MATHEMATICS AT CORNELL: STORIES AND CHARACTERS, 1865—1965

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UNIVERSITY BUILDINGS AND CAMPUS FROM THE SAGE COLLEGE

[FROM A PHOTOGRAPH BY PROFESSOR HARTT.]

PART I: 1865—1898, THE FIRST THIRTY YEARS

The Ithaca Journal, January 1st 1828[1]

Beneath our feet the village lies,
Above, around, on either side
Improvements greet us far and wide.
Here Eddy's factory appears,
First of the hardy pioneers.
Yes, Ithaca, where from this brow
I gaze around upon you, now
I see you not as first I knew.
Your dwellings, humble, how and few,
Your chimney smokes I then could count;
But now my eyes cannot surmount
The splendid walls that meet the eye
And mock my early memory.
Yes, village of classic name,
Wouldst you had more of classic fame!
Go on and prosper! There are still
Plots to improve, and space to fill.
With private zeal, and public spirit,
No small proportion of your merit,
Build railroads, canals, roads, and banks;
Make money plenty, and my thanks
At least you'll have—May education
Here also occupy its station.

[1] As reported in "Ithaca" by Henry Edward abt, 1926, page 58. Note that this poem appeared in the Ithaca Journal forty years before the creation of Cornell University.

PREAMBLE

These notes, MATHEMATICS AT CORNELL, STORIES AND CHARACTERS, 1865—1965, are an attempt to describe the evolution Cornell's department of mathematics from the founding of the university in 1865 to around 1965, the first hundred years.

In a nutshell, the evolution of the department during those hundred years can be broken into four broad periods:

- 1868—1874: The department of Evans and Eddy. (E.W. Evans is the first Chair of the department. He died in 1874.)
- 1874—1910: The department of Oliver and Wait (J. Oliver became Chair in 1874. He died in 1895 and was replaced by L. Wait as Chair. Wait retired in 1910. The period 1895-1910 is a period of transition, under Wait's watch.)
- 1910—1939: The department of Snyder, Hutchinson and Hurwitz. During this period, the Chair position was occupied by various faculty members on a 2 or 3 years rotating cycle. V. Snyder retired in 1838, J. Hutchinson died in 1935. Both had joined the department around 1895. A. Hurwitz, an American student of Hilbert who was about twenty years younger than Snyder and Hutchinson and had joined Cornell in 1912, retired in 1954.
- 1940—1965: The department of Agnew, Walker and Olum. This period saw the growth of the department from a dozen faculty members to almost fifty. R. Agnew and R. Walker successively served as Chair, each for a decade, 1940—1950 and 1950—1960. The department returned to shorter rotating chairmanships starting in 1961. Scientifically, this period is marked by the contributions of M. Kac and J. B. Rosser and, later J. Wolfowitz and J. Kiefer. They all participated to the rise of the stature of the department to its current position as a significant player in the international mathematical community.

I like to illustrate the story of these first hundred years with the following observation. James Oliver was a fellow of the American Academy of Arts and Sciences (1866) and a member of the National Academy of Sciences (1872). Jack Kiefer was elected to the American Academy of Arts and Sciences in 1972 and to the National Academy of Sciences in 1975. On that occasion, he became the first member of the department since James Oliver to be elected to both academies.[2]

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[2] Snyder was elected a fellow of the AAAS in 1919. Kac was elected a fellow of the AAAS in 1959. He became a member of the NAS after leaving Cornell. Wolfowitz was elected to the AAAS in 1970 just before he moved to the University of Illinois, and to the NAS four years later.

About one hundred years had past since Oliver's election, the one hundred years that are covered by these notes.

Part I, 1865—1898, THE FIRST THIRTY YEARS, captures the early years of the department in the context of the emergence of the American scientific community. To a large extend, Part I can be viewed as a description of the life work of James Edward Oliver, put in some historical context.

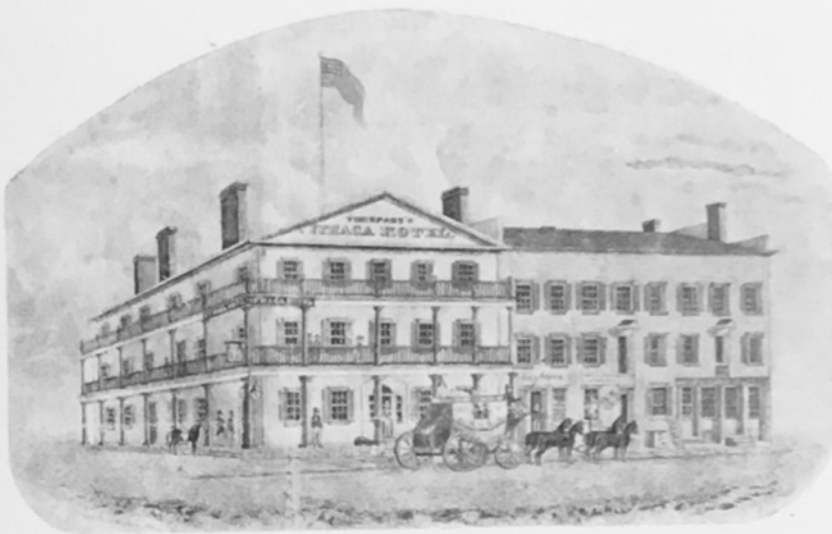
Oliver was a brilliant student at Harvard where he became one of the favorite pupils of Benjamin Peirce (Oliver received is BA in 1849). He was raised in a Quaker family going back to the first settlers. He had a broad scientific knowledge, wide interests, and was considered by his American contemporaries as a mathematical genius even so one cannot today describe any of his written works as a significant contribution. Many accounts note that he was completely disinterested in making a record for himself and that he was, fundamentally, a very open, tolerant, kind, loveable man. He is often described as the ultimate absent minded professor, a bit of an eccentric. He was decisively liberal, anti-slavery, a supporter of women's rights, and a supporter of the "Free Thinkers" movement of his time. This, in fact, almost got him fired from his Cornell position around 1880. Through his deeply rooted interests in research and scholarship, his communicative enthusiasm and his unrelenting efforts, Oliver shaped the future of Cornell mathematics and his influence was felt long after he died in 1895.

To understand the first thirty years of mathematics at Cornell, it is necessary to have some notion of the scientific environment of the time in the United States (or lack thereof). The opening chapter gives a glimpse of the world in which Cornell University was created. One of the greatest mathematics achievement by an author in the United States in the first half of the nineteen century is Bowditch's annotated translation of Laplace treaty on Celestial Mechanics.[3] When the university opened in 1868, the concept of graduate studies barely existed in the United States. By Oliver's death in 1895, the seeds of a solid graduate mathematics program at Cornell had been planted. In 1904, nine years after Oliver's death, Clarence Lemuel Elisha Moore earned his Cornell Ph.D. under Virgil Snyder before taking a position at the Massachusetts Institute of Technology. He was a mathematical grand-son of Felix Klein and the second of 43 Cornell graduate students who earned their Ph.D. under V. Snyder. His name is now attached to the prestigious postdoctoral positions offered each year in Mathematics by the Massachusetts Institute of Technology.

[3] https://archive.org/details/mcaniquecleste00unkngoog/page/n7

PART I: 1865-1898

CHAPTER I: BEFORE CORNELL,1800-1867



ITHACA HOTEL, 1841

CLINTON HOUSE, 1832 *Courtesy of Frank L. Morse*

From "Ithaca", Henry Edward Abt, 1926 (page 57)

The story we want to tell is that of Mathematics at Cornell: how the Cornell mathematics department grew to occupy an enviable position on the national and international stage, how students and faculty contributed to this ascension during the first hundred years or so of the University. The creation of Cornell in 1865 coincides with the emergence of advanced mathematics and mathematical research in the United States.[4] This makes this story richer and more significant. The birth and growth of Cornell's mathematics program illustrates in many interesting ways the evolution of American mathematics, from its very modest beginning to its present preeminent position. To put the development of the Cornell's program in some perspective, we sprinkle Cornell's stories, as often as possible, with connections and comparisons with other programs which either existed and grew (e.g., Harvard and Yale) or emerged (e.g., Johns Hopkins, Clark, Chicago and Stanford) at the end of the nineteenth century.

But before we encounter the first Cornell mathematicians, it may be useful to gather glimpses and pieces of information regarding the world in which Cornell University came to be, the circumstances of its beginnings, and some of the people who influenced the upbringing of early Cornell mathematicians.

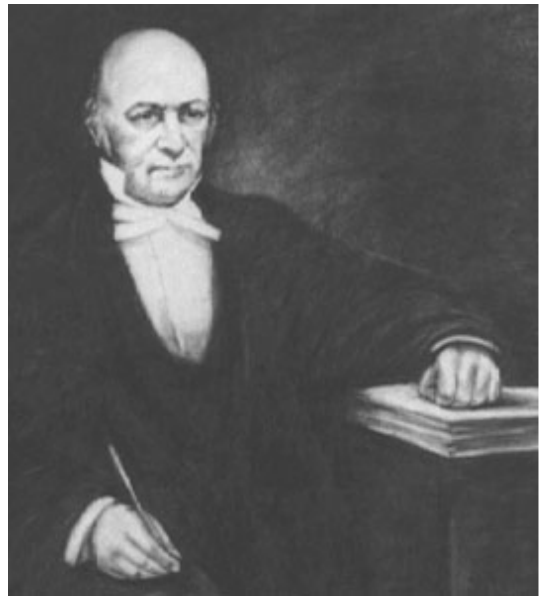
I.1 THREE EUROPEAN SCIENTISTS

In mathematics, the first three quarters of the nineteenth century is the the time of Carl Frederick Gauss, Augustin Cauchy, Niels Abel, Johann Peter Gustav Lejeune Dirichlet, Évariste Galois, Karl Weierstrass, Charles Hermite and Bernhard Riemann. By comparison, mathematics in the United States during that period was, essentially, nonexistent. Before giving a brief review of science and education in the United States at the turn of the nineteenth century, we consider the life and achievements of three European scientists who influenced the education and work of early Cornell mathematicians and, more generally, the development of mathematics in the United States during the the second half of the nineteenth century. They are William Hamilton, William Thompson, also known as Lord Kelvin, and, most significantly for our story, Felix Klein.

[4] See *The Emergence of the American Mathematical Research Community, 1876–1900: J. J. Sylvester, Felix Klein, and E. H. Moore*, Karen Hunger Parshall and David E. Rowe, History of Mathematics Volume: 8; American Mathematical Society, 1994.

WILLIAM ROWAN HAMILTON (1805—1865)

William Rowan Hamilton, born in 1805 in Dublin, is one of Ireland's foremost scientists of all times. By the age of thirteen, under the tutelage of his uncle James, Hamilton had learned at least 13 languages including Sanskrit, Malay, Persian, Arabic and Hindustani. In 1823, at the age of eighteen, he entered Trinity College (the University of Dublin) where, in 1827, after four years of study and at the age of 22, he was offered the Chair of Astronomy over several much more experienced candidates.



W. R. Hamilton

Trinity College was created by Royal Charter in 1592. Until 1830, the undergraduate curriculum included classics, mathematics, a limited exposure to science and some philosophical texts. After 1830, it became possible for students to specialize in mathematics, in ethics and logic, and in classics. After 1851, experimental science was added and, later, history and modern literature. One of the early Cornell Mathematics faculty, James McMahon, graduated with high honors from Trinity College in 1881 before moving to Ithaca.

Notwithstanding the fact that Hamilton held the Chair of Astronomy, he spent his life studying mathematics. He is remembered for two main contributions in very different areas of mathematics.

The first has its origin in ideas Hamilton developed when he was only seventeen and which he published at twenty three in *A Theory of Systems of Ray.*[5] This was followed by 3 supplements published in 1830, 1831 and 1837 in which Hamilton developed geometrical optics. In the third supplement, based on his theoretical consideration, Hamilton predicted the phenomenon of conical refraction which was later observed experimentally by Humphrey Lloyd. Hamilton developed his ideas further in what has become known as Hamiltonian mechanics, a theory in which the *Hamiltonian* of the system represents the total energy. Hamilton's work emphasizes the role of the mathematical construct now known as symplectic structure and his

[5] *Transactions of the Royal Irish Academy*, volume 15 (1828), pp. 69-174.

ideas later played a role in the formulation of quantum mechanics. They have been a key part of mathematics and mathematical physics ever since. The other main contribution of Hamilton to mathematics is the discovery of the quaternions in 1843. Over several thousands of years, mathematicians have extended the meaning of the notion of number. First, as a child, we become acquainted with the natural numbers, those that we use to count things. Later, we learn to make sense of negative integers and rational numbers or fractions. For anyone using them, what make the rational numbers appealing and useful are the fundamental properties of the two operations, addition and multiplication, captured by the formulas

$$a + 0 = a, \qquad 1\times a = a, \qquad a + b = b + a, \qquad a\times b = b\times a,$$
$$a + (b + c) = (a + b) + c,$$
$$a\times(b \times c) = (a\times b)\times c, \quad a\times(b + c) = a\times b + a\times c,$$

together with the facts that any rational number a has an opposite called $-a$ with the property that $a + (-a) = 0$, and, if different from 0, an inverse a^{-1} such that $a\times a^{-1} = 1$.

Moving up through the school curriculum, one then learns that the number line can be used to represent many further numbers called "real numbers" that are intertwined among the rational numbers, filling invisible holes. Among these numbers are $\sqrt{2}$, the length of the diagonal of square with sides of unit length, and π, perhaps the most famous number of all, the half-length of a circle of radius 1. One also learns to solve quadratic equations such as $x^2 - 3x + 2 = 0$, that is, to find the values of x for which $x^2 - 3x + 2$ is, indeed, 0 (in this case, $x = 1$ and $x = 2$, as one easily checks). As it turns out, solving quadratic equations such as this was, at the opening of Cornell in 1868, one of the most advanced of the mathematics entrance requirements.

At first, the equation $x^2 + 1 = 0$ appears to have no solutions because it has no real solutions. The Italian mathematician Gerolamo Cardano (1501—1576) was among the first to publish a text using "imaginary" numbers, including the number $i = \sqrt{-1}$, to provide solutions not only to the equation $x^2 + 1 = 0$ but to every quadratic and cubic equation.

Slowly, mathematicians came to understand that, just like the number line is equipped with addition and multiplication, the plane can be turned into the "complex plane" by using the laws of addition and multiplication of the so called "complex numbers" defined by:

$$(a+ib)+(a'+ib'^{)}=(a+a')+i(b+b'),$$
$$(a+ib)(a'+ib')=aa'-bb'+i(ab'+ba').$$

Among the people who contributed to our understanding of these numbers is Carl Friedrich Gauss who coined the named "complex numbers". Hamilton was one of the first to note that a complex number is, really, just an order pair (a,b) of real numbers, and that these pairs can be added and multiplied using the formulas

$$(ab)+(a',b')=(a+a',b+b'),$$
$$(a,b)(a',b')=(aa'-bb',ab'+ba').$$

One key point of this observation is that these laws of addition and multiplication have all of the same properties that are familiar to us in the case of rational and real numbers.

Hamilton became fascinated with the problem of extending this to triples of real numbers (equivalently, to points in space): since singletons and pairs of reals can be added and multiplied, why not triples? Hamilton understood how to add triples but was stuck with the problem of multiplication. Here is what he wrote in a letter to his son.

"Every morning in the early part of October 1843, on my coming down to breakfast, your brother William Edward and yourself used to ask me: "Well, Papa, can you multiply triples?" Whereto I was always obliged to reply, with a sad shake of the head, "No, I can only add and subtract them."

The famous story goes that, on October 16, 1843, Hamilton and his wife took a walk along the Royal Canal in Dublin. Across Brougham Bridge (now Broom Bridge), a solution suddenly occurred to him. While he could not "multiply triples", he saw a way to do so for quadruples and he carved the basic rules for multiplication into the bridge:

$$i^2=j^2=k^2=ijk=-1.$$

Hamilton called his new numbers “quaternions”. They have most of the usual properties we mentioned earlier except that the multiplication is not commutative (for most quaternions A, B, the products $A\times B$ and $B\times A$ are different).

Later, Ferdinand George Frobenius (1849—1917) proved that tuples of real numbers can be made into an “associative division algebra” only for singletons (real), pairs (complex) and quadruplets (quaternion). As it turned out, there were good reasons why Hamilton could not multiply triples!

The theory of the quaternions occupied Hamilton for the rest of his life. It also captured the imagination of many mathematicians in the United States during the second half of the nineteenth century. Benjamin Peirce who is often referred to as “the father of American mathematics” taught a course on the quaternions at Harvard as early as 1848. Among his pupils that year was a young man named James Edward Oliver who, twenty-six years later, became the second Chair of the mathematics department at Cornell. Peirce’s later student, W. Byerly, reported that quaternions were among Peirce’s favorite subjects. Indeed, Peirce’s most original mathematical work, *Linear Associative Algebra*,[6] is concerned with a broad generalization of the structure of the quaternions. In 1878, Abbott Lawrence Lowell, a pupil of Peirce and future Harvard president (1909-1933), wrote a senior thesis, *Surfaces of the second order, as treated by quaternions,* published in the *Proceedings of the American Academy of Arts and Sciences*. Two of Peirce’s sons, the mathematician James Mills Peirce (1834-1906), and the mathematician and philosopher Charles Sanders Peirce (1839-1914), contributed in different ways to the theory of quaternions. J.M. Peirce, professor of Mathematics at Harvard, was one of the most enthusiastic supporters of the quaternions. His brother Charles was much less enthusiastic, even though he proved (after Frobenius but independently) a result along the same line as Frobenius’ theorem mentioned above. Speaking of his brother, Charles wrote that James “*remained to his dying day a superstitious worshipper of two hostile gods, Hamilton and the scalar* $\sqrt{-1}$.”[7]

Courses on quaternions were taught at Cornell very early on and the first man to graduate from Cornell with a BS in Mathematics, Arthur S. Hathaway ’79, later wrote several memoirs on the subject. In fact, Hathaway was a member of the International Quaternion Society, an association devoted to promoting the study of

[6] http://www.math.harvard.edu/history/peirce_algebra/index.html

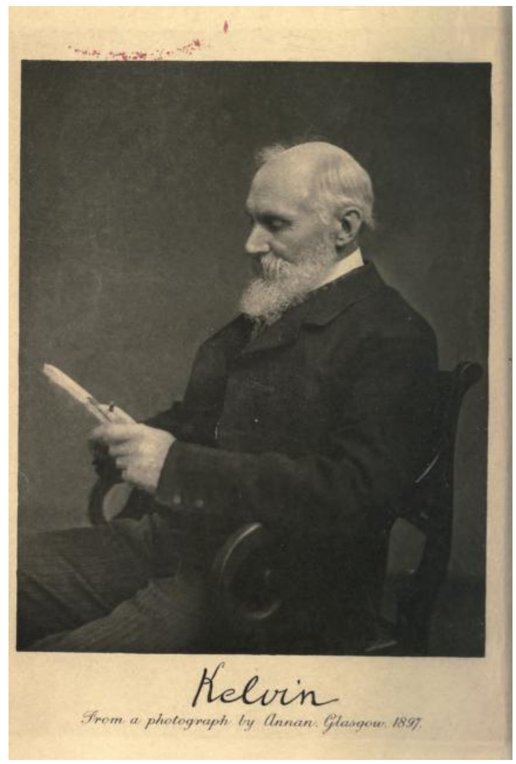
[7] Reported by R.C. Archibald in “Benjamin Peirce’s linear associative algebra and C.S. Peirce”, American Mathematical Monthly, 34, 1927, 525—527.

quaternions and allied systems of mathematics. He served that society as national secretary for the United States.

WILLIAM THOMSON, LORD KELVIN, (1824—1907)

I have visited nearly all the important universities of the world, but the site of none of them may be favorably compared to that of Cornell, with its commanding situation and its wonderful campus.[8]

William Thomson was born in Belfast in 1824. His father James taught mathematics and engineering and tutored William and his brother James. In 1832/33, the family moved to Glasgow when the father became professor of mathematics at the University. William attended Cambridge, Peterhouse.[9] In 1845, he graduated in Mathematics as Second Wrangler[10] and was elected fellow of St Peter (Peterhouse). In 1846, at the age of twenty-two, he was appointed to the chair of natural philosophy in the University of Glasgow, a position he retained for 53 years. Afterwards, he also served as Dean of the faculty 1901-1903 and Chancellor 1904-1907. Thomson was knighted in 1866 and became Baron Kelvin, of Largs in the County of Ayr, in 1892.



Thomson—mathematician, physicist, engineer and inventor— was born a few years before the first two Chairs of the Cornell mathematics department, E.W. Evans (born 1827) and J.E. Oliver (born 1829). He had a broad view of physics. He suggested that there were mathematical analogies between different

[8] Lord Kelvin, on the occasion of his visit to Cornell in 1902.

[9] Peterhouse is the oldest of the constituent colleges of the University of Cambridge.

[10] The Senior Wrangler is the person who achieves the highest overall mark among the Wranglers, the students at Cambridge who gain first-class degrees in mathematics. The list of Senior Wranglers and runner-up from 1748 to 1909 can be found at https://en.wikipedia.org/wiki/Senior_Wrangler_(University_of_Cambridge)#Senior_Wranglers_and_runners_up,_1748–1909

kinds of energy, and brought together subjects including heat, thermodynamics, mechanics, hydrodynamics, magnetism and electricity. His name (Kelvin) is attached to the primary unit of temperature used in the physical sciences. Thomson is connected to Cornell in several different ways.

On May 2 1902, Cornell physics professor and alumnus Edward L. Nichols '75 (Göttingen Ph.D. 1879) joined President Jacob G. Shurman to greet Lord Kelvin

GIFTS TO CORNELL UNIVERSITY.

John D. Rockefeller Promised Half of the $500,000 Required.

ITHACA, N. Y., May 2.—At a mass meeting at Cornell to-day in honor of Lord Kelvin President Schurman announced that the $250,000 for the new Hall of Physics would be forthcoming.

This sum was promised by John D. Rockefeller on condition that the university raise an equal amount. Cornell will therefore have the full $500,000 on commencement day.

The New York Times
Published: May 3, 1902

during his visit to Ithaca. The same day, President Schurman announced that enough money had been raised for the construction of a new Hall of Physics supported in part by an important gift from J.D. Rockefeller. It seems that Kelvin Place in Cayuga Heights is named after him.

Eighteen years earlier, in 1884, Thomson had visited the Johns Hopkins University and delivered a series of 20 lectures on "molecular dynamics and the wave theory of light", the famous Baltimore Lectures. Thomson himself gives the following account.

Having been invited by President Gilman to deliver a course of lectures in the Johns Hopkins University, on a subject in Physical Science to be chosen by myself, I gladly accepted the invitation. I chose as subject the Wave Theory of Light, with the intention of accentuating its failures; rather than of setting forth to junior students the admirable success with which this beautiful theory had explained all that was known of light before the time of Fresnel and Thomas Young, and had produced floods of new knowledge *splendidly enriching the whole domain of physical science. My audience was to consist of professional fellow-students in physical science; and from the beginning I felt that our meetings were to be conferences of coefficients, in endeavours to advance science, rather than teachings of my comrades by myself. I spoke with absolute freedom, and had never the slightest fear of undermining their perfect faith in ether and its light-giving waves by anything I could tell them of the imperfection of our mathematics; of the insufficiency or faultiness of our views regarding the dynamical difficulties of ether; or of the overwhelmingly great difficulty of finding a field of action for ether among the atoms of ponderable matter. We all felt that difficulties were to be faced and not to be evaded; were to be taken to heart with the hope of solving them if possible; but at all events with the certain assurance that there is an explanation of every difficulty, though we may never succeed in finding it.*

The audience included Lord Rayleigh (England), H. A. Rowland (Baltimore), Eli W. Blake Jr. (Providence), Cleveland Abbe (Washington), Albert A. Michelson (Cleveland), Fabian Franklin (Baltimore), Arthur S. Hathaway (Baltimore), George Forbes (England), Henry Crew (Wilmington), Louis Duncan (Baltimore), Arthur L. Kimball (Baltimore), T.C. Mendenhall (Columbus), Edward W. Morley (Cleveland) and R.W. Prentiss (Baltimore).[11] The lecture style was informal and lively.

I was thinking about this three days ago, and said to myself, "There must be bright lines of reflexion from bodies in which we have those molecules that can produce intense absorption." Speaking about this to Lord Rayleigh at breakfast, he informed me of this paper of Stokes, and I looked and saw that what I had thought of was there. It was perfectly well known, but the molecule first discovered it to me. I am exceedingly interested about these things, since I am only beginning to find out what everybody else knew, such as anomalous dispersion, and those quasi-colours, and so on.

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[11] *The life of William Thomson, baron Kelvin of Largs* by Thompson, Silvanus Phillips, Volume 2, page 814.

ADVERTISEMENT.

IN the month of October, 1884, Sir William Thomson of Glasgow, at the request of the Trustees of the Johns Hopkins University in Baltimore, delivered a course of twenty lectures before a company of physicists, many of whom were teachers of this subject in other institutions. As the lectures were not written out in advance and as there was no immediate prospect that they would be published in the ordinary form of a book, arrangements were made, with the concurrence of the lecturer, for taking down what he said by short-hand.

Sir William Thomson returned to Glasgow as soon as these lectures were concluded, and has since sent from time to time additional notes which have been added to those which were taken when he spoke. It is to be regretted that under these circumstances he has had no opportunity to revise the reports. In fact, he will see for the first time simultaneously with the public this repetition of thoughts and opinions which were freely expressed in familiar conference with his class. The "papyrograph" process which for the sake of economy has been employed in the reproduction of the lectures does not readily admit of corrections, and some obvious slips, such as Canchy for Cauchy, have been allowed to pass without emendation; but the stenographer has given particular attention to mathematical formulas, and he believes that the work now submitted to the public may be accepted, on the whole, as an accurate report of what the lecturer said.

A. S. HATHAWAY.

Dec., 1884.

But how can we have such a vivid account of these lectures, none of which had been written beforehand? As it turns out, Arthur S. Hathaway—the Cornellian from the class on 1879 mentioned earlier for his interest in the quaternions of W.R. Hamilton—was in attendance. In addition to being a trained mathematician with a strong interest in mathematical physics (at the time, he was studying at Johns Hopkins under J.J. Sylvester), Hathaway was a skilled stenographer—while attending Cornell, he had served as A.D. White's personal secretary—and he recorded Thomson's lectures.

