chamberlain retired in 1996.

[xiv] (Note added in October 2007) The Department remains united, as the Department of Mathematics and Statistics. The College has reorganized since the departure of Business Administration to form its own school. It is now known as the College of Engineering and Mathematical Sciences and includes engineering, mathematics and statistics, and computer science.

[xv] The story of computing at UVM deserves more space and more prominent attention than it can get in a general history of mathematics. 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 accordingly 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 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 President Fey of UVM offered to buy an IBM 1620 for the University, provided he could be assured the faculty would use it. Prof. Riggs obtained affidavits 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 small beginning, UVM (like every office in the world) has been completely permeated by computers. There are now thousands of powerful computers on the campus, counting PC's, work stations, and mainframes.

[xvi] Such a program was begun in 1970, and about six doctoral degrees were granted before the program was closed in 1976. A carefully prepared plan for a Ph. D. program was approved at all levels except the Board of Trustees in 1990, but then-President Davis, engaged in planning for fiscal austerity, refused to present it to the Board.

(Note added in October 2007). The program was approved in the early 1990s, and UVM has since produced a number of very respectable Ph.D.s, whose dissertations have been published in reputable, even prestigious, journals.

[xvii] (Note added in October 2007) This office is now called Provost.