Twenty years later, when the revised lectures were finally published, Lord Kelvin wrote the following.[12]

> *I desire also to specially thank one of our number, Mr. A. S. Hathaway, for the care and fidelity with which he stenographically recorded my lectures, and gave his report to the Johns Hopkins University in the papyrograph volume published in December 1884. The first eleven lectures, as they appear in the present volume, have been printed from the papyrograph, with but little of even verbal correction; and with a few short additions duly dated. Thirteen and a half years after the delivery of the lectures, some large additions were inserted in Lecture XII. In Lectures XIII, XIV, XV, freshly written additions supersede larger and larger portions of the papyrograph report, which still formed the foundation of each Lecture. Lectures XVI XX have been written afresh during 1901, 1902, 1903.*

After he returned to Cornell as a mathematics faculty member, in 1885, Hathaway sometimes taught an elective course titled "The Molecular Dynamics and Wave Theory of Light", obviously based on Thomson's Baltimore lectures.

Amongst his many inventions, Thomson conceived the first "tide-predicting machine" in the world. One of his machines was exhibited at the 1878 Paris World's Fair at which Cornell's first president, Andrew Dickson White, was one of the official Honorary Commissioners appointed by the the president of the United

[12] https://catalog.hathitrust.org/Record/003907945

States.[13] The first tide predicting machine for the United States was conceived by William Ferrel in 1881-82. These tide machines were mechanical analog computers. Twenty years later, Rollin A. Harris, a Cornell graduate and the third person to earn a Mathematics Ph.D. at Cornell, worked on the conception of the "Tide Predicting Machine No. 2" for the United States Coast and Geodetic Survey.[14] This Machine was in use from 1912 to 1965 (this is not a typo; high and low waters for the United States ports were still computed using this machine in the early nineteen-sixties).[15]

There is another unexpected connection between W. Thomson and Cornell and it lies in the role the telegraph played in both the life of the great scientist and that of the founder of the University. Thomson was knighted on November 10, 1866, at Windsor Castle by Queen Victoria, for his role in laying down the transatlantic telegraph cable. The success of the transoceanic telegraph (July 27, 1866) quickly halted the ambitious overland telegraph project to connect San Francisco to Moscow, a project pioneered by the entrepreneur Perry Collins and supported by the Western Union Telegraph Company, a company led then by Hiram Sibley, and which counted Ezra Cornell as one of its shareholders.

Thomson had worked on the telegraph since 1856. The first attempt to lay a transatlantic cable had ended in failure in 1858. The second attempt was conceived in 1865. The stronger cable made of copper covered with gutta-percha was so heavy that it is said that there existed only one ship in the world, The Great Eastern, capable of embarking the entire cable. Thomson's work was based in large part on theoretical considerations rooted in his understanding of Fourier's theory of heat. In a letter to Helmholtz in 1856, Thomson wrote[16]

I have worked a good deal, too, at the solution of problems (exactly like those of Fourier) regarding the propagation of electricity through submarine wires. It is the most beautiful subject possible for mathematical analysis. No unsatisfactory approximations are required; and every practical detail, such as imperfect insulation,

[13] Autobiography of Andrew Dickson White, Volume I, Chapter XXIX, and Paris universal exposition 1878 Official catalogue of the United States exhibitors, https://archive.org/details/parisuniversale00goog

[14] https://tidesandcurrents.noaa.gov/predma2.html

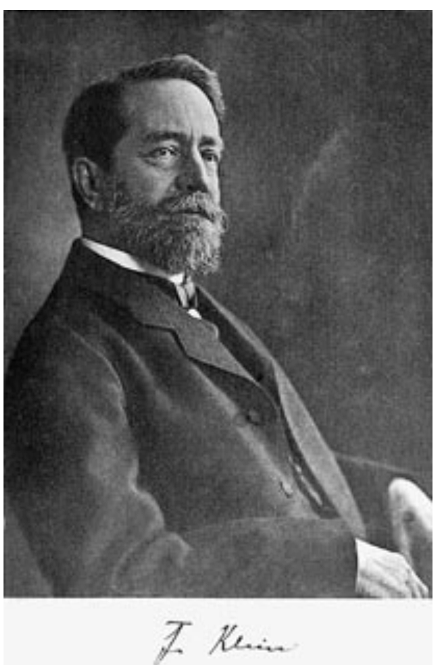
[15] See the section "Intermezzo: Rollin Arthur Harris (1863-1918)"

[16] *The Life of Lord Kelvin, Baron Kelvin of Largs*, by Thompson, Silvanus Phillips, Volume 1, Page 336. https://catalog.hathitrust.org/Record/001477836

resistance in the exciting and receiving instruments, differences between the insulating power of gutta-percha and the coating of tow and pitch round it, mutual influence of the different conductors (when, as is not the case of the Atlantic cable, more than one distinct conductor is used), attempts to send messages in both directions at the same time, gives a new problem with some interesting mathematical peculiarity.

FELIX KLEIN (1849—1925)

Felix Klein was born in 1849 in Düsseldorf. He studied Physics and Mathematics at the University of Bonn (Rheinische Friedrich-Wilhelms-Universität Bonn), graduated in 1866 and received his Ph.D. in 1868 under Rudolf Lipschitz and Julius Plücker. In 1872, he was appointed Professor in Erlangen. Three years later, he moved to the Munich's Technische Hochschule and married Anne Hegel, the granddaughter of the philosopher. In 1880, he obtained a Chair in Leipzig where he stayed until moving to the University of Göttingen in 1886.



The Erlangen Program that Klein published in 1872 characterizes "Geometry" as the study of the properties of a space that are invariant under a given group of transformations (symmetries). This idea shaped the developments of several areas of mathematics during the twentieth century. The second most important contribution of Klein to mathematics concerns complex analysis and function theory where he pursued research directions initiated by Bernhard Riemann and competed with the great French mathematician Henri Poincaré. Over a period of twenty years, he collaborated with Robert Fricke on a monumental four volumes treaty on automorphic and elliptic modular functions.

Klein was an outstanding scholar interested in connections between different areas of mathematics. He is also one of the rare European mathematicians of great repute to take a very deep and sustained interest in the development of mathematics in the United States during the last decades of the nineteenth century. Cornell's department of mathematics is one among many US departments which benefited directly from Klein's interest and the influence he exerted.

In Leipzig, in 1884, two Americans named F.N. Cole and H. B. Fine took Klein's courses.[17] Fine obtained his Ph.D. in Leipzig under E. Study and returned to his alma matter, Princeton, for the rest of his career. The Mathematics building[18] at Princeton, Fine Hall, is named after him. Cole was in Europe on a Parker Fellowship from Harvard. He earned his Harvard Ph.D. in 1886 and taught at Harvard and the University of Michigan before settling at Columbia University. He served as secretary of the American Mathematical Society for 24 years (1896-1920), and the American Mathematical Society's Cole Prizes (in Algebra and in Number Theory) are named after him.

Many Americans studied with Klein at Göttingen after he moved there from Leipzig.[19] They include (all the Göttingen Ph.D.s mentioned in this list were supervised by Klein unless indicated otherwise):

- M. W. Haskell (Harvard, Göttingen Ph.D. 1890, career at Michigan and Berkeley)
- W. I. Stringham (Harvard, Johns Hopkins Ph.D. 1880, career at Berkeley)
- H. D. Thompson (Princeton, Göttingen Ph.D. 1892, career at Princeton)
- W.F. Osgood (Harvard, Erlangen Ph.D. 1890, career at Harvard)
- M. Bôcher (Harvard, Göttingen Ph.D. 1891, career at Harvard)
- H. S. White (Wesleyan, Göttingen Ph.D. 1891, career at Northwestern and Vassar College)
- B. W. Snow (Cornell, Berlin, Physics Ph.D. 1892, Professor of Physics, University of Wisconsin)
- H.W. Tyler (MIT, Erlangen Ph.D. 1889, career at MIT)
- J.E. Oliver (Harvard, Professor at Cornell)

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[17] *The Emergence of the American Mathematical Research Community, 1876-1900: J. J. Sylvester, Felix Klein, and E. H. Moore*. Karen Hunger Parshall, University of Virginia, and David E. Rowe, University Mainz. A co-publication of the AMS and the London Mathematical Society.

[18] Both the original building, built in 1931, and the present building open in 1971, have been named after H.B. Fine.

[19] Ibid

- F.S. Woods (Wesleyan, Göttingen Ph.D. 1895, career at MIT)
- E.B. Van Vleck (Wesleyan, Göttingen Ph.D. 1893, career at University of Wisconsin)
- J.H. Tanner (Cornell, New Hampshire Ph.D. 1901, Career at Cornell)
- V. Snyder (Iowa State College, Cornell, Göttingen Ph.D. 1895, career at Cornell)
- Mary Frances Winston (University of Wisconsin, Chicago, Göttingen Ph.D. 1897, career at Kansas State University and Eureka College)
- Annie Louise MacKinnon[20] (University of Kansas, Cornell Ph.D. 1894, career at Wells College)
- Isabel Maddison (Cambridge and London, Bryn Mawr Ph.D. 1896, career at Bryn Mawr. Maddison was British but spend most of her life and career in the USA).
- C. A. Noble (Berkeley, Göttingen Ph.D. 1901 (Hilbert), career at Berkeley).

Of these American students, James Oliver, is the exception in that he was twenty years older than Klein and already Chair at Cornell at the time of his year-long visit to Göttingen. In 1889, Oliver travelled to Europe with his wife, Sarah, for fourteen months. They had married only a year earlier, in 1888. Originally, Oliver's plan was to spend most of the time in Cambridge to attend lectures and interact with Arthur Cayley. But Cayley was frail and, having received a very positive report from Benjamin Snow, a recent Cornell graduate, Oliver decided to spend most of his time visiting Felix Klein in Göttingen. During that long visit, the two couples, Anne and Felix Klein and Sarah and James Oliver, became quite close.

Oliver's visit had a lasting influence on the Cornell mathematics department. When Klein travelled to the United States in 1893 to attend the International Mathematical Congress[21] held in Chicago during the World Columbian Exposition, he visited his friend Oliver in Ithaca. At the time, V. Snyder was studying with Klein in Göttingen, supported by a Cornell fellowship. The next year, J.H. Tanner, who had recently graduated and been hired at Cornell, joined Snyder in Göttingen. There, Tanner studied under Klein and Hilbert and, acting on behalf of the Cornell mathematics department, convinced Klein's student, E. Ritter, to accepted a position at Cornell. Both Tanner and Snyder spent their career at Cornell. Snyder became the most

[20] http://www.ams.org/publications/authors/books/postpub/hmath-34-PioneeringWomen.pdf

[21] This congress is a precursor of the International Congress of Mathematicians. The first International Congress of Mathematicians was held in Zurich in August 1897.

influential and successful Cornell mathematics faculty of the first three decades of the twentieth century.

Klein's direct influence on the development of mathematics in the United States goes beyond the large group of Americans who went to Europe to study under him. Two of Klein's German students, O. Bolza (Göttingen Ph.D., 1886) and H. Maschke (Göttingen Ph.D., 1880), emigrated around 1888 and 1891, respectively, and pursued their careers in the United States at the University of Chicago. Their presence explains in part the extraordinary success of mathematics at Chicago in the early years of the twentieth century.

I.2 SCIENCE AND EDUCATION IN THE UNITED STATES BEFORE 1870

Harvard College was founded by the colonial legislature in 1636 and the College of William & Mary, by the Virginia government, in 1693. Then came Yale in 1701, Princeton University (the College of New Jersey) in 1747, the University of Pennsylvania (College of Philadelphia) in 1751, Columbia University (King's College) in 1754. They were followed by Brown University (College of Rhode Island) in 1764, Rutgers (Queens College) in 1766, Dartmouth College in 1769 and the University of North Carolina in 1795. Union College, founded in 1795, was the first institution of higher learning chartered by the New York State Board of Regents. The American Philosophical Society was established in 1743, the American Academy of Arts and Sciences in 1790.

The first half of the nineteenth century was a time of tentative developments in education and scholarship in the United States. West Point Academy was founded in 1802 and played a particularly important role in introducing French influence on the development of mathematics in the United States.[22] When Sylvanus Thayer became superintendent in 1817, he reorganized the Academy under the French model of École Polytechnique. Thayer recruited Claude Crozet, a graduate of Polytechnique trained in descriptive geometry, advanced mathematics, and engineering. Crozet is counted among those who introduced the use of the blackboard as a primary tool of instruction in the United States. In *The Teaching and History of Mathematics in the United States*, Florian Cajori quotes the reminiscence of Edward D. Mansfield (1801-1880), a student of Crozet at West Point and, later, Commissioner of Statistics for the State of Ohio from 1859 to 1868.

[22] See chapter III in *The Teaching and History of Mathematics in the United States* by Florian Cajori, 1890. https://archive.org/details/teachingandhist03cajogoog

The surprise of the French Engineer, instructed in the Polytechnique, may well be imagined when he commenced giving his class certain problems and instructions which not one of them could comprehend and perform.

The University of Virginia opened in 1825, the brain child of Thomas Jefferson. It enrolled sixty-eight students taught by eight carefully chosen faculty, five from England and three from the United States. Instruction was offered in ancient languages, modern languages, mathematics, moral philosophy, natural philosophy, chemistry, law, and medicine. After earning a BA and MA from Trinity College, Dublin, in 1841, J.J. Sylvester[23] took a position at the University of Virginia but remained there only a few months. Before returning to England in 1843, he developed a friendship with Benjamin Peirce, Professor at Harvard. At that time, Sylvester was denied employment at Harvard and Columbia because he was a Jew and he later faced similar problems in England. Twenty-three years later, he returned to the United States to take a position at the newly created Johns Hopkins University. He stayed seven and a half years before returning to England to accept a Professorship at Oxford.

The University of Alabama opened in 1831, the University of Michigan in 1841, the University of Iowa 1847 and the University of Wisconsin in 1850. A myriad of smaller colleges opened as well. Geneva College, an Episcopal Institution opened in 1822 and renamed Hobart College in 1852, was one of them. The young Andrew Dickson White, the future founding president of Cornell University, attended Geneva College before rebelling and forcing his father to agree to send him to Yale. Geneva Medical College was founded in 1834 as a separate institution. Between the years 1840 to 1850, 596 physicians graduated from that college including Elizabeth Blackwell (1821–1910), the first women to earned a medical doctorate in the United States. Ziba Hazard Potter, one of the first professors of mathematics at Cornell, earned a medical degree at Geneva Medical College in 1867, a few years before the College was transferred to Syracuse. In Ohio, Marietta College was founded in 1835 with origins going back to 1797 (Muskingum Academy). The first Cornell professor and first Chair of the Department of Mathematics, Evan William Evans, taught at Marietta before joining Cornell.

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[23] *James Joseph Sylvester: Life and Work in Letters*, Oxford University Press, 1998, and *James Joseph Sylvester: Jewish Mathematician in a Victorian World*, Johns Hopkins University Press, 2006, by Karen Parshall.

In any review of the progress of science, therefore, during the first century of the republic, the period which lies between the declaration of independence and the close of the eighteenth century may, without danger of any important omission, be passed over in silence… There were men, it is true, in the colonies and in the newly emancipated States whose native abilities and distinguished attainments as astronomers or physicists won for them a reputation which in their time reached to other lands, and which has since come down to us; but these, though they were masters, were not originators, and their names are but incidentally connected with the history of science.

This quote is from *Scientific Progress: The Exact Sciences*, an article written by F.A. P. Barnard for a collection of essays titled *The First Century of the Republic: a Review of American Progress* published in 1876.[24] Barnard graduated from Yale in 1828 and taught mathematics, chemistry, natural history and English literature, before serving as the tenth president of Columbia College 1864-1889. As an example of distinguished attainments in the colonies, Barnard points to David Rittenhouse (1732-1796), a self-taught man, famous as an inventor, astronomer, mathematician, clockmaker and surveyor.

In 1785-86, teams working for New York and Pennsylvania surveyed the border between the two states. The Pennsylvania team was led by Andrew Ellicott (later Professor of Mathematics at West Point) and David Rittenhouse; the New York team by Philip Schuyler, James Clinton, and Simeon De Witt.

Simeon De Witt (1756-1834)—often considered one of the founders of Ithaca[25]—graduated from Queens College (Rutgers University) in 1776. In Ithaca, De Witt Park and De Witt Mall are named after him. A Geographer, Surveyor General of the Continental Army during the American Revolution, and Surveyor General of the State of New York, De Witt is famous for establishing a detailed map of New York State that was first printed in 1802 (see below). De Witt was part of an influential family which demonstrated significant interests for science, education, economic development and politics over several generations. He was trained as a surveyor by

[24] *The First Century of the Republic: a Review of American Progress*. New York, Harper & Brothers, 1876. https://catalog.hathitrust.org/Record/000329551

[25] See, for example, *Ithaca* by Henry Edward Abt, 1926, pages 31-40.

his uncle, James Clinton (the husband of Simeon's aunt Mary DeWitt). James' brother, George Clinton, was Governor of New-York 1777-1795 and 1801-1804, and Vice President of the United States under T. Jefferson and J. Madison, 1805-1812.

Simeon De Witt's map of the State of New York, 1802.

Simeon De Witt died in 1834, in Ithaca, after serving 50 years as Surveyor General of the State of New York under the State governorships of George Clinton, Martin Van Buren, DeWitt Clinton and Daniel D. Tompkins. The following tribute was written by his son.

My father was a tall, large man, 5 ft. 11 in. high, with a noble, serious face, resembling in some respects that of Genl. Washington, *of grave but cheerful conversation, dignified deportment, affable to all, with that real polish of manner required by the society of the first gentlemen of the time in civil and military life, with whom his official position brought him in constant contact. He was a scholar, having taken the first position & borne the highest honors of his college. A mathematician of no mean acquirements and a philosopher in the widest sense of the word, either in physical or moral science, and to crown all, a true and devout Christian.*

DeWitt Clinton (1769-1828)—after whom Ithaca's Clinton House is named—was James Clinton's son and Simeon De Witt's first cousin. He was educated at King's College (Columbia University). A naturalist who contributed greatly to the development of education in New York State, he served as a United States Senator, was the sixth Governor of New York, and was instrumental in the construction of the Erie Canal. We end this section with a quote from his 1814 address *An Introductory Discourse,* delivered before the Literary and Philosophical Society of New York.

When we adventure into the fields of science the master spirits, who preside over transatlantic literature, view us with a sneer of supercilious contempt or with a smile of complaisant superiority; and consider our productions as oases in the regions of Africa; deriving their merit less from intrinsic beauty and excellence, than from their contrast with the surrounding deserts. And it has even been gravely proposed, as a subject for Inquiry, whether the discovery of America has been advantageous or prejudicial to mankind!

While we look down upon these aspersions it is due to candor, and a just estimate of our own character, to acknowledge that generally speaking, we are far behind our European brethren in the pursuits of literature. The enterprising spirit which distinguishes our national character has exhibited itself in every shape except that of a marked devotion to the interests of science.

At the time of Simeon De Witt's death, Ithaca had a population of about 6,000. Its business establishments included a flour mill owned by Colonel J.S. Beebe and operated by a certain Ezra Cornell. Andrew Dickson White was a two-year old boy living with his parents in the village of Homer, 25 miles from Ithaca. The White family moved to Syracuse five years later.

YALE UNIVERSITY

Strange to say, there was not, during my whole course at Yale, a lecture upon any period, subject, or person in literature, ancient or modern.[26]

Harvard and Yale (and also the University of Michigan) were the first to organize graduate studies. In 1847, Harvard created the *Lawrence Scientific School* and Yale organized the *Department of Philosophy and the Arts*. James Oliver, future Chair of Mathematics at Cornell, earned a Master's degree from the Lawrence Scientific School in 1851. In 1861, Yale started the Sheffield Scientific School in which, at first, mathematics per se was absent. It remained that way until the arrival of John E. Clark in 1873. Andrew Dickson White graduated from Yale in 1853. His close friend Daniel Coit Gilman, future president of the University of California and of the Johns Hopkins University, graduated a year earlier. Evan William Evans, one of the first two professors elected by the Trustees of Cornell University (1867) and the first Chair of the Cornell Department of Mathematics, graduated in 1851 and earned a Master's degree in 1854. Here is a quote from Evans' Yale alumni obituary.

He stood high in college, always took the first prizes in mathematics, and was noted as an English scholar and writer. Among other honors he bore off one of the much coveted Townsend prizes in English literature. He was one of the first editors of the Yale Literary Magazine, one of the best college publications in the country. While excelling in mathematics and philology, he was a good botanist and geologist, and seldom failed to accomplish whatever he undertook.

We know that A.D. White and E.W. Evans met at Yale. In his autobiography, White writes that Evans was known to him "*as one of the best scholars in the Class of 1851,*

[26] Andrew Dickson White, Autobiography, Volume 1, Chapter II.

but also one of its foremost writers". Evans, Gilman and White, were all members of Yale's Skull and Bones secret society.

During the mid-nineteenth century, Yale professors of mathematics were Antony Dumond Stanley (1836—1853) and Hubert Anson Newton (1855—1893). Newton had graduated from Yale in 1851, the same year as Evans. Upon his appointment, he spent a year in Paris where he studied geometry with Michel Chasles. After his return, he turned his attention to astronomy and did excellent work, becoming a member of the National Academy of Sciences. In mathematics, he is perhaps best known as the advisor of Eliakin Hasting Moore (1862—1932), the first Chair of Mathematics at the University of Chicago and a very preeminent figure in the development of mathematics in the United States at the turn of the twentieth century. Moore's 1885 dissertation *Extensions of Certain Theorems of Clifford and Cayley in Geometry of n Dimensions* indicates that Newton had retained some interest in geometry. The little we know about E.W. Evans' mathematical interests indicates that he was also, chiefly, a geometer.

George William Jones, a colorful personality and future Cornell faculty, graduated from Yale in 1859 and earned a Master's three years later. Again, we quote from his Yale obituary.

> *The first teaching position of the student who had shown promise when he captured mathematical prizes in the first two years of his College course was at Iowa State University, where he became professor of* mathematics *in the College. Declining the presidency of that university, he became an assistant professor of* mathematics *at Cornell University in 1877 and a full professor in 1895. He retired from active teaching on a Carnegie foundation in 1907.*

The first Ph.D. in mathematics in the United States was awarded at Yale to John Hunter Worrall in 1862. He served as Principal at the Mathematical and Classical Institute, Westchester, Pennsylvania, until his death in 1892. In 1863, J. W. Gibbs earned his Engineering Ph.D. with a dissertation titled *On the Form of Teeth of Wheels in Spur Gearing.* Charles Green Rockwood defended his dissertation *The Daily Motion of a Brick Tower Caused by Solar Heat* in 1866 and became professor of mathematics at Princeton 1877—1905. He also had interests in volcanology and seismology. Henry T. Eddy, future Cornell Faculty, graduated from Yale in 1867, studied at the Sheffield School and earned a Ph.B. in 1868 (the Philosophy Bachelor, Ph.B., was an undergraduate degree somewhat higher than a B.A or B.S.). After joining the Cornell faculty in 1869 as Assistant Professor, he became the first person to earn a Cornell Ph.D. (in any subject) in 1872.

During his college course he [Eddy] won three first prizes and a gold medal in mathematics and (in Senior Year) a first prize in astronomy. He was given dissertation appointments and was elected to membership in Phi Beta Kappa. He belonged to the Beethoven Society and sang in the College Choir and the Glee Club.

No doubt, Yale was one of the best places to get an education at the time but the recollections provided by students of the period, for instance, by A.D. White and H.T. Eddy, indicate it had many shortcomings. Eddy describes his mathematics study at Yale as follows.[27]

I am convinced that mathematics has been long and sadly misused at the hands of its pretended cultivators—the classical colleges of this country. That this has been done ignorantly and in obedience to long-established educational usages makes it all the more imperative that we should make it our duty to see that so important a matter is rectified as soon as practicable. What the misuse of mathematical study of which I complain is, may perhaps be best apprehended from a statement of my own experience as an undergraduate. Entering college with the usual mathematical outfit, acquired in a country academy in Massachusetts, I was for three years of my college course daily examined on an assigned task in some mathematical text-book. It does not seem to me that my knowledge of mathematics was very materially increased during that time by this process. Certainly a good teacher could in three months' time, at the rate of one lesson per day, have taught me far more than I learned by the process to which I was subjected, and I

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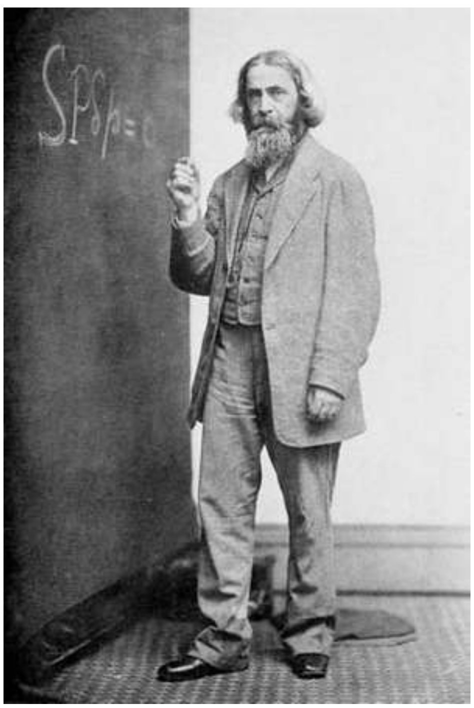
[27] Thirty-third meeting of the Association for the Advancement of Science, 1884, https://catalog.hathitrust.org/Record/006198795

have reason to believe that I was not an inapt nor an indolent student in this branch.

BENJAMIN PEIRCE (1809-1880) AND HARVARD COLLEGE

Gentlemen, that is surely true, it is absolutely paradoxical; we cannot understand it, and we don't know what it means. But we have proved it, and therefore we know it must be the truth.[28]



Benjamin Peirce

The three people most often cited as significant contributors to mathematics in the United States during the first three quarters of the nineteenth century are Robert Adrain (1775-1845), Nathaniel Ingersoll Bowditch (1773-1838) and Benjamin Peirce (1809-1880, pictured left).[29]

Adrain immigrated to the United States in 1798 after being wounded during the rebellion that took place that year in Ireland. His father was a school teacher but his parents died when he was fifteen and Adrain was mostly self-taught. He taught mathematics at The College of New Jersey (Princeton), at several academies in Pennsylvania, at Queens College (Rutgers), Columbia College and the University of Pennsylvania. A contributor and editor of several of the early mathematics journals published in the United States, he is now most famous for his contribution to the method of least squares, *Research concerning the probabilities of the errors which happen in making observations* which appeared in 1808 in his own journal, *The Analyst, or, Mathematical Museum*.

[28] Benjamin Peirce, as quoted by W. E. Byerly in *Benjamin Peirce, 1809-1880: Biographical Sketch and Bibliography* (1925) by R. C. Archibald.
[29] *Of the Human Heart: A Biography of Benjamin Peirce*, Edward R. Hogan, 2008.

The extraordinary story of Bowditch's life and self-directed studies (he left school at age 12 to work in his father's cooperage) is well-known. He is most famous for his translation of the first four volumes of Laplace's *Traité de Mécanique Céleste,* with commentary, a work that represents an extraordinary feat for American mathematics of his time. In the process, he served as mentor and friend to the most influential American mathematician of the nineteenth century, Benjamin Peirce.

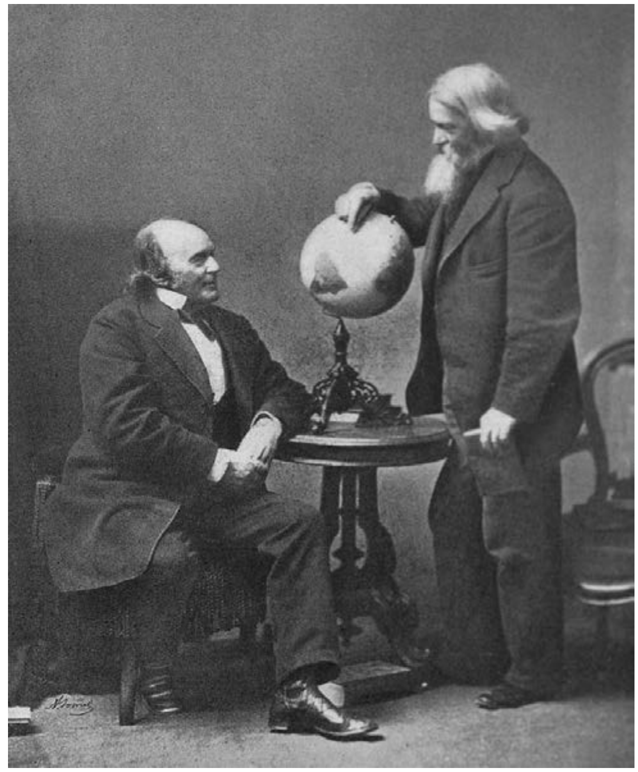
Peirce entered Harvard in 1825 and graduated in 1829 having taken mathematics courses from John Farrar (1779-1853), the Hollis Professor of Mathematics and Natural Philosophy, translator of Lacroix's *Elements of Algebra* and other French texts. In 1831, Peirce became a tutor. He earned a Master's Degree in 1833 and was appointed professor of Mathematics and Natural Philosophy. He later became the Perkins professor of Mathematics and Astronomy, a title he held until his death. In 1852, he was elected a Foreign Member of the Royal Society. In a volume of the American Monthly dedicated to Benjamin Peirce and published in 1925, R.C. Archibald writes

> *Professor Coolidge pointed out that before the time of Benjamin Peirce it never occurred to anyone that mathematical research "was one of the things for which a mathematical department existed." Today it is a commonplace in all the leading universities. Peirce stood alone — a mountain peak whose absolute height might be hard to measure, but which towered above all the surrounding country.*

Later, Archibald adds

> *Mathematical research in American Universities began with Benjamin Peirce. His influence on students and contemporaries was extraordinary; …. In September 1924, President Lowell wrote also: "I have never admired the intellect of any man as much as that of Benjamin Peirce. I took every course that he gave when I was in College, and whatever I have been able to do intellectually has been due to his teaching more than to anything else."*

Breaking with the tradition of his teacher and predecessor, J. Farrar, who had served his students by translating French treatises, Peirce wrote original text books (they often proved difficult for the students to follow). He published research work, especially in astronomy. He and the French astronomer Leverrier became involved in a famous scientific controversy concerning the discovery of the planet Neptune. His memoir on "Linear Associative Algebra" read in 1870 before the National Academy of Sciences, is often considered the first original piece of pure mathematics by someone working in the United States. Peirce played an extraordinary role in the professionalization of science and mathematics in the United States. The expression "The Lazzaroni" or "scientific beggars" refers to a small group of scientists led by Alexander Dallas Bache whose goal was to promote the development of a professional scientific community in the United States. The group included Benjamin Peirce, Louis Agassiz and Charles Henry Davis, Peirce's brother-in-law. They were instrumental in the establishment of the Association for the Advancement of Science (1847) and the National Academy of Sciences (1863). The picture, right, shows L. Agassiz (seated) and B. Peirce.



Louis Agassiz and Benjamin Peirce

In 1849, Alexander Dallas Bache, who had received his education at West Point and was superintendent of the United States Coast Survey, created the Nautical Almanac Office (NAO). The NAO was established in Cambridge, Massachusetts, as a separate organization under the direction of Charles Henry Davis. Originally, Cambridge was chosen because of the presence of Peirce and the existence of the Harvard Observatory. In the following years, several of Peirce's students and associates would find employment with the NAO, including one of his favorite pupils, James Edward Oliver. In 1866, the NAO moved to Washington, D.C., prompting Oliver to resign after 15 years of service.

It is hard to establish an exhaustive list of Peirce's students since most of these men[30] came under his influence when they were undergraduates. The list below while incomplete is extraordinarily impressive. All three presidents of Harvard serving between 1862 and 1933, T. Hill, C.W. Eliot and A.L. Lowell are among Peirce's former pupils!

- Thomas Hill '43, Harvard president (1862-1868), Fellow of the American Academy of Arts and Sciences.
- Benjamin Apthorp Gould '44, astronomer, student of C.F. Gauss at Göttingen, Ph.D. 1848, member of the National Academy of Sciences, Fellow of the American Academy of Arts and Sciences.
- James Edward Oliver '49, AM '54, Professor of Mathematics at Cornell, member of the National Academy of Sciences, Fellow of the American Academy of Arts and Sciences.
- John Daniel Runkle '51, mathematician, MIT Acting President (1868–70), President (1870-78), Fellow of the American Academy of Arts and Sciences.
- Chauncey Wright '52, philosopher and mathematician, proponent of Darwinism, Fellow of the American Academy of Arts and Sciences.
- Charles William Eliot '53, Educator, Harvard President 1869-1909, Fellow of the American Academy of Arts and Sciences.
- James Mills Peirce '53, Perkins Professor of Mathematics and Astronomy at Harvard after 1885, Fellow of the American Academy of Arts and Sciences.
- Frederick William Bardwell '56, Professor of Mathematics, astronomy and engineering, University of Kansas.
- Simon Newcomb '58, mathematician and astronomer, Director of the Nautical Almanac Office 1877-1909, successor of Sylvester at Johns Hopkins, fourth president of the American Mathematical Society, Fellow of the Royal Society and member of the National Academy of Sciences, Fellow of the American Academy of Arts and Sciences.
- Charles Sanders Peirce '59 (BS Chemistry '63), logician, mathematician, member of the National Academy of Sciences, Fellow of the American Academy of Arts and Sciences.

[30] From the founding in 1636 to 1879, there was no women students at Harvard. Peirce died in 1880. https://www.radcliffe.harvard.edu/news/radcliffe-magazine/complicated-history-women-harvard

- George Abbott Osborne ’60, Professor of Mathematics and astronomy, MIT.
- Lucien Augustus Wait ’70, Professor of Mathematics, Cornell University.
- William Elwood Byerly ’71, First Harvard Ph.D. ’73, Assistant Professor at Cornell (1873-76), Perkins Professor of Mathematics at Harvard, 1906-1913, Fellow of the American Academy of Arts and Sciences.
- William Edward Story ‘71, Leipzig Ph.D. ’75, mathematician, Professor of Mathematics at the Johns Hopkins University and Clark University.
- Percival Lawrence Lowell ’76, astronomer, Fellow of the American Academy of Arts and Sciences.
- Benjamin Osgood Peirce ’76, Leipzig Ph.D. ’79, physicist, mathematician, Hollis Chair of Mathematics and Natural Philosophy at Harvard, 1888-1914, member of the National Academy of Sciences, Fellow of the American Academy of Arts and Sciences.
- Abbott Lawrence Lowell ’77, President of Harvard University 1909-33, Fellow of the American Academy of Arts and Sciences.
- Washington Irving Stringham ’77, Johns Hopkins University Ph.D. ’80. Professor of Mathematics, the University of California, Berkeley.

During the third quarter of the nineteenth century, three other men who trained in the United Sates made significant contributions to mathematics research: Josiah Willard Gibbs (1839-1903), George William Hill (1838-1914) and Simon Newcomb (1835-1909), a student of Peirce.

Hill studied at Rutgers where he earned a Bachelor’s degree in 1859. He went to Cambridge, MA, in 1861 to work at the Nautical Almanac Office under Simon Newcomb. He remained with the NAO until his death. He is known for his works on the three-body problem, on the lunar orbits and the mutual perturbations of Jupiter and Saturn. He is the author of James Oliver’s memoir published by the National Academy of Sciences.

J.W. Gibbs[31] graduated from Yale in 1858 and earned one of the first Ph.D.’s in Engineering at the Sheffield Scientific School in 1863. After travelling in Europe, he took an unsalaried professorship in Mathematical Physics at Yale in 1871. There,

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[31] *Willard Gibbs: American Genius*, 1942, by Muriel Rukeyser. Reprinted by the Ox Bow Press, Woodbridge CT.

he revolutionized thermodynamics, physical chemistry and created statistical physics.

Because of their personalities, both Hill and Gibbs had very little direct influence on the development of mathematics and physics in the United States during their lifetimes. On the contrary, Newcomb, mostly known for his work in astronomy, worked tirelessly to develop the American scientific community. Here is what Newcomb wrote in *Abstract Science in America, 1776-1876* published in 1876.[32]

The true scientist takes as much interest in the geography of the moon as in that of the earth, and studies the minutest animalcule as zealously as man himself. The very fact that utility is ostensibly ignored gives a breadth to scientific research which it would otherwise never have had, and to which the discoveries which have been of such incalculable utility to mankind are really due. If the practical man should object to useless knowledge as dross, we should reply, that he cannot have the gold without the dross; that such a thing as a discoverer of useful natural laws and an ignorer of useless ones is unknown in the world's history, and will probably remain so. In fact, so far as the discovery of new laws is concerned, it is impossible to say whether a discovery will or will not be useful until after it is made, perhaps generations afterward; therefore he who waits to see the utility before seeking for the discovery will never discover at all…

As a result of our survey, it will be seen that we must form very different estimates both of the past and future of American science, according to the standard we test it by, and the standpoint from which we view it. When we inquire into the wealth and power of our scientific organizations, and the extent of their publications, — when, in fact, we consider merely the gross quantity of original published research, — we see our science in the aspect best fitted to make us contemplate the past with humility and the future with despair….

The basis of our requirements is a better knowledge of the wants of science among those who give money for its promotion. On the

[32] https://archive.org/details/jstor-25109962

material side we want nothing new at present; we require no increase in the number of our museums, observatories, or laboratories during the present generation. What we do want can be seen by studying the logical connection of our several deficiencies, as we have sought to point them out. We are deficient in the number of men actively devoted to scientific research of the higher types, in public recognition of the labors of those who are so engaged, in the machinery for making the public acquainted with their labors and their wants, and in the pecuniary means for publishing their researches.

I.3 THE FOUNDERS

EZRA CORNELL (1807-1874)

I want to go where I can be of the most service to the general enterprise.[33]

When people first learn that Cornell University was created by a man named Ezra Cornell who made a fortune in the telegraph business, they often imagine a self-centered industrial tycoon giving money to create a university that would immortalize his name. The truth, it seems, is rather different, and the life story and personality of Ezra Cornell are quite relevant if one wishes to understand the university he founded.

Ezra Cornell

Ezra Cornell was not extremely rich. When he died in 1874, 6 years after the opening of Cornell, it was not entirely clear at first that he was financially afloat. In the end, he was, and over a million dollars went to his wife and five living children. It appears that the children rapidly spent most of the money, including the oldest son, Alonzo B. Cornell, who

[33] November 5, 1845, letter from Ezra Cornell to his father, E.B. Cornell.

served as Governor of New York, 1880-83. Ezra Cornell was never the business magnate that John D. Rockefeller, the founder of the University of Chicago, or Leland Stanford were. He was never quite as rich as Johns Hopkins whose will provided a total of seven million dollars for the founding of the Johns Hopkins Hospital and the Johns Hopkins University in Baltimore in 1870. J.D. Rockefeller is often identified as the richest American who ever lived. Stanford and Hopkins have often been listed among the top hundred richest Americans ever; Cornell, never. There is no evidence he was self-centered and, on the contrary, much evidence that he was generous, stubborn, and truly interested in the welfare of mankind and the life of his fellow citizens.[34]

Ezra Cornell was born in 1807 in Westchester County, New York, NY, in a Quaker family of 11 children. He was raised near DeRuyter, New York. From there, at the age of nineteen and with nine dollars in his pocket, he walked to Syracuse, 28 miles away, where he worked as a carpenter for a while. Still on foot, he went from Syracuse to Homer and, finally Ithaca where he worked as a hired carpenter until he convinced Otis Eddy, the owner of a cotton mill on Cascadilla creek, to hire him as a mechanic for one year at $8.00 a month to take care of the factory machines. It is said that when Colonel Jeremiah Beebe offered to hire Cornell to oversee his plaster mill, the machines at Eddy's cotton mill were in such excellent condition that Eddy did not object. In 1831, Cornell married Mary Ann Wood from Dryden. Consequently, he was disowned by the Society of Friends for marrying outside of the faith. Seven years later, during the panic and financial crisis of 1839, Colonel Beebe suddenly sold his business and Cornell became unemployed. At the time, Cornell was leasing a farm and owned a hotel and some parcels of land.

In 1842, Cornell and his brother-in-law, Orrin Wood, became involved in a business venture involving selling a new improved plow in the states of Maine and Georgia. Having discovered first hand that the plow venture had no future in Georgia, Cornell put his hopes on Maine. In Portland, he became acquainted with F.O.J. Smith, a man of many interests. Congress had appropriated $30,000 to build a test telegraph line from Baltimore to Washington, and Smith had taken a contract from Samuel Morse to lay down lead pipes containing telegraph wires at a depth of 2½ feet. On the spot, Cornell described to Smith how he thought this could be done efficiently using a modification of the plow he was selling. For the next twelve years, Cornell invested

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[34] See, e.g., *Cornell: A History* by Morris Bishop (1962), *The Builder, A Biography of Ezra Cornell* by Philip Dorf (1952), *Cornell University: Founders and the Founding* by Carl Becker (1942) and *True and Firm: Biography of Ezra Cornell, Founder of the Cornell University* by Alonzo B. Cornell (1884).

what little money he had (or borrowed) as well as all his time, energy and technical and entrepreneurial ingenuity, in developing and promoting telegraph lines between the East Coast of the United States and the Middle West (and also Canada). In the team he formed originally with his employers, Morse and Smith, he was the first to realize that the problem of wire insulation would doom laying telegraph lines in the ground. Through years of experience, he became one of the most knowledgeable men with regards to laying telegraph lines on poles, something that, at first, proved very problematic for a variety of reasons including the harsh winters of the northeastern United States. With extraordinary resilience and stubbornness, he retained his confidence in the importance and potential of the telegraph and pursued his investment of time, effort and money, sometimes, it seems, against all odds. Finally, in 1856, through the acrimonious consolidation of competing enterprises, Cornell—who was then in serious financial trouble—became one of the principal shareholders of the "Western Union Telegraph Company" (a name suggested by Cornell) presided over by his main earlier competitor, Hiram Sibley. Through consolidation, Western Union had created a monopoly which produced rapidly growing dividends. The value of the company's shares rose accordingly.

Cornell turned fifty in 1857 and it became apparent to him that his holding in the Western Union would bring significant regular dividends. He then returned to one of his constant interests, farming, and in particular, livestock. He acquired from his brother-in-law, Orrin Wood, the 300-acre DeWitt farm, located between Fall Creek and Cascadilla Gorge. This would later become the site of Cornell University. Cornell was convinced that technical improvements and education were the keys to the development of agriculture and farming and, in 1862, he became President of the New York State Agricultural Society and was elected to represent Tompkins County at the New York State Assembly. That same year, during the civil war, the Morrill Land-Grant Act was signed into law by President Abraham Lincoln. Two years later in 1864, Cornell was elected to the New York State Senate where he met a much younger fellow senator, Andrew Dickson White. They first battled, supporting opposing ways of implementing the Land-Grant Act in New York State. But they soon joined forces to propose the creation of an ambitious university and pushed that proposal forward through the difficult legislative process. On April 27, 1865, New York State Governor Reuben E. Fenton signed the Charter establishing Cornell University as the Land-Grant University of New York.

The extraordinary growth of the Western Union under it first president, Hiram Sibley, had led to Cornell's fortune and the creation of the university in Ithaca, on land given by Cornell, and with an initial endowment of $500,000, backed by $700,000 of Western Union shares. In addition, the university was the recipient of

Land-Grant paper scripts for over 900,000 acres of public land with an estimated value of about $600,000.[35] One of the greatest gifts of Ezra Cornell to the university bearing his name lies in the way he proposed to administer and manage the Land-Grant scripts. By the early 1890's, the Land-Grant scripts had contributed over 5 million dollars to the Cornell endowment.

Ezra Cornell died in Ithaca on December 9, 1874, six years after the opening of the university.

ANDREW DICKSON WHITE (1832-1918)

The cardinal doctrine of a fanatic's creed is that his enemies are the enemies of God.[36]

The first president of Cornell University, A.D. White, was born on November, 7 1832 in Homer, New York. A few years later his family move to Syracuse where his father had opened a successful bank. In 1849, he was sent to Geneva College[37] where he dropped out in an attempt to persuade his father to send him to Yale College. His father reluctantly agreed and White became a very successful student at Yale (among his many distinctions there, he won the De Forest prize for public oratory). He graduated in 1853, a year after his friend, Daniel Coit Gilman, who would become the first president of Johns Hopkins University. They both belonged to one of Yale's secret societies, the Skull and Bones. After traveling, studying and working in Europe (1853-54), he returned to Yale, earned a Master's degree in History, and accepted a professorship at the University of Michigan (History and English Literature). He was on the faculty at Michigan from 1858 to 1863. After traveling again in Europe, 1862-63, lobbying

Andrew Dickson White

[35] *Cornell University: Founders and the Founding* by Carl Becker (page 39).

[36] *The History of the Warfare of Science with Theology in Christendom* by A.D. White, 1898.

[37] Now, Hobart and William Smith Colleges.

for support to the United States government in the American Civil War, he returned to Syracuse to attend to family affairs and was elected to the New York State Senate, on the Union Party ticket. In 1862, White wrote a letter to Gerrit Smith, a leading reformer, abolitionist and philanthropist from the Syracuse area, in which he suggested the creation of "a truly great university". Two years later, the New York Senate debate on the implementation of the Land-Grant Act of 1862[38] brought A.D. White and Ezra Cornell together and led to the creation of Cornell University. White served as the founding President of Cornell from 1866 to 1885. Throughout his adult life, he remained involved in political affairs and public service, in particular, foreign affairs and diplomacy.[39] He served as Ambassador of the United States in Germany (1879–1881 and 1897–1902) and Minister to Russia (1892-1894). He died in 1918.

Relations between a living principal benefactor and the first president of a new university have often been difficult. At the creation of the Johns Hopkins University, White's close friend, D.C. Gilman, had a relatively free hand because that university was funded by a bequest of its benefactor. The same cannot be said for Clark University's first president, G. Stanley Hall, whose vision of an elitist research institution was much at odds with the ideas of the founder, Jonas Clark, who was more broadly interested in education for all. Difficulties also arose between Leland and Jane Stanford and the first president of their university, Cornell's graduate David Starr Jordan. William Rainey Harper, the first president of Chicago from 1890 to his death in 1906, pursued his grand vision for the development of the University of Chicago without much concern for the deficits which were only covered through many additional gifts provided by J.D. Rockefeller, the last, of ten million dollars, in 1910. For the most part, the relations between Cornell and White were amicable and constructive, even through the inevitable frictions that arose between these two leaders with vastly different upbringing. For different reasons, Ezra Cornell and Andrew White were steadfast in promoting the new university as a non-sectarian institution. They where also in strong agreement about opening higher education to all men—and women—without prejudice for social status, religion or race. At the end, Ezra Cornell's gift and support allowed Andrew White's ambitious dream and academic vision for a great American University to shape the future of the institution they created.

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[38] Act of the U.S. Congress that provided grants of land to states to finance the establishment of colleges specializing in "agriculture and the mechanic arts."

[39] *Andrew D. White—Educator, Historian, Diplomat by* Glenn C. Altschuler.

CHAPTER II: THE EARLY YEARS, 1868-1879

II.1 THE OPENING OF CORNELL

Fellow-citizens, when Mr. Cornell found himself rich beyond the dreams of avarice, did he give himself up to a life of inglorious ease? No, fellow-citizens; he founded the beautiful library in yonder valley. But did he then retire to a life of luxury? No, fellow-citizens; he came up to this height (and here came a great wave of the hand over the vast amphitheater below and around us) and he established this universe![40]

[40] Autobiography of Andrew Dickson White, Volume I, page 386. An orator, in 1869, at the laying of the corner stone of McGraw Hall, quoted by Goldwin Smith speaking to Andrew D. White (who had not paid attention) after the ceremony. Goldwin Smith noted: "*There is nothing more to be said; no one need ever praise the work of Mr. Cornell again.*"

In 1864, two newly elected New York State senators named Andrew D. White and Ezra Cornell became acquainted through the review of a bill creating the "Cornell Library" in Ithaca and, after opposing each other over the proper use to be made of the Land-Grant funds associated with the Morrill Act of 1862, began to work on the creation of Cornell University. On April 27, 1865, the governor of New York, Reuben Fenton, signed into law the Cornell University charter. The town of Ithaca where the university would rise had a population of seven thousand.

At a meeting of the Board of Trustees, in February 1867, President White proposed to elect the first two professors of Cornell University, Evan W. Evans and William Channing Russel. The life and contributions of E.W. Evans, the first Professor of Mathematics at Cornell, will be discussed later. Russel was elected Professor of modern languages and Associate Professor of history. A graduate of Columbia University and Harvard Law School, he had recently accepted a professorship at Antioch College, Yellow Spring, Ohio, after practicing law in New York City and serving as officer in the Civil War. Russel was born in Boston in 1814. He played a key role during Cornell's early years. He soon became Vice-President of the University and served as Acting President during Andrew D. White's long absences between 1876 and 1881(Commissioner to the Paris Exposition in 1878, and United States Minister to Germany, 1879-1881). In 1881, at the age of 67, Russel was forced to resign his positions of Vice-President and Professor at Cornell, an event that created great controversy.[41] From 1881 to 1883, he was Professor of History at Brown University.

On Wednesday, October 7, 1868, several hundred people attended the opening ceremonies of the University where Ezra Cornell spoke briefly.

I hope we have laid the foundation of an institution which shall combine practical with liberal education, which shall fit the youth of our country for the professions, the farms, the mines, the manufactories, for the investigations of science and for mastering all the practical questions of life with success and honor. I believe that we have made the beginning of an institution which will prove highly beneficial to the poor young men and the poor young women

[41] See, e.g., Morris Bishop, *A History of Cornell*, Chapter XII, The Doubtful Years, 1876-1881.

of our country . . . I trust we have laid the foundation of a university - an institution where any person can find instruction in any study.

In the absence of Governor Reuben Fenton, Lt. Gov. Woodford administered the oath of office to Andrew Dickson White, Cornell's first president, and presented him with the Charter, Seal and Keys of the University.

Cornell's first entering class counted 412 students. They had taken an entrance examination on October 6, in the basement of the Cornell Library in downtown Ithaca. The students and many professors were housed in Cascadilla Place. Originally, Cascadilla Place was intended to be a water cure hospital of which E. Cornell was the main investor. In 1866, Cornell and the trustees of the new university convinced the other investors to accept fifty cents on the dollar to cede the building (still unfinished) to the University. Cascadilla Place became the first building of the future Ithaca campus. At the University's opening, building number 1 or the South Building, later to be renamed Morrill Hall, was barely finished. Building number 2 or the North Building, which would become White Hall, was under construction. The South Building housed instruction and some dormitories, as did the North Building after 1869.

A historical glimpse at Cornell's early years is found in an article by the Norwegian-American Hjalmar Hjorth Boyesen published in Cosmopolitan magazine in November 1887. Boyesen was educated at the Universities of Leipzig and Oslo and emigrated in 1869. He taught North European Languages at Cornell, from 1874 to 1880, before joining Columbia University.

To him who now walks across the University campus, with its stately piles of masonry, its broad, elm-shaded avenues and its clusters of pretty cottages, it seems scarcely credible that all this is the work of less than twenty-five years. The writer can well remember the time, not so very remote, when the campus was an ungraded, rough-looking hill-top, surmounted by three ugly barracks of gray sandstone. There were no definable sidewalks, and after every storm the clayey roads were rivers of mud, which no one crossed without dire necessity. It was no unusual thing for professors, who had disregarded the peril, to arrive in their class-rooms covered with mud from head to foot. It is needless to say that they always met with an enthusiastic reception….

A queerer, more variegated, and heterogeneous body of men probably never gathered in one spot, since Romulus inspected the gentlemen who had accepted his invitation to found the Roman Empire. The odds and ends of humanity, who had found no

Building 1, also known as the South Building and, later, Morrill Hall

convenient niche in the world and held the world responsible for their failures, were largely represented. There was a sprinkling of political refugees from Bulgaria, Serbia, and Russia. A few representatives of Brazil and Central America, and not a few of the all-pervasive species, the American crank, were to be seen floundering through the mud on the newly opened campus. The number, all told, who descended upon Mr. Cornell and his coadjutors was not far from eight hundred. The weeding out of the absolutely impossible characters from this interesting crowd was a work which could not be delayed. But it went against the grain with

Mr. Cornell, and no man seemed to him so foolish or vicious as to deserve dismissal without a fair trial. The most transparent humbugs, who told fictitious but thrilling autobiographies, I have seen him listen to with the utmost courtesy and patience. One of the most difficult things to make him understand was that any person could be so ignorant as not to be benefited by university teaching….

No one who knows the interior of the State of New York and the social conditions in its many small towns and villages will need to be told that the early days of "Cornell" were not all sweetness and light. There were zeal for learning, earnestness, and energy; a more or less potent conviction that something new and great was here being fashioned out of chaos, fruitful with blessings to the human race. But society was crude and raw. The Faculty was an exceedingly heterogeneous and ill-assorted body, including gentlemen of refinement and culture, and cranks and cads, skillful, no doubt, in their specialities, but odd in manners and costume. The students, after the first weeding-out process had been completed, were young men who had come to work and had little time to cultivate the amenities of life. Even now, the proportion of idle young men, who go to college in obedience to the wishes of their parents rather than their own, is far smaller than in any other institution with which I am acquainted. A healthy tone prevails. There is time for work, and there is time for play; but the frivolous youth who devotes himself to the latter, to the exclusion of the former, will yet find himself in uncongenial company at "Cornell." Nearly all classes of our composite society are now represented in the student body. A healthy Americanism—a spirit of equality, earnestness, and a contempt for shams—is what most forcibly strikes a foreign visitor.

The Faculty has undergone a similar evolution. It has, indeed, never lacked able men; but most of the odd characters who constituted an undue proportion during the formative period have gradually disappeared….

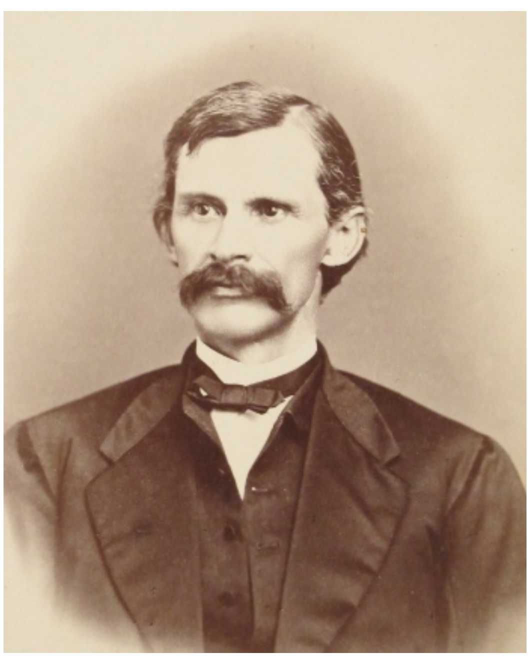
Cornell has always prided itself on being abreast of the times, and there is scarcely a branch of useful knowledge which is not represented in its corps of instructors, numbering upward of a hundred persons. The Faculty proper consists of forty-six members, *among whom are representatives of branches of knowledge not usually included in an academic curriculum. Thus there are, for instance, Professors of Military Tactics, Electrical Engineering, Civil Engineering, Mechanical Engineering, Applied Mechanics, Veterinary Medicine and Surgery, Architecture, and Agriculture. A few years ago a School of Law (which has now eighty-four students) was added to the University; a School of Pharmacy with nine students is also in operation, and a School of Medicine is among the possibilities of the near future. Though the instruction in practical branches covers a much larger area than in any other institution, here or abroad, the aim is to make these technical students not merely arid specialists, but men of broad culture. There are three general courses, leading to the degrees of Bachelor of Arts, Bachelor of Philosophy, Bachelor of Science or of Letters.*

It is safe to assert that no American institution of learning has reached, in so short a time, so commanding a position as is occupied by "Cornell" to-day. Ezra Cornell builded, perhaps, better than he knew. The institution which he founded has demonstrated its usefulness, and has a secure hold upon the future.

II.2 The Department of E.W. Evans, Z.H. Potter and H.T. Eddy

Evan William Evans (1827-1874)

Evan William (or Wilhelm) Evans was born Jan. 6, 1827 in Llangyfelach, near Swansea, South Wales. His family joined a Welsh settlement in the township of Pike, Bradford County, Pennsylvania, in 1831. After graduating from Yale in 1851, Evans became Principal of the Delaware Literary Institute, in Franklin, NY. He returned to Yale and served as tutor in 1856-57 before accepting the position of Professor of Mathematics and Natural Philosophy at Marietta College, 1857-64. He then left Marietta (perhaps, for health reasons) and was engaged in mining engineering (perhaps in West Virginia) when he was called by his fellow Yale alumni Andrew White to become Professor of Mathematics at Cornell.



Evan W. Evans

By choosing Evans as Professor of Mathematics, President White was calling on a trusted acquaintance who would play a leadership role among the faculty of the new university, and it appears that Evans embraced and fulfilled that role during his short tenure. At the time of his appointment, Evans was already affected by tuberculosis. During the years, 1871-74, he was on leave most of the time. (He tended his resignation in 1873 but President White refused to accept it.) He passed away at the age of forty-seven in Ithaca in 1874, the same year Ezra Cornell died.

College of Mathematics. 69

College of Mathematics and Engineering.

FACULTY.

The PRESIDENT.
Professor EVANS, *Dean*.
Professor CLEVELAND.
Professor MORRIS.
Professor POTTER.

I. SCHOOL OF MATHEMATICS.

The full course in this division of the College comprehends nine Trimesters, or three years, and enters complete into the General Course in Science. For the other courses, and especially for the Course in Agriculture, a shorter curriculum is provided, in which Algebra is completed in the Fall Trimester, geometry in the Winter and trigonometry in the Spring—all mathematics beyond this point being optional in those courses. Astronomy is taught in the fourth year of the General Courses. The following is the full mathematical scheme:—

FIRST YEAR.—*Fall Trimester.*—Loomis's "Treatise on Algebra" completed. *Winter Trimester.*—Loomis's "Elements of Geometry" begun. *Spring Trimester.*—Loomis's "Elements of Geometry" completed; conic sections.

SECOND YEAR.—*Fall Trimester.*—Loomis's "Trigonometry," plane and spherical, with applications to mensuration, surveying and navigation. *Winter Trimester.*—Loomis's "Analytical Geometry." *Spring Trimester.*—Church's "Differential Calculus."

THIRD YEAR.—Church's "Integral Calculus;" applications of the calculus to subjects in physical science; and lectures on higher geometry and quaternions.

A page of the Cornell Register of 1868-69

Evans was recognized as an excellent specialist of cymric philology and he left an unfinished *History of Wales.* We know little about his mathematics interests. He wrote an elementary book on geometry, *Primary Elements of Plane and Solid Geometry,* published in 1862. More impressive is the following paragraph taken from William Elwood Byerly's obituary,[42] written by J.L. Coolidge.

> *Byerly's professional life is largely explained by the influence of two unusual men. The first and greater of these was Benjamin Peirce, who towered above his mathematical contemporaries as a mountain peak in a level plain…*
>
> *The other man who influenced him similarly was his predecessor in the Cornell professorship, Evan W. Evans. He introduced Byerly to the modern technique in analytic geometry. Very soon after the latter's appointment at Harvard, he initiated a course in this subject which he taught regularly until his resignation. The course has continued uninterruptedly since, and in spite of all modifications, the traces of the original inspiration persist.*

ZIBA HAZARD POTTER (1836-1913)

During Cornell's first year of operation, 1868-69, Evans was assisted by Ziba Hazard Potter. Potter was born in Potter, Yates County, NY, in 1836, the son of Dr. Hazard Potter and Louisa S. Ballou. The town of Potter (1832) is named after one of Ziba's ancestors, Arnold Potter, who owned more than 35,000 acres there. Ziba Potter appears to have studied medicine with his father. He graduated from Hobart College in 1857 and earned an AM in 1860. He served four years as Assistant Surgeon in the U.S. Army during the Civil War and was in charge of the Hospital at Fort Randall in the Dakota Territory until 1867, when he resigned. The record shows he received an MD from Geneva Medical College in 1867. *One can only wonder how he became Assistant Professor of Mathematics at Cornell where he taught from 1868 to 1882*. From 1877 to 1882, he also served as Medical Examiner. Nonetheless, Potter was

[42] W.E. Byerly is one of the first two Harvard graduate students to earn a Ph.D. and the first to do so under B. Peirce. Upon graduating in 1873, he joined the Cornell faculty before returning to Harvard in 1876 for the rest of his career.

apparently a good teacher. Alumni A.W.S.'78 wrote the following reminiscence in *Cornell Alumni News* of October 23, 1930.

In 1874-5 I studied elementary mathematics in White Hall with Professor Ziba Hazard Potter. He was an excellent teacher, a man of fine human sympathy, and a lover of a joke. One day in class he spoke of the impossibility of squaring a circle. Then he said: "If you should hear of anybody trying to square a circle, tell him you have a better job for him; ask him how much he would charge a day to throw feathers over a barn." All my life this has been my standard of futility.[43]

Ziba Hazard Potter

Potter also earned a law degree from the Albany Law School and Union College and, after leaving Cornell, moved to Washington, D.C. and worked for the Department of Interior. He died in Bethlehem, Pennsylvania, in 1913.

Two military men, W.E. Arnold (1869-75) and W. Hamilton (1869-70), also served as Assistant Professors of Mathematics during the department's early years. Major William E. Arnold was also Professor of Military Tactics. These choices of men are significant as they tell us something about the priorities of the new university: The needs for mathematic instruction was obvious but it was met with a rather modest (if not inexistent) interest in mathematics scholarship. The first four men hired by Andrew White and the Board of Trustees to form the Department of Mathematics were a medical doctor, two military officers and a Yale graduate best remembered for his interests in Cymric literature and the history of Wales.

[43] This is a rather high-level mathematical joke: The problem of squaring the circle has its root in Greek mathematics but a definite proof of the impossibility of squaring the circle only came with the proof that the number π is transcendent (Ferdinand von Lindemann, 1882). https://en.wikipedia.org/wiki/Squaring_the_circle

HENRY TURNER EDDY (1844-1921)

Henry Turner Eddy

In September 1869, Cornell hired Henry Turner Eddy[44] as Assistant Professor of Mathematics, the first member of the department with a marked interest for research and scholarship in mathematics. Eddy was born June 9, 1844, in Stoughton, Massachusetts. He was a brilliant student at Yale where he earned a Ph.B. in 1868.[45] The next year, he taught Latin and Mathematics at the University of Tennessee. At Cornell, he earned a Civil Engineering degree in 1870 and, in 1872, the first Ph.D. of any kind ever awarded by Cornell. His dissertation was in Applied Mathematics but there is no record of its title. During the year 1872-73, he served as Acting Chair in the absence of Professor Evans, whose health was failing. At the end of that academic year, Eddy resigned and moved to Princeton where he served as Adjunct Professor for a year before joining the University of Cincinnati. There, he was Professor of Mathematics, Astronomy, and Civil Engineering for sixteen years. In 1890, while serving as Acting President and President-Elect at Cincinnati, he accepted the position of President at the Rose Polytechnic Institute at Terre Haute, Indiana, where he stayed from 1891 to 1894. He finished his career at the University of Minnesota where he served as Dean of the Graduate School, and retired in 1912. A building of the University of Minnesota old campus is named after him. Despite holding important administrative positions, he remained active in research all his life. He died in Minneapolis on December 11, 1921. In 1893, an International Mathematical Congress convened in Chicago as part of the World's Columbian Exposition, with the participation of the great German mathematician Felix Klein.

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[44] No connection with Eddy Street and Eddy Gate which are named after Otis Eddy, the Ithaca entrepreneur who employed the young Ezra Cornell as a mechanic in his cotton cloth factory.

[45] The Philosophy Bachelor (Ph.B.), was an undergraduate degree that was considered somewhat higher than other Bachelor's degrees.

On this occasion, Klein also delivered a famous series of lectures in Evanston (Northwestern University). Eddy was among the American speakers at the congress and his lecture on *Modern Graphical Methods* was said to have impressed Klein, who was deeply convinced of the importance of developing the connections between mathematics and its applications. In 1904 at the St Louis Mathematical Congress held on the occasion of the World's Fair and Louisiana Purchase Exposition, Eddy was again one of the American speakers in the Applied Mathematics section and he delivered a talk on *The electro-magnetic theory and the velocity of light.*

In *Mirror-Image Twins: The Communities of Science and Technology in 19th-century America*, Edwin Layton writes[46]

> *The development of graduate-level work at American universities after the Civil War produced engineers who had the training to develop and apply methods of mathematical theory to materials. Henry Turner Eddy, a graduate of Yale's Sheffield Scientific School who received his Ph.D. from Cornell, was among the first of this new generation of scientific technologists. In 1878 he published an extension of the new graphical methods in his Researches in Graphical Statics. It was one of the first American engineering books to be translated into German; Florian Cajori, the historian of American mathematics, called it "the first original work on this subject by an American writer."*

Cornell University and its Department of Mathematics can be proud of their first doctorate recipient. It took fourteen years for another Ph.D. in Mathematics to be awarded at Cornell, to graduate student Hiram John Messenger,[47] in 1886.

WILLIAM ELWOOD BYERLY (1849-1935)

The first Mathematics Ph.D. at Harvard went to William Elwood Byerly in 1873. Byerly immediately joined the faculty at Cornell, replacing H.T. Eddy who left for Princeton that year. Three years later, in 1876, Byerly returned to his *alma mater* where he later held the title of Perkins Professor, from 1905 to 1913 when he resigned because he was losing his eyesight.

[46] *Technology and Culture* 12 (1971): 562—580.
[47] Messenger would later become a Cornell Trustee and endow the famous *Messenger Lectures.*

William E. Byerly

Byerly was very popular among Cornell students and, upon learning of his future departure, they organized protests, asking he be retained at all costs!

Byerly did not really pursue mathematical research but was a superb teacher of advanced mathematics. He wrote several influential text books, improved Harvard Mathematics curriculum, and promoted higher education for women. At Cornell, he taught Christine Ladd and Martha Carey Thomas (later, President of Bryn Mawr) and, at Harvard, he played an important role in the development of Radcliffe College as the following quote from (then) Harvard President Emeritus Eliot makes clear.

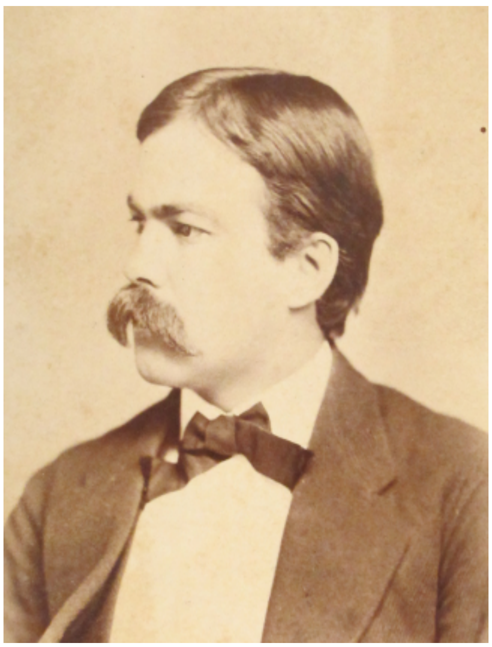
I have known about Professor Byerly's work from the beginning and I still know about it. I can only say that he has been the most indispensable person connected with the growth and development of Radcliffe College.

II.3 The Department of J.E. Oliver, L.A. Wait and G.W. Jones

Two other Harvard graduates and former pupils of Benjamin Peirce joined the department during these early years, the young Lucien Wait in 1870 and James Oliver in 1871. More than anyone else, they shaped the future of Mathematics at Cornell. In succession, Oliver, until his death in 1895, and then Wait, until his retirement in 1910, chaired the department for a total of 36 years following the death of E. W. Evans in 1874. During most of the chairmanship of Oliver (famously, a living caricature of the absent-minded professor), Wait served as Associate Chair. A full account of James Oliver’s life and contributions will be given in the next chapter. In 1877, Oliver and Wait were joined by George W. Jones and, together, they shaped the department until the end of the nineteen century.

LUCIEN AUGUST WAIT (1846-1913)

"Lucien Wait devoted his whole life to the Cascadilla School, contributing much of his own professor's salary to the development of the School. In 1910, Wait transferred his School to a group of Ithaca businessmen who formed the Cascadilla School Association in 1914."



Lucian A. Wait

Lucien August Wait was born at Highgate, Vermont, on February 8, 1846. He was educated at Phillips Exeter Academy and graduated from Harvard in 1870, joining Cornell as an Assistant Professor of Mathematics. He married Anna J. Dolloff in 1873 in Exeter, New Hampshire. In 1873-74, Wait was on leave from Cornell, serving as United States Consul in Athens and the Piraeus. In Ithaca where a street is named after him,[48] Wait is remembered as one of two young faculty members[49] who, in 1876, founded the Cascadilla School, a successful prep-school for students wishing to enter Cornell University. The school still exists as a private high school.

From what we know, it seems that Wait never had much interest in research. He was an educator, an excellent teacher and an organized and skilled administrator. He wrote[50]

The needs, then, seem to me to be these: a more democratic department organization, in which all members may feel an equal interest, in order to facilitate the department business, improve the methods of teaching, and promote advanced study; fewer trustees,

48 Wait Avenue which forms a crescent off Thurston Avenue.

49 The other is Bela P. MacKoon who taught Latin and German.

50 *Advanced Instruction in American Colleges*, The Harvard Register, vol. 3, p. 127, 1880.

> *better teachers, and more of them; larger salaries; more sympathy, and intelligent cooperation between all branches of the university.*

If some of Wait's recommendations have still to be fulfilled, his first point describes admirably the spirit in which the governance of the Cornell Department of Mathematics is organized up to now!

Postponing our discussion of Professor Oliver and his leading role in the development of mathematics at Cornell until the next chapter, let us introduce the colorful character George William Jones. In doing so, we will make a detour via Iowa to get a glimpse of the professional lives of some early Cornell faculty.

GEORGES WILLIAM JONES (1837-1911)

George W. Jones

Jones was born on October 14, 1837, in East Corinth, Maine. He graduated from Yale (A.B. 1859, M.A. 1862) where he was a contemporary of William A. Anthony (1860), later Professor of Physics at Cornell (1872-1887). In the 1860s, both Anthony and Jones taught at the Delaware Literary Institute in Franklin, NY, where Jones served as Principal from 1862 to 1868. In 1868, Jones became the first Professor of Mathematics and Civil Engineering at the Iowa State Agricultural College where he served as Acting President while the President Elect, Adonijah Welch, was finishing his term as US Senator from Florida. Iowa State College, located in Ames, Iowa, was created by the state legislature in 1858 and became a Land Grant Institution[51] in 1862 under the name of Iowa State College of Agricultural and Mechanic Arts. The first students entered in 1869, and the first class (24 men and 2 women) graduated in 1872.

[51] Under the Morrill Act of 1862.

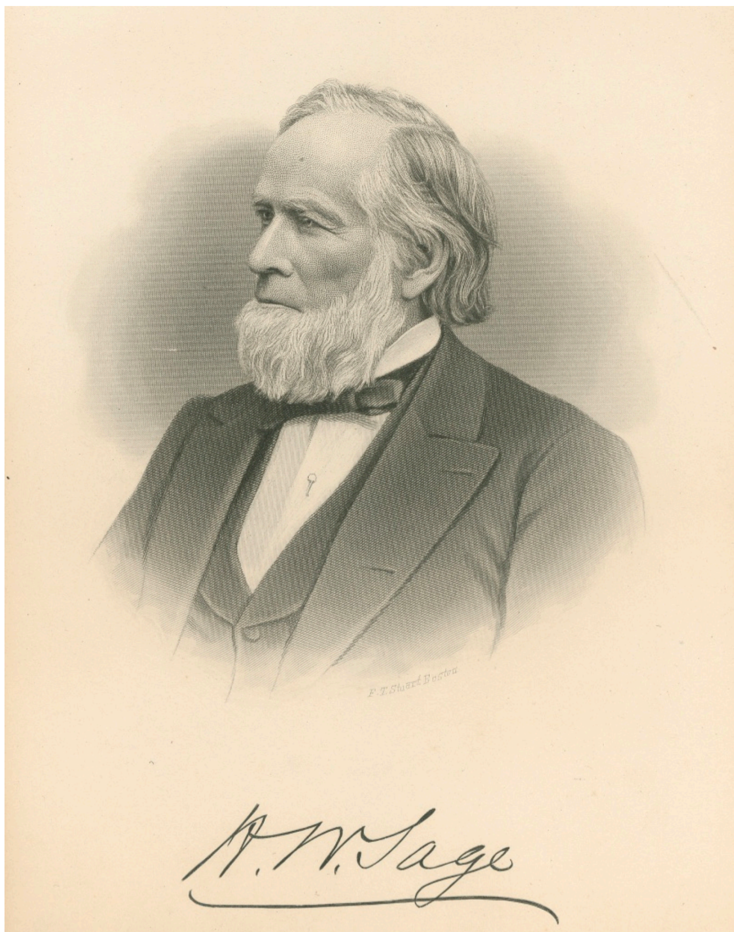
A house, known later as "The Maples" and "Music Hall", was erected for Professor George W. Jones. It later became the home of Jones' successor, Edgar Stanton[52] (Iowa State, Class of 1872), Professor of Mathematics from 1874 until his death in 1920. It then housed the Music Department until it was razed in 1978. Jones' colleague, William A. Anthony, had left the Delaware Literary Institute in 1867 to teach at Antioch College, Ohio. He joined the Iowa faculty in 1870 as Professor of Physics, staying two years before he moved to Cornell where he is credited with teaching one of the first Electrical Engineering courses in the United States.

The Maples, the home built for Professor Jones at Iowa College

During the year 1873, political unrest shook Iowa State College and its Board of Trustees. Grangers and Greenbacks (two independent political movements which played an important role in Midwest politics at the time) asserted that the College was "drifting away from the original intent," meaning that it was not a practical farm school. With the aim to restore harmony, the board called for the resignation of

[52] Stanton was also a former pupil of Jones at the Delaware Literary Institute.

President Welsh and the entire faculty. This was immediately followed by the reelection of all but three faculty including G.W. Jones who failed to be reelected by one vote, 5 to 6[53]. In his report on this episode, E.D. Ross notes that Jones' academic responsibility in the College and his abrupt manners did not help him in this instance, and that the cause of the deposed professors was supported by the opposition as a case of autocratic suppression of freedom of teaching, and as a result, the disturbance was increased rather than moderated. As fate would have it, Jones' nephew, Raymond A. Pearson '94, a graduate from the Cornell Agriculture College, served as the President of Iowa State University from 1912 to 1926!



Henry W. Sage, Chairman of the Board of Trustees
1875-1897

Jones was indeed a supporter of the Grange and Greenback movements and, after losing his faculty position, he became the publisher of the *Western Farmer and*

[53] *The Iowa State College of Agriculture and Mechanic Arts* and *A history of the Iowa state college of agriculture and mechanic* by Earle D. Ross.

Patron's Helper, the official newspaper of the the Iowa State Grange, in Des Moines. In the summer of 1877, he accepted the position of Assistant Professor of Mathematics at Cornell where his colleague W.A. Anthony had been teaching for 5 years. In fact, Anthony and Jones were not the only two faculty members from Iowa State College to join Cornell during the mid-1870s. In these early years, the Cornell administration was famously struggling to develop agricultural and farming programs. The first attempts in this direction form a well-known sequence of tragi-comic incidents[54] but, in 1873, Professor Isaac P. Roberts left Iowa State to join Cornell. Over time, Roberts would create a successful agriculture program.

Roberts was born on a farm in Seneca County, New York, on July 24, 1833. He was educated in the district school of the town of Varick and at the Seneca Falls Academy. He practiced carpentry and taught in schools during the winters until he could buy a farm. After moving to Iowa in a pioneer wagon, he was offered, in 1869, the position of "Superintendent of the Farm" and "Secretary of the Board of Trustees" of the Iowa State Agricultural College at Ames, and shortly afterward was made Professor of Agriculture. E.D. Ross relates Roberts' move from Iowa to Cornell as follows.

> *During the faculty reorganization in 1873 Roberts, distrustful of board policies and dissatisfied with living conditions at the farm house, accepted a call to the New York Agricultural College at Cornell, where he was destined to have a long and influential career as a teacher and administrator. This opportunity came largely through the influence of his former colleague in the physics department, William A. Anthony, who had resigned the previous year and preceded him at Cornell…. These differences were the preliminaries of a real administrative crisis which culminated in the legislative investigation of 1874—a combination of tragedy and comedy.*

About the influence of Roberts at Cornell, Liberty H. Bailey wrote the following paragraph.

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[54] *A History of Cornell* by Morris Bishop.

For thirty years Professor Roberts led the work in agriculture at Cornell University. These were the eventful and triumphant years of 1873 to 1903. They began in doubt and with small things, but they were large with faith. He developed one of the best institutions of its kind.

Let us now return to G.W. Jones. Having been involved with the Greenback party and publicly defended strikers in Iowa, Jones had the reputation of being a political radical and this almost cost him his job in 1880[55] when the Cornell trustees under the leadership of Henry W. Sage considered purging the Cornell faculty of its most radical elements. We will return to these events later as they also involved James Oliver. Ultimately, the large purge did not take place, and Jones remained at Cornell.

In Ithaca, Jones organized a Society for the Prevention of Crime and promoted total alcohol abstinence, concluding a speech he gave at a meeting in the Methodist Church by the following sentence.

I have come to the conclusion that when Christ turned that water into wine, HE DID WRONG!

It is said that Jones was never heard again in any Ithaca church.[56]

In *A History of Cornell,* Morris Bishop quotes a student recalling that Jones taught spherical trigonometry using his abdomen for illustration. Around 1884, Jones, who was known as Piute Jones for his assumed resemblance to Piute Native Americans, started a summer prep school of Mathematics and Languages, to prepare students for the Cornell's entrance and scholarship examinations. In the *Alumni News* of 1942, Romeyn Berry, author of the lyrics for the Cornell song *The Big Red Team* in which he dubbed Cornell athletics the "Big Red", remembers his arrival in Ithaca in the summer of 1899.

The boarding house lady told us where Barnes Hall was. We found it in the afternoon, matriculated in Piute Jones's summer school,

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[55] Morris Bishop, *A History of Cornell, Chapter XII: The Doubtful years 1876-1881.*
[56] Morris Bishop, *A History of Cornell*, page 119.

paid our fees and purchased the prescribed textbooks. Piute Jones's school was dedicated to coaching sub-freshmen for the University Scholarship examinations. Mr. Elmer Bogart '94 was in charge for Piute. Recitations would be held in Barnes six days a week, he said, from three to six: one hour each to Latin, Greek, and mathematics. We were to study all morning and again for another hour after dinner. But he warned us not to attempt to study in the evenings on top of all that. The evenings, he said, were to be devoted exclusively to healthful recreation.

"Piute's Summer School" was a fixture of Cornell student life for many years. Here is one entry of the 1906 senior class year book.

> Eugene C. Crittenden, of Oswayo, Penn., after three years in the Mansfield Normal School, and three years of teaching, heard of "Piute," and came to Ithaca to attend the Jones Summer School in 1902. He liked the place so well that he has stayed here most of the time since then. As "Critt" was somewhat of a grind, another three-year period sufficed for him to take his A.B., start a collection of keys, and be appointed to the faculty. Now he is planning to get another section of the alphabet after his name, and incidentally is acquiring a reputation for busting Freshmen.

CORNELL'S TRIO: OLIVER, WAIT AND JONES

Professors Oliver, Wait and Jones formed a famous trio of educators whose reputation reached beyond Cornell via their treatises on elementary university mathematics:

- *A Treatise on Trigonometry.* By Profs. Oliver, Wait and Jones. Ithaca: Finch & Apgar 1881, second edition, New York: J. Wiley & sons, 1883.
- *A Treatise on Algebra.* By Profs. Oliver, Wait and Jones of Cornell University. Ithaca, NY, 1882; second edition, Dudley F. Flinch, 1887.

Jones alone later added drill books to the series:

- *A Drill-book in Trigonometry.*
- *A Drill-Book in Algebra.*

- *Logarithmic Tables.*
- *Five Place Logarithms.*
- *Some Proofs in Elementary Geometry*.

He also co-authored

- *A Treatise on Projective Geometry,* by G. W. Jones and A. S. Hathaway. Ithaca, N.Y., Dudley F. Finch, 1888.

ALGEBRA.

I. PRIMARY DEFINITIONS AND SIGNS.

ALGEBRA is that branch of Mathematics which treats of the relations of numbers. It is distinguished from Arithmetic, as having wider generalizations, as using signs and letters more freely, and as recognizing negatives and imaginaries. The applications of many words common in Arithmetic are greatly extended in Algebra, and their definitions are correspondingly enlarged.

The symbols explained below constitute a symbolic language, a species of short-hand writing, wherein numbers and their relations are more conveniently expressed than in the ordinary language of words. In this language the signs stand for words and phrases, and generally have the same grammatical relations as the words and phrases themselves. The words may be restored at any time. The reader should constantly practice translating from one form to the other till both are familiar.

This symbolic language is one of the characteristic features of Algebra; and among its many advantages are these: clearness, brevity, and generality of statement; the ability to mass directly under the eye, and thus to bring before the mind as a whole, all the steps in a long and intricate investigation; and the facility of tracing a number through all the changes it may undergo. Some other sciences, for example Chemistry and Logic, have a symbolic language of their own.

Here is what Florian Cajori says, in his 1890 report[57] surveying Mathematical education in the United States, concerning Cornell and its trio of Mathematics professors.

The Treatise on Algebra is not a book intended for beginners, but primarily for students entering the Freshman class at Cornell, and who have had extensive drill in elementary algebra. Most of our American colleges would find the book too difficult for use, on account of deficient preparation on the part of students entering.

If we compare Oliver, Wait, and Jones's Algebra with algebras used in our colleges ten or fifteen years ago, we discover most radical differences and evidences of a speedy awakening of mathematical life among us. A great shaking has taken place among the "dry-bones" of American mathematical text-books, and no men "shake" more vigorously than the professors at Cornell. Among the improvements we would mention a clearer statement of first principles and of the philosophy of the subject, the introduction of new symbols, a more extended treatment and graphic representation of imaginaries, and a more rigid treatment of infinite series. With some corrections and alterations in subsequent edition, we have little doubt that the book will become the peer of any algebra in the English language.

I.4 THE FIRST STUDENTS

Eight students graduated, all with Bachelor of Arts degrees, at the end of Cornell's first academic year (Spring 1869). In Spring 1870, there were eight Bachelors of Arts, seven Bachelors of Philosophy, eight Bachelors of Science, and one Civil Engineer's degree (Henry T. Eddy).

The Class of 1871 had seven B.A.'s, nine Ph.B.'s, seventeen B.S.'s, seven Bachelors of Civil Engineering and one Bachelor of Veterinary Science. The class of 1872 had four B.A.'s, nine Ph.B.'s, thirty nine B.S.'s, sixteen B.C.E.'s, one B.V.S., one Master of Science (David Starr Jordan) and one Ph.D. (Henry T. Eddy). Between the

[57] *The Teaching and History of Mathematics in The United States* by Florian Cajori, 1890.

opening in 1868 and 1877/78, Cornell awarded a grand total of 4 doctorates (one in Mathematics to H.T. Eddy, as noted above).

Among the students of the Class of 1872, John Manly Chase (B.S.) became Professor of Mathematics at the Delaware Literary Institute and, later, Pastor and Professor of Mathematics at Mills College, Oakland, California. John Warren Mack (B.S.) served as Professor of Mathematics and French at the Ithaca Academy and, later, Professor of Mathematics at the Delaware Literary Institute. Three of the students graduating with a Bachelor of Civil Engineering taught mathematics later: Rufus Basset Howland was Professor of Mathematics at the Wyoming Seminary, 1873-1917; Sylvester Niles Williams served as Professor of Mathematics at Cornell College in Iowa, 1873-1883, and later taught civil engineering.

An allegoric depiction of Professors Wait, Jones and Anthony from an early student year book

Edward Wyllys Hyde was amongst the most mathematically gifted of the early students. He became a Civil Engineer (1874) and followed in the footsteps of Henry. T. Eddy by becoming Professor of Mathematics and Engineering at the University of Cincinnati where he also served as President. Hyde shared with Eddy a strong interest in scientific research. He is remembered for his contribution to vector analysis. His book, *Grassmann's Space Analysis*, was published by Wiley and Sons in 1906 as a reissue of chapter 8 of *Higher Mathematics*, edited by M. Merriman and R. S. Woodward, 1896.

Some other students attending Cornell during this early period showed interest in mathematics. Here is a selection.

Emma S. Eastman '73

Emma Sheffield Eastman was the first woman to graduate from Cornell (Ph.B., 1873). She had studied at Vassar College and started attending lectures at Cornell in 1871. In 1873-74, she taught science and mathematics at High School in Portland, Maine. Eastman married Leroy A. Foster '72 (Foster died in 1882), and worked for women's suffrage for much of her life. She died in California in 1932.

George Tayloe Winston (Lit.B., 1874) stayed at Cornell for one year after graduation as Instructor in Mathematics. The next year, he was Assistant Professor of Literature at the University of North Carolina, and married Caroline S. Taylor, a fellow Cornell student. In 1891, he was elected President of the University of North Carolina at the age of thirty-nine. In 1896, he became the first regular President of the University of Texas. (The position was occupied earlier by an Interim President.) He left in 1899 to accept the presidency of the Agricultural and Mechanical College of North Carolina (now North Carolina State University). A southern gentleman and ardent proponent of public education, his views on races and their social differences would be completely unacceptable by today's standards.

Cornelia Alice Preston (B.S., 1874) attended Vassar College for two years before enrolling at Cornell in 1872. After graduating in 1874, she taught Higher Mathematics and History in Utica. She married her classmate George B. Upham. From 1945 to her death in 1947 at the age of ninety-five, she was reported to be the oldest living Cornelian.

Oliver Hazzard Perry Cornell (C.E., 1874) was the youngest son of Ezra Cornell and served as Instructor in Mathematics before a successful career in the railroad industry.[58]

Edward Leamington Nichols (B.S., 1875) went to study in Leipzig and Berlin before earning his Ph.D. in Physics in Göttingen in 1879 under J. B. Listing. His career took him to Johns Hopkins, Menlo Park (Edison Laboratory), and to universities in Kentucky and Kansas, before he became Professor of Physics at Cornell in 1887. In 1904, he welcomed Lord Kelvin for a visit in Ithaca. Nichols was a member of the National Academy of Sciences and served as President of the American Association for the Advancement of Science (1907) and of the American Physical Society (1907–08).

After graduating, Charles Ambrose Van Velzer (B.S. 1876) served as Instructor in Mathematics at Cornell for two years before joining Johns Hopkins University as a University Fellow to work with J.J. Sylvester. (For more on the famous mathematician J.J. Sylvester, see the next Chapter.) Van Velzer stayed 3 years at Johns Hopkins but left without a Ph.D. when he was appointed Instructor of Mathematics at The University of Wisconsin, Madison, in 1881. He was Chair of Mathematics between 1884 and 1894 and supervised the first two Mathematics Ph.D.'s awarded by the University of Wisconsin (Henry F. Stecker, 1897 and Theodore Running, 1899). He left the University of Wisconsin in 1906, during the presidency of Charles Van Hise, following a dispute with the university regarding Van Velzer's coal mining activities. He was replaced at the University of Wisconsin by Edward Burr Van Vleck. He later taught at Carthage College in Kenosha, Wisconsin. Van Velzer authored a number of books, including *Plane and Solid Geometry: Suggestive Method* and *University Algebra*, published by Tracy, Gibbs

[58] The Cornell Civil Engineer, Vol 20, 1912, page 581.

and Company. *Universal Algebra* was written as a textbook for Madison's first-year mathematics course.

Arthur Stafford Hathaway (B.S., Mathematics, 1879) was the first of only five students whose degree explicitly mentions Mathematics. (Degrees awarded to students during the early years fluctuated greatly and specialties were generally not recorded.) He was probably the most mathematically gifted students during Cornell's early years. His life and accomplishments are described in the next chapter.

Of Lena Lillian Hill, B.S., Science and Letters, 1879, the *Cornell Sun* wrote in 1885 on the day of her marriage to Frank Edward Severance '79, that she was remembered as "one of the brightest Lady students" at Cornell. After graduating with a bachelor in science and letters in three years, she taught Mathematics and History at Omaha High School, 1879-84, and Mathematics in the Brearley School, New York City, 1884-5. Lena was a founder of the Association of Collegiate Alumnae (later the American Association of University Women) in the Buffalo area and chaired its Education Committee. In this position, she worked closely with A. D. White, and he accompanied her on a trip to Albany to fight for pension legislation for teachers in New York State. In 1910, this campaign succeeded with the passage of the first teachers' pension bill.[59] The *Cornell Alumni News* (May 30, 1900) reports on Lena and her husband as follows.

> *Mr. Severance has traveled widely, at home and abroad. In 1890-91, after a winter in Italy, he visited Egypt, Ceylon, the Straits Settlements, South China, Japan and the Pacific Coast of America, making a tour of 37,000 miles around the world. On this trip he was accompanied by Mrs. Severance.*

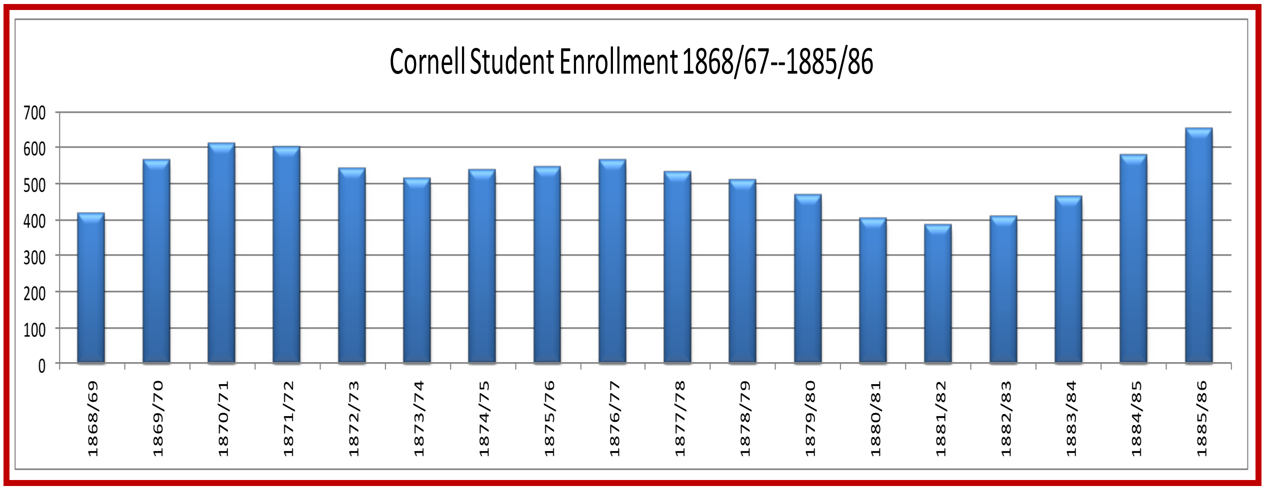
Lena later published a short book *The Theory of Equipotence: method of analytical geometry of Sig. Bellavitis* (1930), based on her 1879 undergraduate thesis.[60] In modern parlance, the subject is the theory of vectors defined as equivalence classes of pairs of points. The little book starts with the following dedication.

[59] http://socialarchive.iath.virginia.edu/ark:/99166/w6vh86c6 (From the description of Lena Lillian Hill Severance papers, 1903-1916. (Cornell University Library). WorldCat record id: 64072005).
[60] Available at https://catalog.hathitrust.org/Record/000360799.

> This book, inspired by the munificent gift of Mr. and Mrs. Darwin D. Martin to found a chair in Mathematics in the University of Buffalo, is inscribed to my teacher who was a linguist as well as a mathematician, the late Lucien A. Wait, Professor of Mathematics in Cornell University, Ithaca, New York.

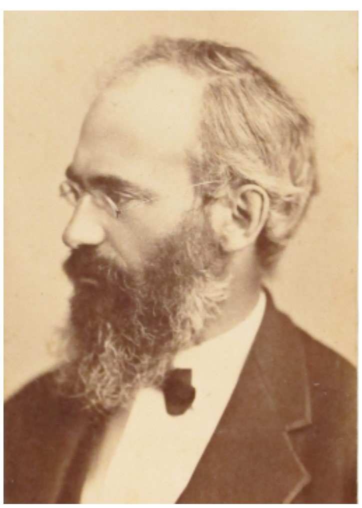
Lena Hill Severance died in 1944.

CHAPTER III: TRANSITION, 1879-1887



III.1 JAMES EDWARD OLIVER (ALMOST SACKED)

There is a wide-spread notion that mathematics is mainly important for the preliminary training of certain crude powers, and as auxiliary to certain bread-winning professions, and that only literary studies can afford that fine culture which the best minds seek for its own sake. Time, no doubt, will rectify this misapprehension; but meanwhile, it hinders our success.[61]



Jimmie Oliver is one of the central characters of our story. No one has ever played a more important role in shaping the future of the Department of Mathematics at Cornell.

Oliver was born in Portland, Maine, on July 27, 1829. His ancestry goes back to the early settlers of Massachusetts and his Quaker family lived in Lynn, Massachusetts. Until turning seven, James was home-schooled by his mother who had been a school teacher. Oliver's obituary for National Academy of Sciences—written by George William Hill—reports that, as a child, Oliver took great interest in the anti-slavery, temperance, and anti-tobacco

[61] James Oliver, 1886/87 Department Report to the President.

reforms. In 1846, at just seventeen, he entered Harvard and joined the sophomore class. There, his roommate was Horace Davis who later served as President of the University of California. Here is what H. Davis said of Oliver.

There was in Oliver's composition a deep vein of poetry mingled with his mathematics, as is not uncommon. The class made him their class-day poet, and were so pleased with his poem that they printed it to take home with them, something unusual in those days.

Oliver was also a man of deep religious convictions, not dogmatic, but broad and inclusive. His faith was firm and constant, and, wherever he went and whatever he did, he carried with him the consciousness of his Heavenly Father. In all my life I have never met a man who more sincerely lived up to his convictions, nor one in whom the milk of human kindness more thoroughly pervaded all his acts and life.

At Harvard, Oliver was one of Benjamin Peirce's favorite pupils as few were able to follow the teacher's enthusiastic but chaotic lectures. After graduating in 1849[62] and on Peirce's recommendation, Oliver took a position at the Office of the American Ephemeris and Nautical Almanac, in Cambridge, MA, and remained in this position until the Nautical Almanac Office moved to Washington in 1867. G. W. Hill provides the following recollection of his former colleague Oliver at the Nautical Almanac.

Oliver did not take kindly to the work necessitated by the publication of the American Ephemeris. He found the endless repetitions of the same arithmetical processes extremely wearisome. All that could be learned in this way was soon exhausted and the interest attached to the novelty of the work soon worn threadbare. It soon became drudgery to him, and he would rather have devoted his energies to original research in higher algebra. At the time I first met him I remember his conversation at the office was plentifully interlarded with the words quantics, invariants, covariants, discriminants and the like. When Oliver

[62] Oliver also earned a Master's in 1854.

began to discourse eloquently on these things, I remember distinctly that the rustling of the leaves of the tables of logarithms would cease, and did not commence again until he got through.

After leaving the Almanac Office, Oliver spent time in New York and Philadelphia where he gave private lessons and continued to compute for the Almanac Office. In 1870, he lectured at Harvard on thermodynamics. Already in 1867, when A.D. White was searching for future Cornell faculty, Oliver was recommended to him for the position of Professor of Mathematics, most certainly by B. Peirce. White chose Evans instead but, four years later, in the summer of 1871, Oliver accepted an assistant professorship at Cornell. At the time, he was already a Fellow of the American Academy of Arts and Sciences (1861) and was elected to the National Academy of Science the following year in 1872. He was also a fellow of the American Philosophical Society and of the American Association for the Advancement of Science. Oliver became Professor in 1873 and led the department until his untimely death in 1895 at the age of 65. Here is yet another paragraph from Oliver's NAS memorial article written by G.W. Hill, a paragraph which relates to Oliver's work at Cornell.

In the early part of his career there he was under the necessity of giving much time to junior courses in mathematics; but after 1889 his work was chiefly in post-graduate courses, where he was more in his element. The range of subjects covered by Professor Oliver in his lectures in different years is certainly remarkable: Analytic Geometry, Infinitesimal Calculus, Quaternions, Definite Integrals, Spherical Harmonics, Elliptic Functions, Theory of Probabilities, Theory of Functions, Abelian and Automorphic Functions, Finite Differences, Factorials and Difference Equations, Differential Equations, Non-Euclidean Geometry, Celestial Mechanics, Mathematical Optics, Mathematical Theory of Electricity and Magnetism, Mathematical Pedagogy.

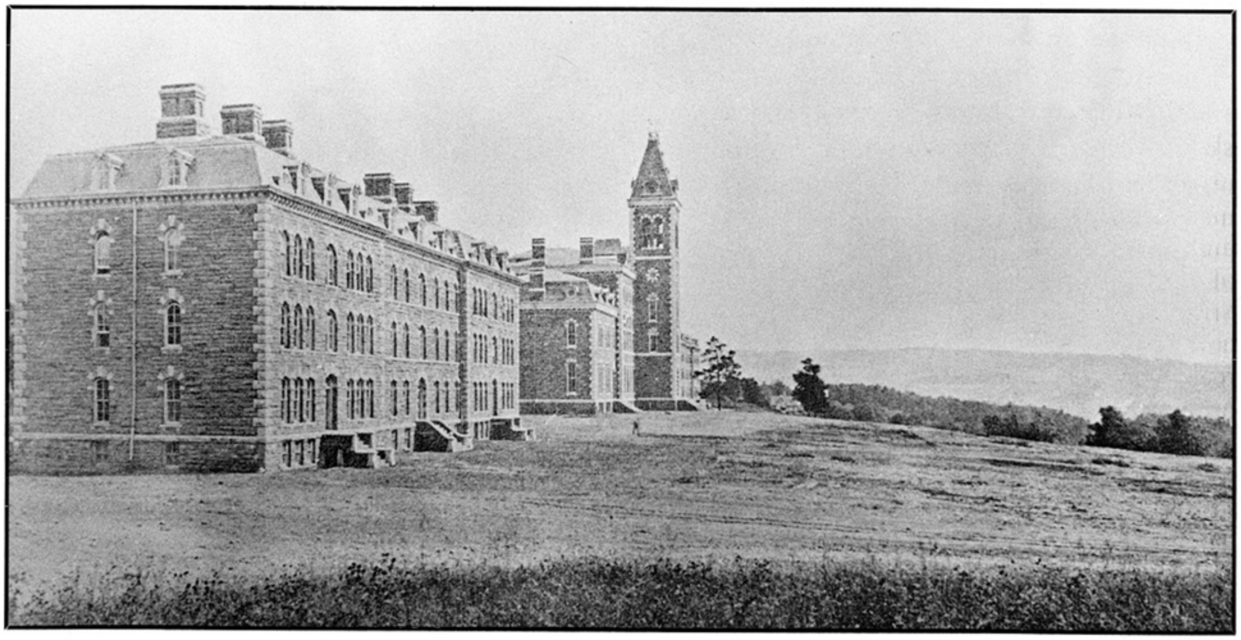
It is stated that in the same year he often lectured on as many as seven of these subjects… He was fond of applying mathematics to out-of-the-way subjects. Thus he attempted the illustration of the science of economics by the employment of algebraic formulas. While at Cornell he established a seminarium in economics. Several previous investigators had made a beginning in this line.

> *Professor Oliver's aim was to define the relation between the theory of probabilities and economic laws. The difficulty in the way seems to be the exceeding complexity of the motives which urge men to the carrying out of economic actions, which refuses to be submissive to formulation.*

In Cornell's lore, Oliver is remembered primarily as a perfect example of the absent-minded professor. Morris Bishop tells the stories of Oliver having invited a lady to the theatre only to arrive past midnight at her residence to face an irate father; missing three classes in a row when working on a formula; and skipping stones and his gold watch into the lake. In the *Cornell Sun* (April 3, 1895), Professor Bur wrote

> *his mind was too discursive in its method and too unpractical in its bent to lead him largely into publication, and it is as a teacher and a man that he will be longest and most affectionately remembered. He was absent-minded, unmethodical, prone to digression, but his acuteness of mind, his power of sustained research, his comprehensiveness of view, his utter freedom from bias, his unflagging enthusiasm, made his leadership for those who had the wit and mettle to follow it a thing of perpetual inspiration.*

Oliver's liberalism and open-mindedness almost cost him his job and Cornell one of its best faculty. The period 1876-1881 was one of great difficulty at Cornell, described in Morris Bishop's history as *The Doubtful Years*. The university faced violent attacks in the press directed towards co-education, curricular reforms and, most of all, irreligion. *Infidel Cornell* was how the university was known. Other difficulties arose as well: the campus' poor sanitation, a tight budget negatively impacted by the ownership of the western lands of the Morrill Act (later a blessing, but a very real burden at the time), and a period of economic depression (the long depression of 1873-1879) during which well trained students, including engineers, could not find work. Most significantly, President A.D. White was absent from Ithaca for most of this period. He was on leave in 1876/77, as Honorary Commissioner for the State of New York at the Paris Exhibition of 1878, and American Minister (Ambassador) in Berlin from 1879 to his precipitous return in Ithaca for the academic year 1881/82. During these absences, Vice President



An early photograph of White Hall and McGraw Hall, facing the valley

William Channing Russel served as Acting President. In this role, facing the many difficulties we just alluded to, he managed to become unpopular with both the trustees and the faculty. For the Board of Trustees under the leadership of Henry Sage, the perceived radicalism of Vice President Russel and the Cornell faculty became viewed as endangering the future of the institution.[63] In January 1881, the Executive Committee of the Board of Trustees decided on a purge that would involve terminating the appointment of G. W. Jones and J. E. Oliver of Mathematics,[64] C. H. Wing, A. A. Breneman of Chemistry and C. M. Stebbins of French. The entire Department of Architecture led by C. Babcock would also be eliminated. Morris Bishop reports that, informed by mail while in Berlin, President White replied that *"Oliver was a great mathematician, but let him go. We could part with Jones and Strebbins, but we should keep Wing and Breneman, and we should hold on to Architecture, in the hope for better times."*

[63] An interesting if partial perspective on these events is given in an article devoted to James Oliver in *The Free Thought Magazine,* Vol 13, 1895. https://books.google.com/books?id=9PE5AQAAMAAJ

[64] Regarding Jones, see Chapter I. Oliver, a member of the Unitarian Church in Ithaca, was singled out for appearing at an event as a co-speaker with arch-atheist Robert G. Ingersoll. See Morris Bishop's *A History of Cornell*, page 205.

Fortunately, this purge was postponed until A.D. White's return from Berlin. In the meantime, Henry Sage and the Board of Trustees focused on obtaining the resignation of Vice President Russel. At the end, A.D. White did resume his active presidency, and Russel resigned and left Cornell after a very painful public controversy. The wider purge never took place.

The entire Cornell Faculty in 1882. Bottom row, left, J. Oliver, second row, left, G. Jones.

The year 1881-82 saw the lowest total student enrollment, 384, in Cornell history. During the next four years, A.D. White and H. Sage often disagreed, but were nevertheless able to put the university on a renewed path of growth and success. The complications and controversies generated by the will of Jennie McGraw Fiske[65] must have occupied many, but it did not derail the university progress.

[65] See, Chapter XIII, The Great Will Case, in Morris Bishop's *A History of Cornell.*

ENTRANCE EXAMINATION PAPERS.

JUNE 1882.

I. ENGLISH GRAMMAR.

1. Name the diphthongs in the English alphabet.

2. Specify and illustrate the various means of distinguishing between the masculine and the feminine gender of nouns.

3. What kind of nouns add *es* to the singular in order to form the plural?

4. How many case-forms in English? Write the possessive singular and the possessive plural of the following words: *ox*, *deer*, *lady*, *hero*, *genius*, *justice*, *James*, *church*.

5. Is there any difference between a demonstrative adjective and a demonstrative pronoun? Name some demonstrative words and state whether they are adjectives or pronouns.

6. What inflection does the adjective retain? Explain and illustrate.

7. Classify pronouns. Define each kind of pronoun. What distinction is there between the use of *our* and *ours*? How are reflexive pronouns formed?

VI. ELEMENTARY ALGEBRA.

1. Define: an irrational number, an incommensurable number, an imaginary, a coefficient, the degree of a polynomial, the lowest common multiple of two polynomials.

2. Explain what is meant by $x^{\frac{2}{3}}$; by $x^{-\frac{1}{6}}$. Their product equals what, and why?

3. Find the value of

$$-x^5-2x^4+3x^3+4x^2-6x-5 \text{ when } x=-2.$$

4. Solve the set of equations

$$x+y+z=2, \qquad 2x+3y+4z=9, \qquad 3x-2y+z=-3.$$

5. Find the value of x from the equation

$$\frac{x}{a}+\frac{x}{b-a}=\frac{b+a}{b}.$$

6. Find the highest common divisor of x^3-1 and x^3-x; of $4x^2-12x+9$ and $6x^2-13x+6$.

7. Simplify $$\frac{3abc}{bc+ca-ab}-\frac{\frac{a-1}{a}+\frac{b-1}{b}\div\frac{c-1}{c}}{\frac{1}{a}+\frac{1}{b}-\frac{1}{c}}.$$

8. Solve the quadratic $ax^2+2bx+c=0$. Form a quadratic whose roots shall equal those of the given quadratic taken with opposite signs.

9. Simplify the binominal surd $\sqrt{(7-4\sqrt{3})}$.

II.2 ABRAM ROGERS BULLIS (1854-1928)

Among the students of this period, special attention is due here to Abram Rogers Bullis. The Abram R. Bullis Chair in the Department of Mathematics was created in 1989 through the estate of his daughter, Nettie Bullis.

Abram Rogers Bullis was born on September 4, 1854, in Farmington, New York, the son of Abram Rogers Bullis and Lydia Porter Lapham. He was one of seven siblings. His father was a medical doctor who had studied at Geneva Medical College and practiced in Macedon and Farmington (east of Rochester). His mother, Lydia, died when he was eight years old and the young Abram went to live with his grandfather, Charles Bullis, in Macedon. After attending Macedon Academy 1868-1869, Abram taught in neighboring schools including at Macedon Union School. He enrolled at Cornell in 1877 and graduated in 1881 with a Bachelor of Science in Mathematics and a bachelor thesis titled *Solution of a Problem in Probability.* In 1882, he added a Bachelor in Civil Engineering. After leaving Cornell, Abram returned to Macedon where he spent most of his life working as a surveyor in Wayne County, New York. He married Josephine Breese in 1884 and they had two children, Charles Rogers Bullis (1891) and Jeannette Aurelia Bullis (1893). He was an early member of the New York Mathematical Society and remained a member of the American Mathematical Society for 26 years.

During his time at Cornell and after returning to Macedon, Bullis was a regular contributor of solutions to mathematical problems for two periodicals published by Artemas Martin, the *Mathematical Visitor* (1879-1894) and the *Mathematical Magazine* (1882-1884). His extraordinary book collection is preserved as part of the "Bullis Collection" in Macedon Public Library.[66] Interest in life-long education and the pursuit of scholarship was passed from generation to generation in the Bullis family. Abram's daughter, Jeannette (Nettie) Bullis, graduated from Macedon High

[66] https://nyheritage.org/collections/bullis-family-collection and https://bullisbookchronicles.blogspot.com

School in 1911 and delivered a valedictory address titled *Life Like Every Other Blessing Derives Its Value From Its Use*. She attended Cornell in 1918, taught in Marion, New York, and became a bookkeeper for Gleason Works before advancing to the position of Corporate Secretary and Private Assistant to the company

90. Proposed by ARTEMAS MARTIN, LL. D., U. S. Coast and Geodetic Survey Office, Washington, D. C.

Solve the equation

$$\sqrt{[2(a^2+b^2)x^2-x^4-(a^2-b^2)^2]}+\sqrt{[2(a^2+c^2)x^2-x^4-(a^2-c^2)^2]}+\sqrt{[2(b^2+c^2)x^2-x^4-(b^2-c^2)^2]}=x^2\sqrt{3}$$

by quadratics.

Solution by ABRAM ROGERS BULLIS, B.S., B.C.E., Macedon, Wayne County, New York.

By squaring and transposing, the given equation becomes

$$\{(a^2+x^2-b^2)(a^2+x^2-c^2)-2a^2x^2-\sqrt{[4a^2x^2-(a^2+x^2-b^2)^2]}\sqrt{[(4a^2x^2-(a^2+x^2-c^2)^2]}\}$$
$$+\{(b^2+x^2-c^2)(b^2+x^2-a^2)-2b^2x^2-\sqrt{[4b^2x^2-(b^2+x^2-c^2)^2]}\sqrt{[4b^2x^2-(b^2+x^2-a^2)^2]}\}$$
$$+\{(c^2+x^2-a^2)(c^2+x^2-b^2)-2c^2x^2-\sqrt{[4c^2x^2-(c^2+x^2-a^2)^2]}\sqrt{[4c^2x^2-(c^2+x^2-b^2)^2}\}=0.$$

Now, since placing each bracket equal to zero satisfies the above and reduces each bracket to the same form, we have, after squaring and arranging,

$$x^4-(a^2+b^2+c^2)x^2=a^2b^2+b^2c^2+a^2c^2-a^4-b^4-c^4;$$

from which, by completing the square and taking the square root, we find

$$x^2=\tfrac{1}{2}\{a^2+b^2+c^2+\sqrt{[6(a^2b^2+b^2c^2+a^2c^2)-3(a^4+b^4+c^4)]}\},$$

and hence $$x=\tfrac{1}{2}\sqrt{\{2(a^2+b^2+c^2)+2\sqrt{[6(a^2b^2+b^2c^2+a^2c^2)-3(a^4+b^4+c^4)]}\}}.$$

President, James Gleason. She died in 1979. Her significant bequest still supports a number of post-secondary scholarships for students of school districts around Macedon.

III.3 ARTHUR STAFFORD HATHAWAY (1855-1934)

Arthur S. Hathaway was born September 15, 1855 in Keeler, Van Buren County, Michigan. He graduated from Decatur High School in 1869 and entered Cornell in 1875. At Cornell, Hathaway, who was a trained typist and stenographer, served as A.D. White's personal secretary. In 1878 and '79, he represented Cornell at the fourth and fifth annual intercollegiate contests in New York City and placed second and first, respectively, in Mathematics. In December 1878, he married fellow Cornell student Susan Hoxie from Scipio, Cayuga County, NY. Susan Hoxie was the first female elected member of Cornell Agricultural Club and the first woman to enroll in the Agriculture course of study at Cornell (1875-78). She was born in 1848

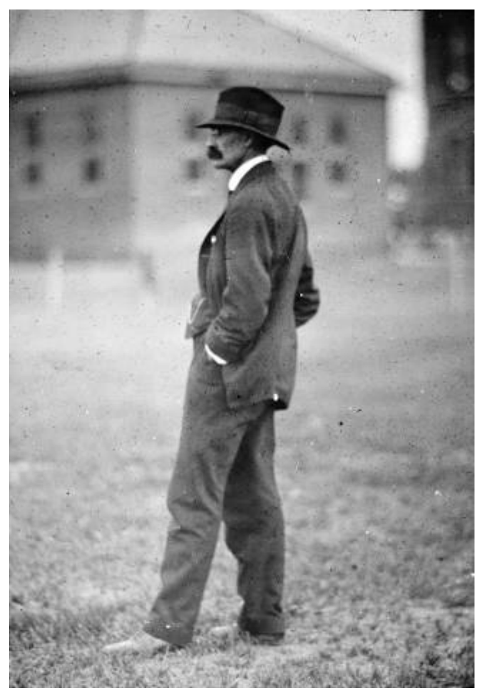
and taught at Blooming Grove School, Buffalo Normal School and Schodack School before attending Cornell. Both Arthur and Susan were Quakers. In 1879, Hathaway graduated with a Bachelor of Science in Mathematics. During the summer, he and his wife moved to Baltimore where Arthur planned to teach at the Friends High School while attending classes in the Theory of Numbers given by Professor J. J. Sylvester at The Johns Hopkins University.

In a very sad turn of events, in March 1880, Susan and their son died in childbirth. The son was named Edward Oliver Hathaway. Arthur stayed in Baltimore where he worked as a court stenographer from 1881 to 1882 while attending Sylvester's classes and seminars at Johns Hopkins. In 1882-84, he was a Fellow in Mathematics but, at the end of 1883, Sylvester returned to England, accepting the Savilian Professorship in Geometry at Oxford University. Despite outstanding work for an American student of the time, Hathaway never earned a Ph.D.

In Volume 6 of the *American Journal of Mathematics* (1883-84), Hathaway published *Some Papers on the Theory of Numbers,* the first of two papers where he developed an abstract algebraic theory of rings, ideal and division in the spirit of the work of Kummer, Dirichlet, Kronecker, Dedekind and others. The second paper in the series appeared in the same journal in 1887 and refers extensively to the work of his European predecessors. We reproduce here the introduction of the first article which gives a glimpse of Hathaway's personal and mathematical life at the time of his family's tragedy.

The principles upon which the following papers are founded were developed while attending the Lectures of Professor Sylvester on the Theory of Numbers, in 1879-80; and were presented before the Mathematical Seminary in May, 1880, Jan., Feb., March, 1881. The death of my wife, who had shared with me in the work, and the professional duties of a stenographer, left neither opportunity nor inclination to make a more extended publication of them. Feeling confident, however, that the principles were of value in simplifying *the Theory of Numbers, I returned to the subject in the beginning of the present year (1884). It is due to Professor Sylvester to state that the beginnings of my knowledge in the Theory of Numbers were obtained entirely from short-hand notes of his lectures; and that it was his suggestive presentation of the Theory of Congruences that led to the development of these principles. The first paper, while it is introductory to, is intended to form a part of the second paper. The latter paper is founded upon an extension of the idea of division, which permits the consideration of any dividend whatever. Subjects which are ordinarily considered only in the general theory of Ideal Primes can thus be treated much more simply; and so naturally is one led to the necessary treatment, that I arrived at the solutions of the principal problems of these subjects without any knowledge of the theory of Ideal Primes. An example is the resolution of cyclotomic functions with respect to a prime modulus not only, which lies at the foundation of Kummer's theory of Ideal Primes, but with respect to a power of a prime.*

The fall of 1884 was marked at Johns Hopkins by the famous "Baltimore Lectures" given by Sir William Thomson (later, Lord Kelvin) on *Molecular Dynamics and the Wave Theory of Light.* Hathaway was in attendance and the existence of a detailed record of Thomson's lectures is entirely due to him and a combination of his excellent mathematics training and stenographic skills. From this experience, Hathaway retained a constant interest in mathematical physics alongside his expertise in algebra and number theory.



Arthur Hathaway at Rose Polytechnics

In 1885, Arthur married Ada Jackson with whom he would have four children. He left Johns Hopkins (without a doctorate) and accepted an instructorship at Cornell where he was promoted to Assistant Professor in 1890. He left Cornell in the summer of 1891 to join Rose Polytechnics where H.T. Eddy had just become President.[67] Hathaway stayed at Rose Polytechnics until his retirement in 1920. He was a fellow of the American Association for the Advancement of Science. Upon his retirement, he moved to Boerne, Texas, where he passed away in 1934.

At Cornell, Hathaway was highly appreciated by his former teachers and played an important role in the development of the graduate program by bringing his invaluable Johns Hopkins experience to the department. He taught entry level classes but also elective classes on the Theory of Numbers, Molecular Dynamics (after the Baltimore Lectures of Lord Kelvin), Quaternions, Differential Equations, and The Potential Function and Spherical Harmonics. He was an active member of the Mathematical Club created by Oliver in 1890. In 1891, he published an interesting article on the "Early History of the Potential" where he points out the priority of Lagrange over Laplace in the introduction of the notion of potential. At Rose Polytechnics, he published two text books and an article on the quaternions. He was very active in the profession, teaching at the University of Chicago during several summer quarters, and writing about engineering education. He was also a frequent contributor to the *Mathematical Monthly*. After his retirement, he published a research article, *An harmonic groups* in the *Annals of Mathematics* (1926).

Of his teacher, James Oliver—after whom his first child was named—Hathaway said (quoted by F. Cajori):

> *Professor Oliver is a rare genius, powerful, able, but without the slightest ambition to publish his results. He works in mathematics for the love of it. I have seen work of his done one or two years ago. Practically the same work appeared in the American Journal of Mathematics, written by prominent authors, that I had urged him to publish, and which he had promised to do, but which, with his characteristic dilatoriness and diffidence in this respect, he failed to do until it was too late. I consider him fully equal in point of natural ability to Professor Sylvester, and he is better able than Professor Sylvester, I think, to acquire knowledge of what others have done. He lacks, however, the energy and ambition of Professor Sylvester, and does not concentrate his powers on any one subject. His work is immethodical, and leads in whatever*

[67] Eddy was a Cornell mathematics faculty member (1869-73) and the first Cornell Ph.D. in any subject (see Chapter I)

direction his mind is bent at the moment. The result is that he is a far more amiable and congenial person to meet than Professor Sylvester. He never obtrudes self upon you, and wherever you may lead he will follow. Indeed, his simplicity of character and interest in everything that interests anybody else is one of his greatest charms. There are few subjects in which he does not know more than most people—you find it out when you are talking with him—but he does not seem to know it, at least he never obtrudes it.

III.4 THE JOHNS HOPKINS UNIVERSITY

When Professor Sylvester was called to the chair of mathematics in the Johns Hopkins University, Professor Peirce of Harvard, being asked what he thought would be the opinion of American mathematicians respecting the new appointment, replied that no American mathematician had a right to have any opinion on the subject, except himself, and one of his old pupils, a distinguished professor of mathematics in one of our leading colleges.[68]

The Johns Hopkins University was established in 1876, supported by Johns Hopkins' bequest of seven million dollars to be shared equally between the university and the hospital. Daniel Coit Gilman, a friend and former classmate of A.D. White at Yale, resigned from his position of President of the University of California and became the first President of the new university. During the next decades, he changed the course of higher education in the United States by creating an institution centered on graduate studies and research, the first American research university. The mathematician Fabian Franklin, biographer of Gilman, quotes the following recollection of what Gilman told the Johns Hopkins Board of Trustees in December 1874.[69]

He [Gilman] said to them [the Trustees] in substance, that he would make it [the Johns Hopkins University] the means of promoting scholarship of the first order, and this by offering the

68 Lucien Wait, in *Advanced Instruction in American Colleges*, The Harvard Register, vol. 3, p. 127, 1880.
69 *The life of Daniel Coit Gilman*, by Fabian Franklin, 1910, page 188.

kind of instruction to advanced students which other universities offer in their post-graduate courses, and leaving the kind of work now done by undergraduates to be done elsewhere. For this purpose, he would select as professors men now standing in the front rank in their own fields; he would pay them well enough to leave them at their ease as regards the commoner and coarser cares; would give them only students who were far enough advanced to keep them constantly stimulated to the highest point; and he would exact from them yearly proof of the diligent and fruitful cultivation of their specialties by compelling them to print somewhere the results of their researches. Now, what this means, and how great a contribution it would be to the intellectual progress and fame of the United States, may be inferred when we say that we could at this moment name twenty men, employed at small salaries in existing colleges, whose work in certain fields of research would be of inestimable value to the science and literature of the world, but who are compelled, in order to earn their livelihood, to pass most of their time teaching the rudiments to boys, or preparing school-books; and that American graduates who would like to pursue certain lines of culture to their latest limits are compelled every year either to go abroad or content themselves with the necessarily imperfect aid which they can get in the post-graduate courses from overworked and halfpaid professors who are doing the work of schoolmasters.

In 2011, Lloyd B. Minor, then Johns Hopkins' Provost, wrote

For all of Gilman's great ideas, attempts to develop graduate education at Johns Hopkins would have in all likelihood failed had it not been for the creation of a novel fellowship system. Before opening, Johns Hopkins advertised that it would offer ten graduate scholarships of $500 a year in addition to exemption from tuition. One of that first class of Ph.D. recipients, Thomas Craig, had learned about the fellowships from an article in the New York Tribune *and contacted Gilman at once. The two met the following week and kept in touch until Craig began his studies at Johns Hopkins, Gilman even lending him money and warning him against the dangers to his health of over-study.*

Thomas Craig earned one of the first three Ph.D.'s awarded at Johns Hopkins in 1878. He was a student of James Sylvester.

If the opening of Johns Hopkins changed the course of higher education in the United States, its significance for mathematics was even greater. At Yale and Harvard, mathematics was, at best, an established but dreaded part of classical study, taught mostly for its assumed value as a training of the mind. Only the University of Virginia made repeated but overall unsuccessful efforts to bring mathematical scholars to America (including, for a short time, a young James Sylvester). At Cornell, mathematics was certainly not an area of particular emphasis except for its necessary value towards training in the physical sciences, engineering, architecture and agriculture. In his 1888 report, President Gilman recalled having once answered the Trustees' question *"how to begin a university?"* by saying

> *Enlist a great mathematician and a distinguished Grecian; your problem will be solved…*

He did just that, bringing to America a world class research mathematician, James Joseph Sylvester. In support of Sylvester's appointment, Benjamin Peirce wrote to Gilman

> *Hearing that you are in England I take the liberty to write you concerning an appointment in your new university, which I think it [sic] would be greatly to the benefit of our country and of American science if you could make. It is that of one of the two greatest geometers of England, J. J. Sylvester. If you enquire about him you will hear his genius universally recognized, but his power of teaching will probably be said to be quite deficient. Now there is no man living who is more luminous in his language, to those who have the capacity to comprehend him than Sylvester, provided the hearer is in a lucid interval. But as the barn-door fowl cannot understand the flight of the eagle, so it is the eaglet only who will be nourished by his instruction. But as the greatness of a university must depend upon its few able scholars, you cannot have a great university without such great men as Sylvester in your corps of teachers.*

The life and career of Sylvester[70] is a very interesting story of success against silent (and not so silent) discrimination. He made fundamental contributions to several areas of Mathematics, in particular, Algebra. He was born in London in 1814 (he was seven years younger than Ezra Cornell, five years younger than B. Peirce and fifteen years older than J. Oliver). After studying at the University of Cambridge (St. John College), he finished second Wrangler in 1837. However, he was not issued a degree because, being Jewish, he could note state his acceptance of the Articles of the Church of England. He was able, however, to take a professorship at University College, London, and became a Fellow of the Royal Society (1839). In 1941, he received Bachelor's and Master's degrees from Trinity College, Dublin, and made his first journey to America for a short but very unsuccessful tenure at the University of Virginia. He returned to England in 1843. For the next thirty years, he worked in England making important contributions to Mathematics while working as an actuary and teaching at the Royal Military Academy. In 1872, the University of Cambridge officially issued the Bachelor's and Master's degrees he had earned thirty-five years earlier.

In 1876, Sylvester came back to America at the invitation of D.C. Gilman and stayed 7 ½ years at Johns Hopkins, from the opening in 1876 to December 1883. During that period, Johns Hopkins awarded 9 doctorates in Mathematics, more than all other American institutions combined (the year when the doctorate was awarded is provided):

- Thomas Craig, 1878 (Professor at Johns Hopkins)
- George Bruce Halsted, 1879 (Professor at the University of Texas)
- Fabian Franklin, 1880 (Instructor at Johns Hopkins, later Editor of the *Baltimore News*)
- Washington Irving Stringham, 1880 (Professor at the University of California)
- Oscar Howard Mitchell, 1882 (Professor at Marietta College)
- Christine Ladd, 1882 (received in 1926[71]) (Student of C.S. Peirce,[72] studied color vision)

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[70] *James Joseph Sylvester: Life and Work in Letters*, Oxford University Press, 1998, and *James Joseph Sylvester: Jewish Mathematician in a Victorian World*, Johns Hopkins University Press, 2006, by Karen Parshall.

[71] Women were not accepted as regular students at Johns Hopkins in the early years.

[72] Charles Sanders Peirce, the youngest son of Benjamin Peirce, was one of the most original American mathematicians and philosophers of his time.

- William Pitt Durfee, 1883 (Professor at Hobart College)
- George Stetson Ely, 1883 (US Patent Office)
- Ellery William Davis, 1884 (Professor at the University of Nebraska)

Other Fellows attending Johns Hopkins during this period include Cornell's graduates Charles Van Velzer (Professor at the University of Wisconsin) and Arthur Hathaway (Professor at Cornell and Rose Polytechnics). During the same period, Yale awarded only 3 doctorates in Mathematics; Harvard and Cornell, none.

In addition to Sylvester, Gilman hired William Story, a Harvard graduate with a Ph.D. from Leipzig (1875). Two people were in fact in competition for the position of assistant to Sylvester, William Story, then instructor at Harvard, and William Byerly, assistant professor at Cornell, both former pupils of Peirce. Apparently, Harvard gave strong recommendations to both with a slight preference for Story and Story prevailed. Most accounts of this event fail to mention that Byerly immediately received an offer from Harvard and returned to his alma mater for the rest of his career! While both Byerly and Story proved to be dedicated teachers, only Story made significant contributions to mathematical research. He later became the leader of mathematics at Clark University where research, scholarship and graduate education were paramount.

Florian Cajori reports the following account of Sylvester's teaching provided by Arthur Hathaway. [73]

I can see him now, with his white beard and few locks of gray hair, his forehead wrinkled over with thoughts, writing rapidly his figures and formulae on the board, sometimes explaining as he wrote, while we, his listeners, caught the reflected sounds from the board. But stop, something is not right, he pauses, his hand goes to his forehead to help his thought, he goes over the work again, emphasizes the leading points, and finally discovers his difficulty. Perhaps it is some error in his figures, perhaps an oversight in the reasoning. Sometimes, however, the difficulty is not elucidated, and then there is not much to the rest of the lecture. But at the next lecture we would hear of some new discovery that was the outcome of that difficulty, and of some article for the Journal[74]*, which he*

[73] *The Teaching and History of Mathematics in The United States* by Florian Cajori, 1890.
[74] The *American Journal of Mathematics*.

had begun. If a text-book had been taken up at the beginning, with the intention of following it, that text-book was most likely doomed to oblivion for the rest of the term, or until the class had been made listeners to every new thought and principle that had sprung from the laboratory of his mind, in consequence of that first difficulty. Other difficulties would soon appear, so that no text-book could last more than half of the term. In this way his class listened to almost all of the work that subsequently appeared in the Journal. It seemed to be the quality of his mind that he must adhere to one subject. He would think about it, talk about it to his class, and finally write about it for the Journal. The merest accident might start him, but once started, every moment, every thought was given to it, and, as much as possible, he read what others had done in the same direction; but this last seemed to be his weak point; he could not read without meeting difficulties in the way of understanding the author. Thus, often his own work reproduced what others had done, and he did not find it out until too late.

A notable example of this is his theory of cyclotomic functions, which he had reproduced in several foreign journals, only to find that he had been greatly anticipated by foreign authors. It was manifest, one of the critics said, that the learned professor had not read Kummer's elementary results in the theory of ideal primes. Yet Professor Smith's report on the theory of numbers, which contained a full synopsis of Kummer's theory, was Professor Sylvester's constant companion.

This weakness of Professor Sylvester, in not being able to read what others had done, is perhaps a concomitant of his peculiar genius. Other minds could pass over little difficulties and not be troubled by them, and so go on to a final understanding of the results of the author. But not so with him. A difficulty, however small, worried him, and he was sure to have difficulties until the subject had been worked over in his own way, to correspond with his own mode of thought. To read the work of others, meant therefore to him an almost independent development of it. Like the man whose pleasure in life is to pioneer the way for society into the forests, his ragged mind could derive satisfaction only in hewing out its own paths; and only when his efforts brought him into the *uncleared fields of mathematics did he find his place in the Universe.*

Upon Sylvester's departure in December 1883 to accept the Savilian Professorship in Geometry at Oxford University, President Gilman attempted to hire Felix Klein who was Professor in Leipzig and one of the most influential and renowned mathematicians of the time (see, chapter I). Klein considered the possibility seriously but, ultimately, decided against it. Simon Newcomb became the head of the Johns Hopkins department while retaining his position at the United States Naval Observatory as Director of the Nautical Almanac Office. The dominance of the Johns Hopkins Mathematics department over research and graduate study in the United States faded away over the next decades. The *American Journal of Mathematics*, created under Sylvester's leadership with the help of Story and Craig, remains today a premier research mathematics journal and a worthy symbol of the extraordinary contributions of the Johns Hopkins University to the emergence of mathematical research in the United States.

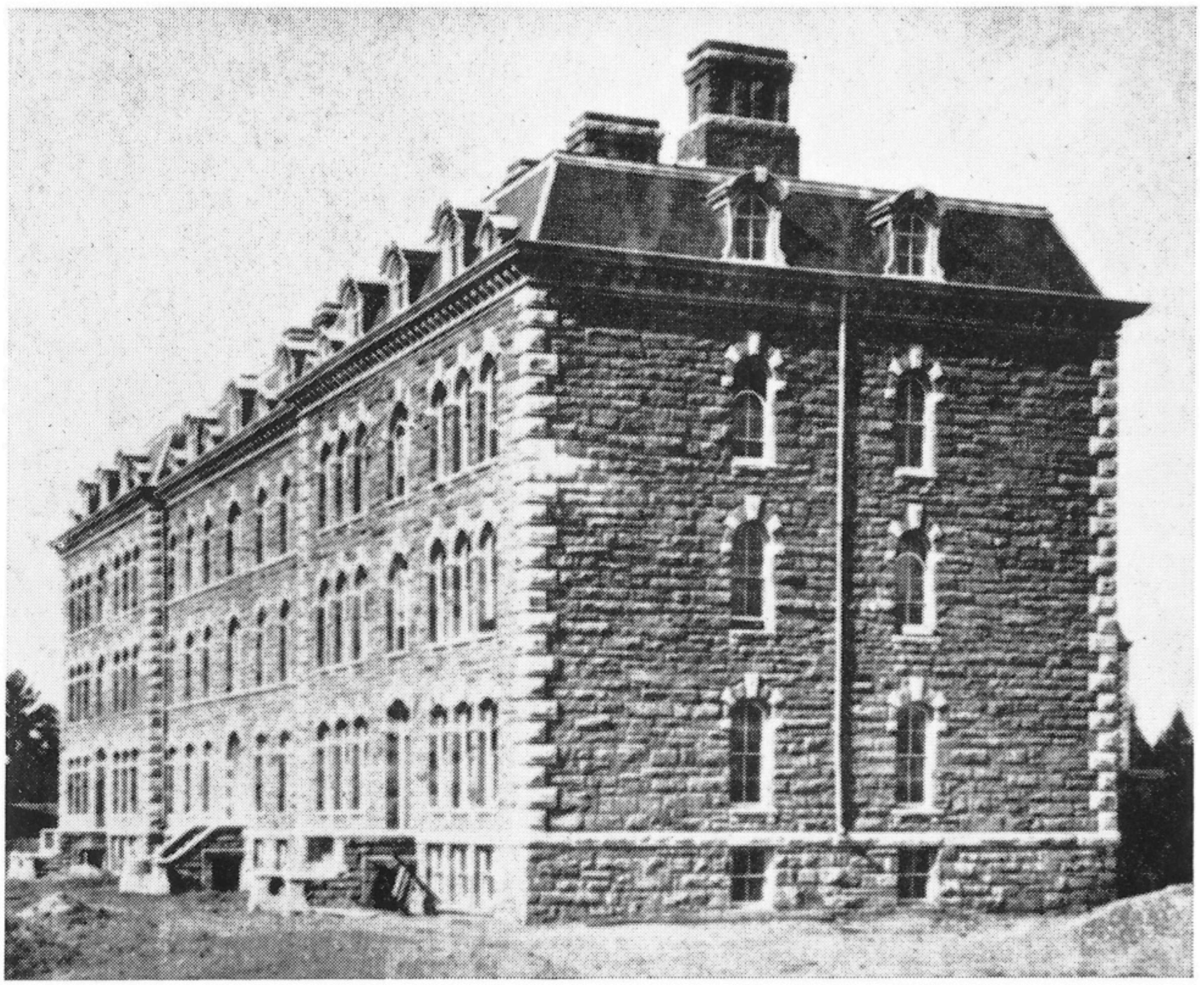
III.5 TOWARDS A GRADUATE PROGRAM

JAMES MCMAHON (1856-1922)

At Cornell, on June 20 1883, the Board of Trustees passed a resolution renaming the south and north buildings as Morrill Hall and White Hall, respectively. In December 1884, the Board of Trustees assigned "Room Q" in White Hall to the Mathematics Department. The department would remain in White Hall for one hundred and fifteen years. It was significantly strengthened by the arrival of James McMahon, announced on Tuesday, July 8, 1884 in *The Daily Democrat*

Mr. James McMahon, who has been in Ithaca for the last year and a half, and has aided the mathematical faculty of the University in the preparation of their new algebra soon to be published, has been appointed instructor in mathematics for the coming year. Mr. McMahon is a graduate of Trinity College, Dublin, of the class of '81. He ranked among the first members of his class in mathematics and metaphysics throughout the course, and took highest honors in those subjects at graduation, securing the Wray and Brooke prizes.

Mr. McMahon has also been instructor in logic in the Correspondence University[75] since its organization.



An early picture of the North Building which became White Hall in 1883

McMahon, certainly the best educated Cornell mathematician at the time, became a pillar of the department and served until his retirement in 1922. He contributed greatly to establishing higher standards of scholarship and research for students and faculty. He served as General Secretary (1898) and Vice President (1901) of the American Association for the Advancement of Science. He was born in Armagh County Ireland, on April 22, 1856, the son of Robert McMahon and Mary Hewitt. After graduating from Trinity College, Dublin in 1881, he moved to Ithaca as mentioned in the quote from the Daily Democrat included above. He married

[75] President A.D. White had launched a "Correspondence University" as part of Cornell. It did not last long.

Katharine Crane, sister of Professor T. F. Crane (one of Cornell's early faculty and later Dean of the College of Arts and Sciences, 1902-1909). After Oliver's death and until his own death in 1922, McMahon lived in Oliver's Cottage, 7 Central Avenue, adjacent to Professor Crane's Cottage. McMahon was one of the early organizers of the Sigma Xi Society, viewed at the time as the Phi Beta Kappa of the sciences. (The Phi Beta Kappa Society was perceived as being tied to an older collegiate focus oblivious to science and engineering.) Throughout his life, McMahon was interested in the applications of mathematics and mathematical physics and was praised by his Cornell colleagues for his collaborative spirit and willingness to share his mathematical expertise.

As mentioned earlier, in the summer of 1885, Arthur Hathaway joined the department, bringing his experience from Johns Hopkins with him. For the first time, the department had three faculty members with an interest in pursuing original research in mathematics: Oliver, McMahon and Hathaway.

GRADUATE FELLOWSHIPS

The Cornell register of 1885/86 includes the following paragraph regarding the general organization of the university.

> SCHOLARSHIPS AND FELLOWSHIPS.
> The Scholarships and Fellowships of Cornell University were founded, in the prosperity of the University, in grateful remembrance of financial aid once given in a time of need by its Trustees, the Hon. Ezra Cornell, John McGraw, Esq., the Hon. Henry W. Sage, the Hon. Hiram Sibley, and President Andrew D. White. In accordance with their wishes as then expressed, a sum of money (amounting to one hundred and fifty-five thousand dollars) has been permanently set aside to provide encouragement and assistance for students of high character and ability of either sex, in the prosecution of collegiate work, and of advanced study and research after graduation.

After the return of President A.D. White from Berlin in 1881, Cornell enrollment grew again to 573 in 1885.[76] White embraced and promoted the development of research, saying in February 1881: *"The number of Cornell's students will be determined largely by its reputation for research as well as for instruction."* The

[76] See the bar graph at the beginning of this chapter.

western land operations[77] finally turned some revenue and in 1884, Cornell awarded its first graduate fellowships, seven in total, including one in mathematics to Edward Charles Murphy. Murphy earned a Bachelor in Civil Engineering in 1884 and a Science Master with a thesis on “Mechanical Quadratures” in 1885. He taught at the University of Kansas, returned to Cornell to teach and earn a Ph.D. in Civil Engineering in 1900 and later worked for the U.S. Geological Survey. There were 8 Fellows in 1885/86, and 8 or 9 per year from 1887/88 to 1890/91. This number doubled after 1891 and these 18 Fellows were joined by 5 or 6 Graduate Scholars each year.

The 1885/86 Cornell University Register lists 5 graduate students with interest in mathematics, including one woman, Elisabeth Margaret Mooney (later, Mrs. P. Milmoe, Preceptress of the Canastota Academy, 1886-1895). The fellow in Mathematics for that year (the second such fellow after E.D. Murphy) was Hiram John Messenger who had graduated with a Bachelor of Literature in 1880. Messenger was born in Canandaigua, NY in 1855. He taught at Cortland Normal School 1880/81 and Napa College 1881/83 before returning to Cornell as a graduate student in mathematics. He earned his Ph.D. in 1886, becoming the first graduate student to earn a Ph.D. in Mathematics at Cornell.[78] His thesis, *Modern Methods in Geometric Conics* was supervised by James Oliver. After serving as Adjunct Professor at NYU (then known as the University of the City of New York) for several years, he spent one year at the Institute of Actuaries in London and on his return, became an actuary first with Metropolitan Life and later, with Travelers Insurance Company. He wrote extensively on actuarial and public health questions. Messenger was one of the first 16 members the New York Mathematical Society (the precursor of the American Mathematical Society). He became a Cornell Trustee and established the now famous Messenger Lectures.[79]

One graduate from 1887, George Egbert Fisher, remained at Cornell for two years as an instructor before accepting an assistant professorship at the University of Pennsylvania where he stayed for the rest of his career. There he went on to earn a Ph.D., in 1895, with a dissertation titled *Some Points in the Theory of Invariants and Covariants.* He became Professor in 1903 and served as Chair of his department and Dean of the College.

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[77] This refers to the land scripts from the Morrill Act that were part of the original funding of Cornell University.

[78] The first Ph.D. awarded at Cornell went to H.T. Eddy, in 1872, and was in Applied Mathematics. However, Eddy was an Assistant Professor in Mathematics at that time.

[79] *Cornell Alumni News*, Volume 16, 1913-1914, page 157.

In 1888, Rollin Arthur Harris and Cadwallader Edwards Linthicum earned their mathematics doctorates. Each had been a Fellow in preceding years. We know little of Cadwallader (a graduate of Yale who appears to have made a career in real estate in New York, perhaps following in his family tradition), but we will later give an account of the life of Harris, an outstanding scientist. That year, Anna Mary Widman, who had just earned her Cornell Ph.B., became the first women to be named Fellow in Mathematics. However, she declined the position and, instead taught mathematics at Ithaca High School, 1889-92. In 1892 she married James Manning Bronson, later editor of the *Syracuse Herald*, who died in 1905. After 1911, Widman worked as a librarian at Brown University. She died in 1947.

During the year 1885-86, the following advanced courses were taught in the Department:[80]

- Modern methods in algebra and analytic geometry (J. McMahon)
- Special higher mathematics (L. Wait)
- Differential equations (J. Oliver)
- Finite differences (J. Oliver)
- Theory of functions (J. Oliver)
- Theory of numbers (A. Hathaway)
- Conic sections (J. Oliver)
- Descriptive astronomy (J. Oliver)
- Physical astronomy (J. Oliver)
- Astronomical problems (J. Oliver)
- Quaternions and Grassmann's Ausdehnungslehre (J. Oliver)
- Projective geometry (G. Jones)
- Probabilities and insurance (G. Jones)
- Special work toward theses (J. Oliver)

The different courses of study requiring mathematics (the amount of mathematics required is indicated) were as follows:

- BACHELOR OF ARTS, Freshman Year, 3 hours per week, each term.
- BACHELOR OF PHILOSOPHY, Freshman Year, 3 hours per week, each term.
- BACHELOR OF SCIENCE OR BACHELOR OF LETTER, Freshman Year, 5 hours per week, each term.

[80] *The Cornell University Register, 1885-86.*

- THE COURSE IN AGRICULTURE, Freshman year, 5 hours per week, each term.
- THE COURSE IN ARCHITECTURE, Freshman year, 5 hours per week, each term; Sophomore year, 5 hours per week, first two terms.
- THE COURSES IN CIVIL ENGINEERING, Freshman year, 5 hours per week, each term.
- COURSES IN MECHANICAL ENGINEERING, Freshman and Sophomore years, 5 hours per week, each term.
- COURSE IN ELECTRICAL ENGINEERING, Freshman and Sophomore years, 5 hours per week, each term.
- MARINE ENGINEERING, one year, 5 hours per week, each term.
- COURSE IN INDUSTRIAL ART, Freshman year, 5 hours per week, each term; Sophomore year, 5 hours per week, first term.

The first steps towards creating a mathematics graduate program at Cornell described above were, without a doubt, the result of the vision and labor of James Oliver. We reproduce below Oliver's 1886/87 Department Report to Charles K. Adams, the newly installed second president of Cornell University (1885-1892).

MATHEMATICS.

To the President of Cornell University,

Sir :—

Most of the Mathematical Department's work falls under three chief heads: First, instruction in subjects prescribed to freshmen in the University's general or technical courses, together with the conducting of examinations for admission to the University, and for scholarships; secondly, supplementary and advanced instruction given to students that elect it, and especially to upperclassmen and graduates; thirdly, for, though this is not strictly department work, yet it helps the department and the University,—the writing of text-books and of memoirs.

We think that all this work has been as well done as could reasonably be expected of us with the means at our command; but we are quite aware that it can be better done if we can receive the additional assistance that we ask for. Indeed, it has been with the greatest difficulty that we have gone through this year without additional help. The great increase in the number of students during the present year, amounting in the average to seventy-eight per term or twenty-nine and one-fourth per cent, above last year's number, together with the certainty that next year will bring a further increase of about sixty Sophomores or sixty-six per cent, of last year's number, and the probability that the next Freshman class will be quite as large, and perhaps larger than the present one—all this makes it absolutely necessary that we have next year either two instructors or one instructor and a paid examiner. We believe that the following is a moderate estimate of the number of hours of instruction that must be given next Fall term. In making it, the average size of each section outside of special work is taken as twenty-five students; which of course implies that some of the sections would be considerably larger, since owing to conflict of hours and the special needs of other departments the sections cannot be made in all cases equal. For example: one section this year has contained forty-four students, and another thirty-six; while a section in calculus required for the architectural students alone has numbered only five.

Fall Term 1887

# of Sections	Class	# instructor hours per week	# students
6	Sophomores	30	150
10	Freshmen	50	250
2	Freshmen	6	50
		86	450

Hours per week given to elective work

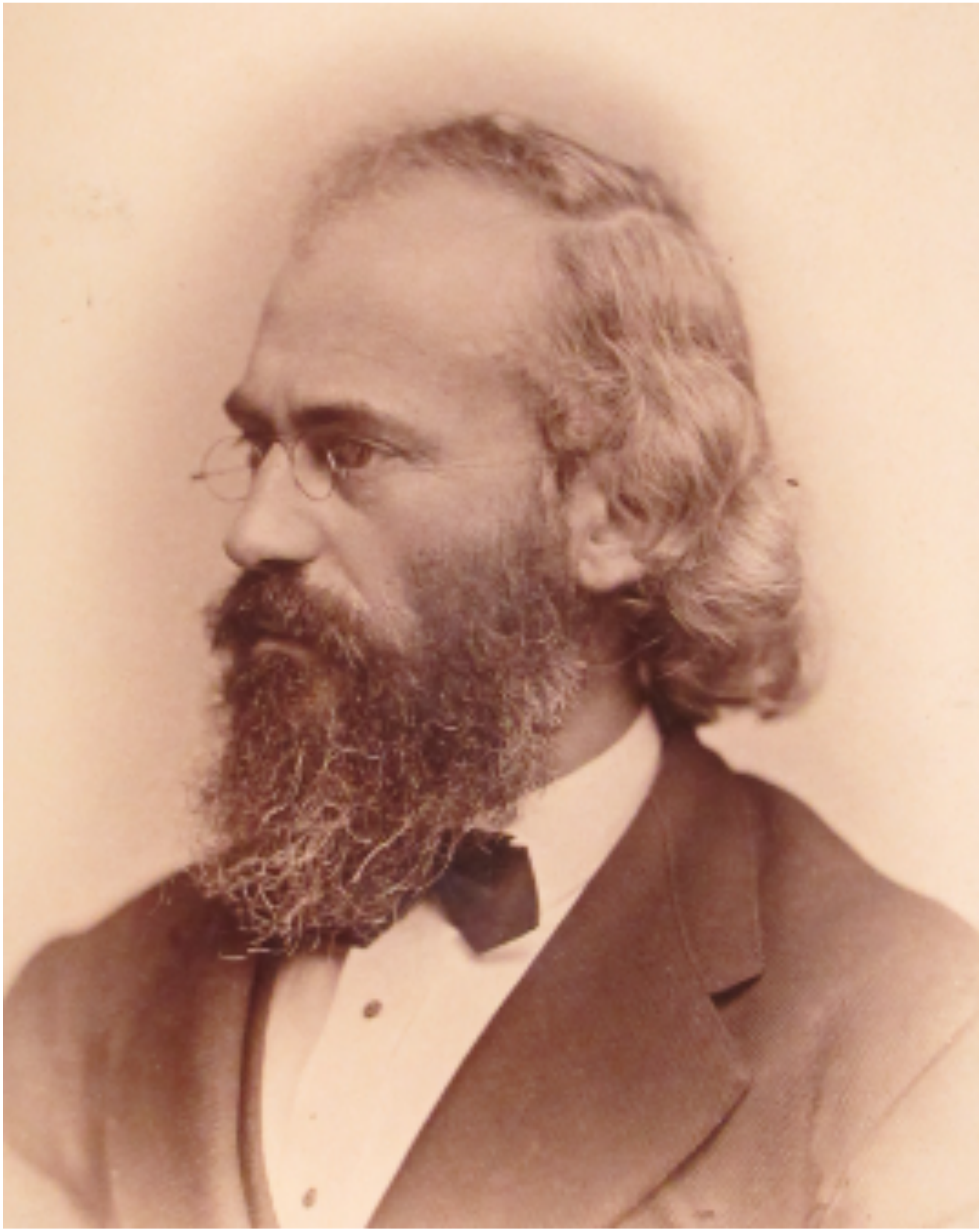
Faculty	# hours per week
Oliver	13
Jones	5
Wait	5
McMahon	3
Hathaway	3
Total (General and Special)	115

The work in these two terms will be the same, save only for the natural shrinkage in the number of students, and for the discontinuance in the spring term of the one small section of sophomores in architecture that has been already mentioned. Throughout the year, the number of hours required for special work would be much larger, or else instruction that may fairly be expected of the Mathematical Department in every great University like ours, would be left unprovided for, if we had not economized most of the special work by arranging it in pairs of alternating courses so that each topic shall come only every second year. [See "Announcement of Courses of Instruction for 1887-8."] The 115 hours per week thus required of us in lectures and recitations, give an average of twenty-three per week for five teachers, or over nineteen per week for six, or sixteen and three-sevenths per week for seven. It is possible, though not very likely, that the coming freshman class may be no larger than the present one; in which case the hours per week would average twenty-one, seventeen and one-half, or fifteen for five, six, or seven teachers. It may be thought that the freshman and sophomore work could be economized by making still larger sections; but these immature students need each one of them to get frequent opportunities to recite, and to receive that kind of care which must be given to individuals, and not merely to masses. They would have suffered seriously this year if the different teachers had not tried to make good their want of teaching force by employing at their own personal expense certain graduate students to criticize the pupils' written exercises; a work which, under the circumstances, needed to be done, but which none of us had the time and strength to do himself. Professor Jones alone has spent in this way over $175 this year, and the rest of the department as much more.

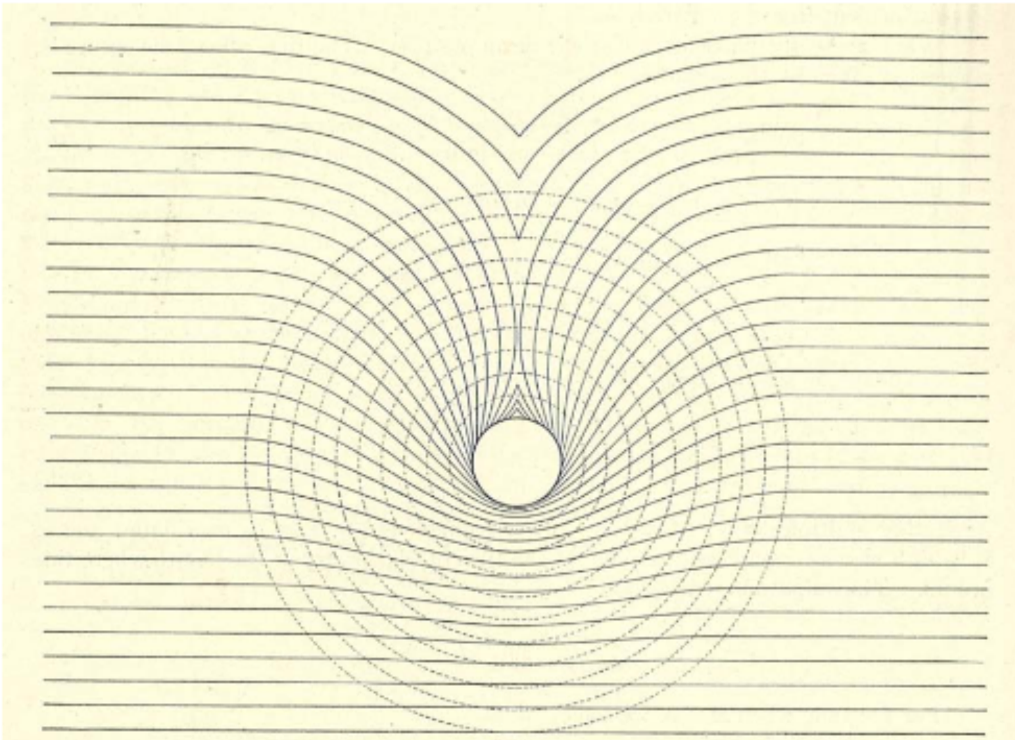
To the elective work needed to supplement or continue what is required, each one of the five teachers in the department has this year given from two to seventeen hours per week in lectures, recitations, and seminary, or in connection with students' theses; in all about twenty-five hours per week. From the nature of the case the classes thus taught are mostly small, and some of them are single students; yet were the instruction not offered and given, the young men who now come to fit themselves for mathematical teachers and specialists, would have to go elsewhere, and the University's reputation would suffer. As it is, we think that the number and average strength of these desirable student increases year by year; and that they do much to raise the University's intellectual tone while they remain with us, and to increase its reputation and clientage afterward. At present about one-fifth of the graduate students are taking their chief work with us. This is a larger number than are in any other Department or School, excepting perhaps the School of Mechanical and Electrical Engineering, whose teaching force is more than double our own, and whose material equipment, outside of the University Library, exceeds ours a hundred-fold. We are not unmindful of the fact that by publishing more we could help to strengthen the University, and that we ought to do so if it were possible. Indeed, every one of us five is now preparing work for publication or expect to be doing so this summer, but such work progresses very slowly because the more immediate duties of each day leave us so little of that freshness, without which good theoretical work cannot be done. A reprint of our algebra, increased to 412 pages, has, however, appeared this year, and has attracted favorable notice from the press and from distinguished mathematicians. All five of us have in some way contributed to the work, but much more of it has been done by Professor Jones than by anyone else. The chapters with which we propose to complete the book deal mainly with special applications, or with topics peculiar to modern analysis. Meanwhile we have successfully used the volume in all the Freshman sections this year. Of Mr. Hathaway's memoir in the Theory of Numbers now appearing in the American Journal of Mathematics, we shall speak later. An able quasi-editorial article in the May Academy on the best mode of preparing for the Cornell scholarship examinations in mathematics, is by Professor Jones, and seems likely to do much good. The greatest hindrance to the success of the department, especially in the higher kinds of work, lies, as we think, in the excessive amount of teaching required of each teacher: commonly from seventeen to twenty or more hours per week. The department teaches more men, if we take account of the number of hours' instruction given to each, than does any other department in the University. Could each teacher's necessary work be diminished in quantity, we are confident that the difference would be more than made up in quality and increased attractiveness. To get the best results, we believe that no teacher should lecture over fifteen hours per week: indeed, some leading universities require even less than this, and we are glad to know that the same thing is true in some of the departments here, though the subjects they have to present can hardly be more difficult and abstract than the higher mathematics. We have always had to contend with one other serious difficulty. There is a wide-spread notion that mathematics is mainly important for the preliminary training of certain crude powers, and as auxiliary to certain bread-winning professions, and that only literary studies can afford that fine culture which the best minds seek for its own sake. Time, no doubt, will rectify this misapprehension; but meanwhile, it hinders our success.

On the other hand, our work has been much helped recently by certain advances in University policy. Our classes in advanced work have covered decidedly more ground this year than formerly, and covered it better than in previous years. We attribute this chiefly to the increased strictness with which the University committee has weeded out weak and worthless students from the University, and with which our department has stopped such men as could not continue successfully their mathematical work. We have stopped no technical student, however, except after consultation with the professor of Civil or Mechanical Engineering, or of Architecture. Our classes also continue to receive benefit from the presence of students holding University Scholarships and Fellowships. Besides teaching very large sections with great efficiency and success, Professor Jones has helped us all by doing admirably the laborious and important work of chairman of the committee of freshman instructors. In this position it is his duty to throw the Freshmen into sections in all their studies so as to accommodate conflicting interests and approximately equalize the sections; as well as to advise those who are doubtful as to their studies. The first of these duties has always mainly devolved upon the mathematical department or some member of it. We think that improvement is quite as observable this year in the higher work of the department as with the freshman and sophomore classes. It is slow building up here an interest in studies so abstract while the University offers such admirable facilities for work more immediately "practical"; yet one of our number—whose experience as a student, and as a teacher, enables him to judge—assures us that, now Professor Sylvester has gone back to England, the opportunities offered here to the average student of the higher pure mathematics are quite as good as those at any other university in the country.

Respectfully submitted,
J. E. OLIVER,
Professor of Mathematics



James Edward Oliver



Effect of a Circular island on Cotidal Lines from Harris' "Outlines of Tidal Theory" from Appendix 7, Annual Report for 1900, p. 602.

Rollin Arthur Harris was born in Randolph, New York in 1863, the son of Francis Eugene Harris, originally, from Marlboro, Vermont, and Lydia Helen Crandall, born in Kinderhook-on-the-Hudson, New York.[81] His father Francis started to work as a farm boy at the age of eleven and later learned carpentry. He moved to Chautauqua County in 1852 and, four years later, married Lydia. They had six children, four daughters and two sons. Rollin was the third child and first boy. His oldest sister, Cora Ethel, 6 years his senior, studied at Fredonia Normal School. He received his education in Jamestown public schools before enrolling at Cornell in the sophomore class in 1882. He earned a Bachelor of Philosophy in 1885, with Honors for General Excellence and Special Honors in Mathematics. His dissertation was titled *The Theory of Projectiles in a Resisting Medium.* Two of his siblings, Gilbert Dennison

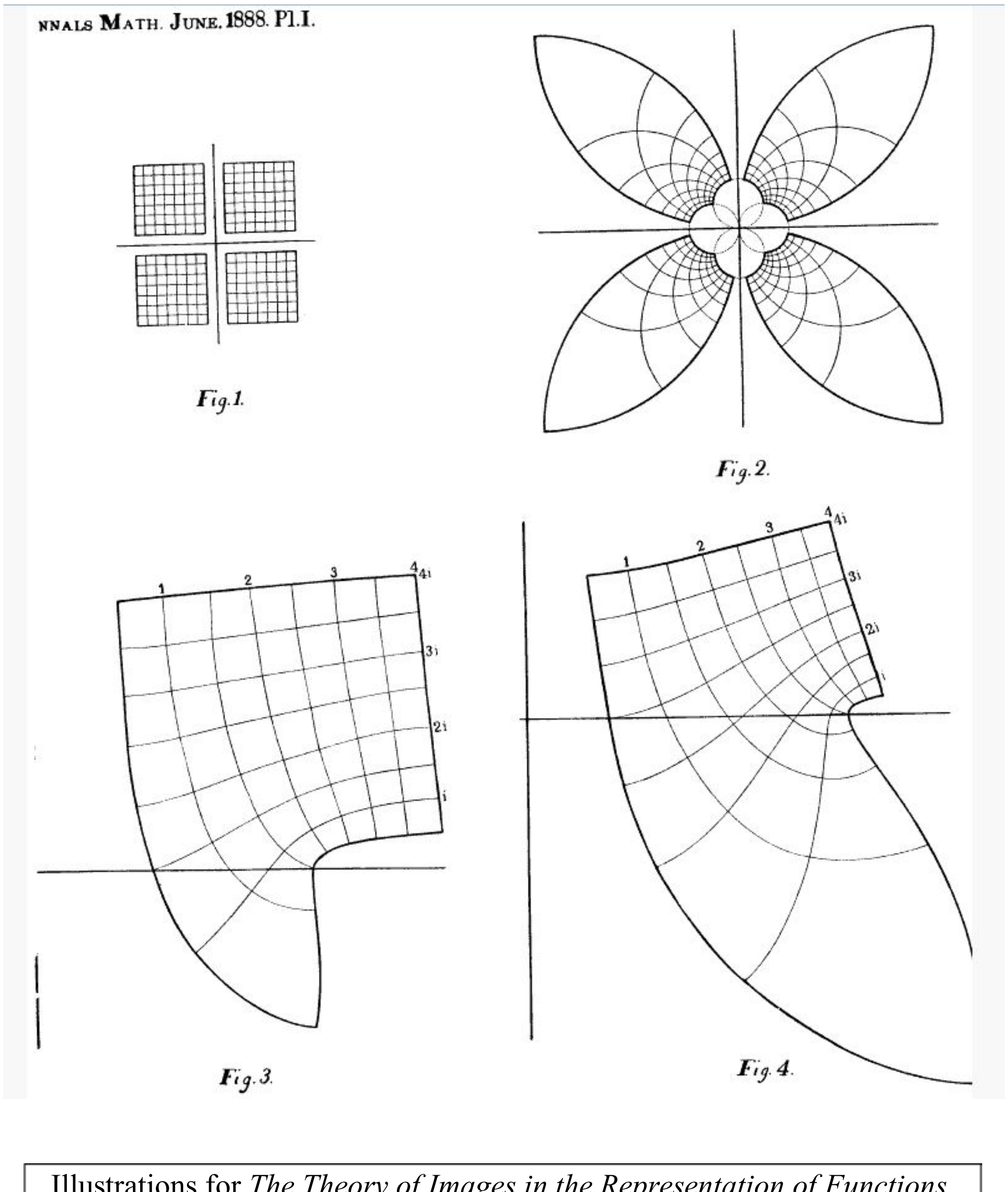
[81] Volume 3 of *History of Chautauqua County and Its People* (3 Volumes, 1921, John F. Downs and Fenwick Y. Hedley)
https://babel.hathitrust.org/cgi/pt?id=loc.ark:/13960/t24b37g7q;view=2up;seq=8

(Ph.B., 86) and Florence Bell Flory (B.A., 97) also graduated from Cornell. Gilbert Dennison Harris later returned to Cornell as Professor of Paleontology. He is directly responsible for the existence of the Paleontological Research Institution, home of "The Museum of the Earth" in Ithaca. Flory spent most of her life studying and teaching foreign languages. She was a graduate student at Cornell and, ten years later, at Columbia University. She died in 1968 at the age of 93.

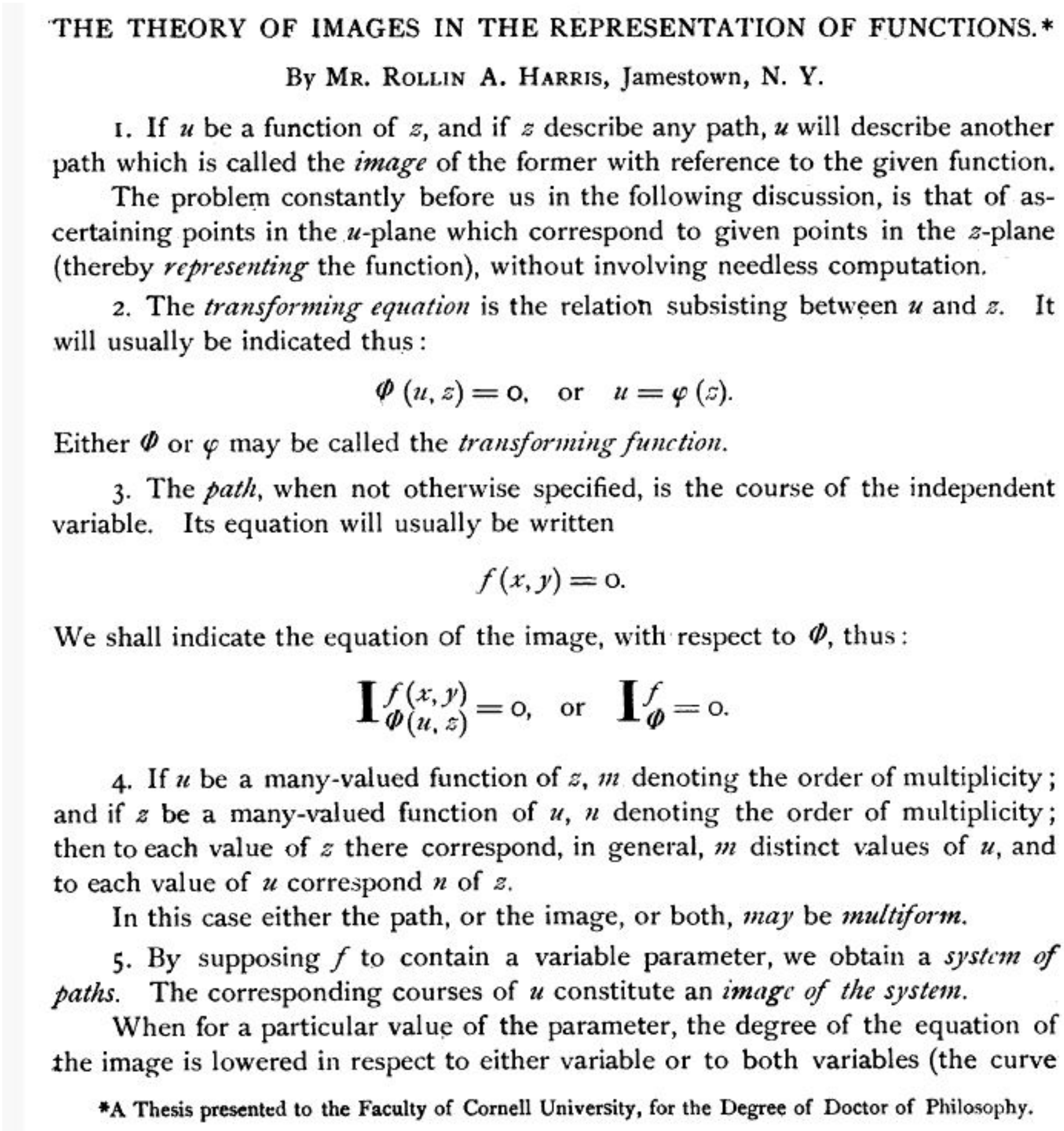
Arthur Rollin Harris, 1885, Cornell student file

HARRIS AND MCMAHON

Rollin Harris spent the next year, 1885-86, teaching at the Cayuga Lake Military Academy in the village of Aurora. He then returned to Cornell for graduate study. He was a Sage Fellow in 1886-87 and earned his Ph.D. in 1888 with a thesis on *The Theory of Images in the Representation of Functions*.



Illustrations for *The Theory of Images in the Representation of Functions*, 1888.



THE THEORY OF IMAGES IN THE REPRESENTATION OF FUNCTIONS.*

By MR. ROLLIN A. HARRIS, Jamestown, N. Y.

1. If u be a function of z, and if z describe any path, u will describe another path which is called the *image* of the former with reference to the given function.

The problem constantly before us in the following discussion, is that of ascertaining points in the u-plane which correspond to given points in the z-plane (thereby *representing* the function), without involving needless computation.

2. The *transforming equation* is the relation subsisting between u and z. It will usually be indicated thus:

$$\Phi(u, z) = 0, \quad \text{or} \quad u = \varphi(z).$$

Either Φ or φ may be called the *transforming function.*

3. The *path*, when not otherwise specified, is the course of the independent variable. Its equation will usually be written

$$f(x, y) = 0.$$

We shall indicate the equation of the image, with respect to Φ, thus:

$$\mathbf{I}^{f(x,y)}_{\Phi(u,z)} = 0, \quad \text{or} \quad \mathbf{I}^{f}_{\Phi} = 0.$$

4. If u be a many-valued function of z, m denoting the order of multiplicity; and if z be a many-valued function of u, n denoting the order of multiplicity; then to each value of z there correspond, in general, m distinct values of u, and to each value of u correspond n of z.

In this case either the path, or the image, or both, *may* be *multiform.*

5. By supposing f to contain a variable parameter, we obtain a *system of paths.* The corresponding courses of u constitute an *image of the system.*

When for a particular value of the parameter, the degree of the equation of the image is lowered in respect to either variable or to both variables (the curve

*A Thesis presented to the Faculty of Cornell University, for the Degree of Doctor of Philosophy.

We do not know for sure who Harris' advisor was, but his work was promoted by James McMahon and it seems plausible that he was Harris' advisor. McMahon was only seven years older than Harris and he had joined the faculty as an instructor in 1883. In his retiring address as Vice President of the American Association for the Advancement of Science,[82] James McMahon points to the work of Rollin Harris on tidal theory as a significant application of the theory of elliptic functions and

[82] *Science*, Vol. 16, No. 395 (Jul. 25, 1902), pp. 121-130

harmonic analysis to physical problems. Here are two paragraphs of McMahon's address that relates to Harris' work.

Some interesting applications of this method to tidal theory have recently been made by Dr. Rollin A. Harris in his Manual of the Tides, published by the U. S. Coast and Geodetic Survey. I would mention especially his use of an elliptic function as the transforming function the form

$$x + iy = sn(\varphi + i\psi).$$

The two sets of orthogonal curves drawn by him may be seen in the Annals of Mathematics, Vol. IV., page 83. By imagining thin walls erected along certain of the stream lines, we see, for instance, the nature of the flow around an island lying between two caps…

I may mention here a new method of obtaining solutions of Laplace's three- dimensional equation used by Dr. Harris and applied to tidal problems. He uses the more general complex variable containing two imaginary units i *and* j. *An arbitrary function of the form*

$$\varphi(ax + iby + jcz)$$

is a solution of Laplace's equation provided $i^2 = j^2 = 1$, *and* $a^2 = b^2 + c^2$. *When this function is expanded, the real part, and the coefficients of* i, *of* j, *and of* ij, *are all separate solutions of the differential equation. A great number of solutions of this and similar equations can be obtained by this method. It is to be hoped that Dr. Harris may have time to develop it further.*

Some of the mathematical foundation for Harris' work described above by J. McMahon is contained in his Cornell dissertation and subsequent articles from around 1888. As the following list of mathematical publications indicates, Harris remained interested in mathematics throughout his career.

- *The theory of images in the representation of functions*. Ann. of Math. 4 (1888), no. 3, 65–86.
- *On the expansion of snx*. Ann. of Math. 4 (1888), no. 3, 87–90.
- *Note on the theory of images*. Ann. of Math. 4 (1888), no. 4, 128.
- *On the invariant criteria for the reality of the roots of the quintic*. Ann. of Math. 5 (1891), no. 6, 217–228.
- *Note on isogonal transformation; particularly on obtaining certain systems of curves which occur in the statics of polynomials*. Ann. of Math. 6 (1892), no. 4, 77–80.
- *Note on the Use of Supplementary Curves in Isogonal Transformation*. Amer. J. Math. 14 (1892), no. 4, 291–300.
- *On two-dimensional fluid motion through spouts composed of two plane walls*. Ann. of Math. (2) 2 (1900/01), no. 1-4, 73–76.
- *Numerals for Simplifying Addition*. Amer. Math. Monthly 12 (1905), no. 3, 64–67.
- *On Harmonic Functions*. Amer. J. Math. 34 (1912), no. 4, 391–420.

It seems that Harris spent the year 1888-89 in his home town of Jamestown in Chautauqua County. The next year, 1889-90, he was a Fellow in Mathematics at the newly created Clark University where he pursued special studies in mathematics and lectured on the subject of his Cornell dissertation. In 1890, he took a position with the Tidal Division of the U. S. Coast and Geodetic Survey as "computer." (At the time, human beings served as "computers.")

This was a turbulent period at the Coast and Geodetic Survey (the same federal administration where James Oliver had begun his scientific career). Harris was hired under the leadership of Thomas Mendenhall who had been named Superintendent (1889-1894) by President B. Harrison. Mendenhall was born and raised in Ohio and was, primarily, an autodidact. He became a great scientist and teacher and one of the first faculty members at the Ohio State University (He was one of the scientists attending W. Thomson's Baltimore lectures discussed earlier in sections I.1 and III.3.) Before leading the Survey, he spent several years at the newly created University of Tokyo, teaching physics. When President Cleveland was elected for his second term, succeeding Harrison after being beaten by him at the end of his first term, he replaced Mendenhall with General W. Duffield. Duffield's tenure as

Superintendent from 1894 to 1898 is remembered as one of the worst leadership periods in the history of the Coast and Geodetic Survey.[83]

After entering the Survey as "computer," Harris became involved in surveying the literature on tidal records and predictions. Over the years, his work led to the publication of the monumental *Manual of Tides*, a text of 1,200 quarto pages containing a large amount of original contributions. The *Manuel of Tides* was originally published as eight separate appendices to the Coast and Geodesic Survey annual reports of 1894, 1897, 1900, 1904 and 1907. Harris was a Fellow of the American Association for the Advancement of Science. His obituary in the February 1918 issue of the journal *Science* contains the following paragraphs.

"It is gratifying to know that the "Manual of Tides" has received the recognition it merited from scientists the world over. Perhaps it may not be out of place here to quote the words of the eminent French mathematician Henri Poincaré. In his "Mécanique Céleste" he subjects the various tidal theories to searching analysis and sums up by saying that "it appears probable that the final theory will have to borrow from that of Harris a notable part of its essential features."

Dr. Harris published a number of articles in Science and other scientific journals on mathematical and tidal subjects. Mention should also be made of "Arctic Tides," a monograph published by the Coast and Geodetic Survey in 1911 which is a classic of its kind.

Personally, Harris was a man of modest bearing, somewhat reticent, but possessed of a pleasing sense of humor. He was an indefatigable worker with a high conception of the obligations of the scientist. He was a member of scientific societies, both local and national. He leaves a widow, Emily Doty Harris, whom he married in 1890."

[83] *A Change in Direction by Successive Change in the Points of Direction: The Nadir of the Coast and Geodetic Survey under Gen. W.W. Duffield (1894-1897)* by John Cloud, ftp://ftp.library.noaa.gov/docs.lib/htdocs/rescue/coastandgeodeticsurvey/Duffieldchapter.pdf

Another obituary appeared in the *Journal of the American Meteorological Society*. That obituary refers to articles published by Harris in the *Monthly Weather Review* such as *A partial explanation of some of the principal ocean tides* (1900), *Note on the oscillation period of Lake Erie* (1902), *The semidiurnal tides in the northern part of the Indian ocean* (1903), *Early knowledge of the tides at Panama* (1906) and *Deflecting force due to the earth's rotation* (1908).

THE THEORY OF TIDES

The National Oceanic and Atmospheric Administration (NOAA) Central Library's *Coast and Geodetic Survey Heritage* webpage includes information about Harris's contributions. In *Science on the Edge: The Story of the Coast and Geodetic Survey from 1867-1970 (Chapter VII),* John Cloud writes the following paragraphs about the administration of General W.W. Duffield at the NOAA.

But there were two very different creative triumphs during the Duffield era, created by the draughtsman and oceanographer Adolph Lindenkohl and the mathematician and tidal scientist Rollin A. Harris. As if by main force of intellect alone, these men managed to make dramatic advancements in their science and its presentation to the world…

[Concerning Harris' work] The tasks were daunting, particularly since the most important conceptual problems were beyond the recognition or even perception of most of humanity. As Harris noted: "Since it has been universally recognized that the tides result from the attraction of the moon and sun, the popular mind has taken little interest in the manner in which these forces operate in order to produce the tides. The apparent hopelessness of the task has doubtless deterred many investigators from devoting to it a full measure of their attention. In fact, as will be shown below, there is no such thing as "the tidal problem" analogous to the astronomers' "problem of three bodies." The tide involves a number of problems, and to even discover what these problems are requires a good knowledge of the forms, sizes, and depths of the oceans, together with knowledge of the tide producing forces. The observed tides themselves render great assistance in this matter; for their times and ranges indicate the ways in which the various oceans probably oscillate, and so, in a measure, the underlying tidal problems requiring solution."

Harris' contributions to tidal theory were created on a foundation of the most comprehensive history yet written on the evolution of ideas about the tides from antiquity to the end of the 19th century. From this he proposed a new concept and theory to ocean cotidal maps.

Harris analyzed the problems involved at every conceivable scale, at one end of the range concerning the Sun-Moon-Earth system and planetary geometry. At the other end of the scale, Harris analyzed the complex physics of individual waves on the ocean.

In the end, his greatest contribution was made in the middle scale, concerning the systems of tidal waves between ocean continents. The Manual as such was never consolidated into a single volume during Harris' lifetime, which was cut short in 1918 when he died of heart disease, at the age of 55. Four years later, H.A. Marmer, who succeeded Harris as a major authority on tides and currents within the Coast and Geodetic Survey, published a short history of the mighty challenges overcome to develop the modern theories of the tides. Marmer contrasted the next-to-most-current theory of tides, based on the concept of progressive waves, which had their origin in the great Southern Ocean. Succeeding that was a theory of stationary waves.

"This newer theory is diametrically opposed to the ideas advanced in the Southern Ocean theory of the making of the tide. It does away with the conception of a single world phenomenon and substitutes regional oscillating areas as the origin of the dominant tides of the various oceans. It may be of interest to note here that the older theory is due to European mathematicians and tidal workers, while the newer theory is the outgrowth of American genius. Almost entirely, the stationary wave theory is the work of one man, the late R.A. Harris of the United States Coast and Geodetic Survey…. Now to come back to the tides, the Stationary Wave theory states that the dominant tides of the world are caused by stationary waves that are set up and maintained in various portions of the oceans by the periodic tidal forces of the sun and moon. According to this theory therefore, the tides do not constitute a general world phenomenon, but a local phenomenon, the tides of any given region being due primarily to the stationary wave oscillation of that region."

Harris' work included delineations of partitions of ocean basins with resonating strips, which overlap and interact in complex ways. Where the nodal lines of overlapping strips intersect or come close together, no-tide points result, around which the cotidal lines rotate through all directions. Harris called these amphidromic systems, from the Greek words amphi (around) and dromos (running). Harris' many contributions to tidal theory were uneven in strength. His major critic was Sir George Darwin, a son of Charles Darwin and major tidal mathematician. Darwin was polite, but thoroughly dismissive of Harris' theory: "I venture to *express my admiration at the courage of the attempt, and although, as I think, it is a failure, yet it may inspire others to more successful attacks."*

However, Harris' work was acknowledged immediately by the small subset of mathematicians and tidal workers who could comprehend it and its significance. These included the distinguished French mathematician and polymath physicist Henri Poincaré. His lectures on topics in celestial mechanics addressed tidal theories, noting that: "His [Harris'] way of seeing things differs greatly from that of Whehell and his general principles do not run into the same objections. It is very likely that the definitive theory will take a large part of its outline from the theory of Harris."

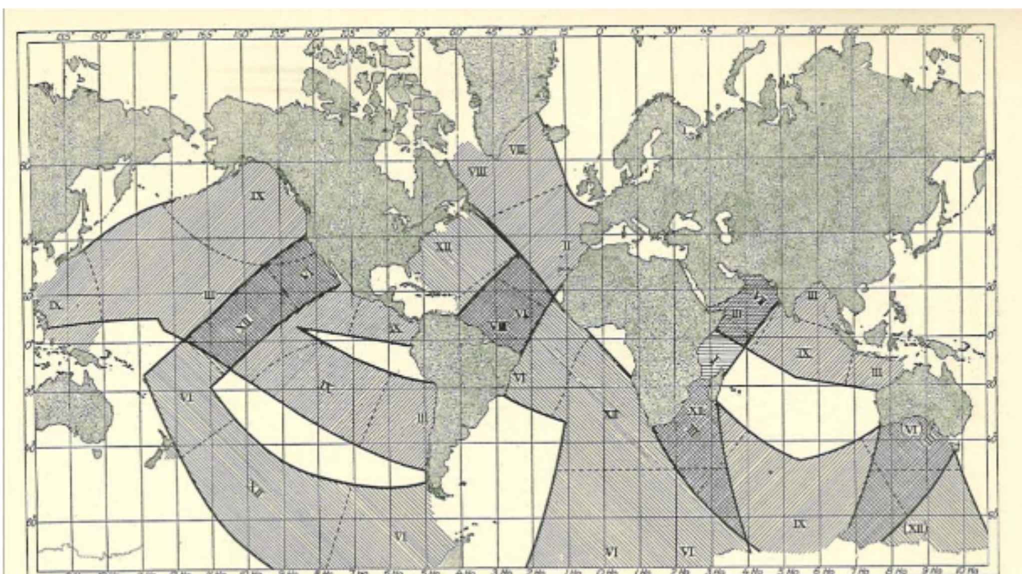


FIG. 4. Systems for the Semi-daily Tides. The shaded portions of this chart represent the regions most concerned in the production of tides, together with landward dependencies which possess tides simultaneous with those of the systems proper. The Roman numerals refer to Greenwich lunar time of high water. The values upon Fig. 4 are nearly those which would result from theoretical considerations. The values upon Figs. 5, 6, 7 and 8 are made to agree with observation as nearly as possible. The Arabic numerals on Figs. 5, 6, 7 and 8 denote mean ranges in feet of the observed semi-daily tide. The Roman numerals are placed upon that side of a cotidal line towards which the wave appears to progress.

Systems for the Semi-Daily Tides, by Rollin A. Harris, from his Manual of Tides, Annual Report for 1900

The book *Ebb and Flow: Tides and Life on Our Once and Future Planet* by Tom Koppel,[84] contains a long discussion of Harris' contributions. The following paragraphs from Koppel's book explain briefly some of Harris' ideas.

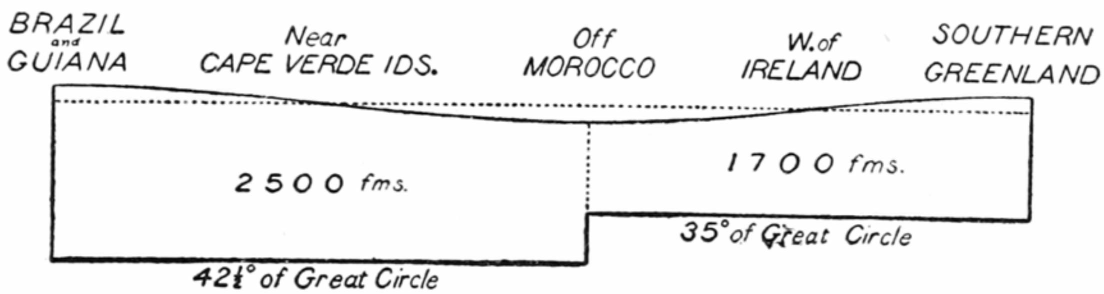
The Challenge to offer a better account of world tidal patterns was taken up in the first years of the twentieth century by an American mathematician educated at Cornell University, Dr. Rollin Harris, whose career was devoted to computing tides for the US Coast and Geodesic Survey. Harris hearkened back to the mid-seventeenth century ideas of Fitzroy and Airy—that ocean basins might oscillate, or rock back and forth in the form of standing waves—and to Whewell, who had envisaged rotational systems of waves moving around a point of no tide. Instead of a progressive wave moving around the Southern Ocean, Harris saw each ocean as made up of one or more largely separate great basins of water that are repeatedly disturbed by the periodic tide-generating forces. Because of different depths and dimensions of the ocean basins, each will have a somewhat different natural period of oscillation and will oscillate more or less to keep time with the different combinations of tide-generating forces, according to their periods. Some ocean basins may be more inclined to oscillate in time to lunar forces, for examples, other to solar forces. The amplitude of the oscillations may differ greatly between ocean basins and may also differ from what we would expect simply looking at the simple astronomy of Newton's tidal theory…

Rollin Harris looked at the world's oceans and seas and, based on their dimensions and what was (very imperfectly) known in the early twentieth century about their recorded depths, he divided them into areas that, he calculated, should oscillate in rhythm with one or another of the major tide-generating forces…

A fundamental and astonishing aspect of Harris' work is that it mixes a complete up-to-date review of all previous works on the subject, deep theoretical considerations involving new ideas, extensive analysis of the data available at the time for tides phenomena around the word, and the consideration of problems paused by specific geographical locations such as the Red Sea, the Strait of Gibraltar, Lake Erie, The Indian Ocean, the Arctic, etc. It seems that he considered any and every body of water on earth! In attempting to provide new theoretical grounds to make progress on the extremely difficult task of predicting tides accurately around the word, Harris developed his ideas by making simplifying assumptions that were hard to justify. (For instance, his theory ignored the rotation of the earth.) This accounts in part for the sharp objections from George Darwin, even while he, Darwin, had no

[84] Dundurn, publisher, 2007.

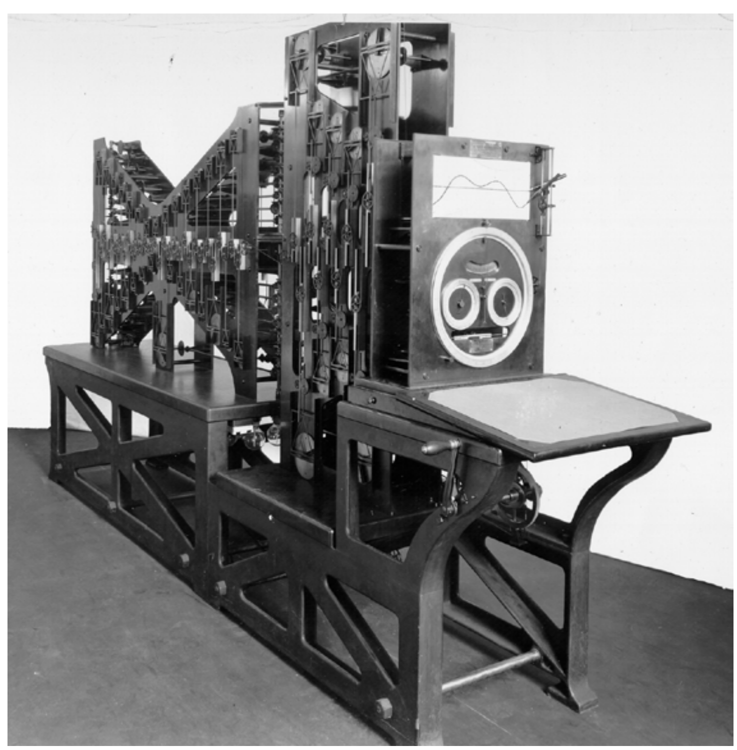
alternative theory to offer. But, as later contributors such as A.T. Doodson noted, Harris' work and his insights were validated by the much improved alignment of the resulting predictions with actual observations. See *"Tides: A Scientific History,"* by David Edgar Cartwright, 1999, Cambridge University Press.



This diagram shows the binodal oscillation going on in the North Atlantic Ocean. When it is high water at either end, it is low water off Morocco and vice versa. The depth of the southern portion being greater than the depth of the northern, a half wave-length in the former exceeds a half wave-length in the latter—the period in each case being very nearly 12 lunar hours.

TIDE MACHINE NO. 2

Tide machines were mechanical analog computers that used mechanical components to compute information such as the height and time of high and low tides for specific locations around the world. The conception and construction of the first Tide Predicting Machine is credited to William Thomson (Lord Kelvin) whose machine was shown at the Paris Exhibition in 1878. The first US Tide Machine was conceived by William Ferrel and built by E. G. Fisher in 1881.



US Tide Machine No. 2 (shown right and on the next page) was designed during the last decade of the nineteenth century by Rollin Harris and built during first decade of the twentieth century by Harris and E.G. Fisher. Some of the concepts are described in *A proposed tidal analyzer* published by Harris in *Phys. Rev.* (Series I) 8, 1899, and read at the August 1898 Boston meeting of the American Association for the Advancement of Science. The machine was completed in 1912 and remarkably, remained on duty generating tide tables for U. S. ports until 1965. It was 11 ft (3.35 m) long and 7 ft (2.1 m) high and weighed 2,500 lb (1135 kg).[85] The machine is also known as Old Brass Brains or the Harris-Fisher tide machine. It is build on similar general matematical principles used by the earlier machines of Thomson and Ferrel, but provided much more detailed information on tides at the output.

[85] https://en.wikipedia.org/wiki/Tide-Predicting_Machine_No._2 and https://tidesandcurrents.noaa.gov/predma2.html

HARRIS' LAND

The work of Harris, of outstanding and sustained scientific value, led to an interesting, if forgotten, episode illustrated by a *New York Times* article from October 11, 1913. The title and beginning of the article are reproduced below.

GREAT NEW LAND FOUND IN ARCTIC

Discovery Reported by Russian Government Exploration Steamers at Alaskan Port.

AS LARGE AS GREENLAND

So Commander Wilitzsy Declares—Stefansson on Same Quest—Harris Tidal Theory Borne Out.

St. MICHAEL, Alaska, Oct. 11---The Russian Government steamers Taimyr and Waygatch, under Commander Wilitsky, which have been engaged in arctic exploration north Siberia for three years, arrived here to-day for coal.

Capt. Wilitsky reports the discovery of a body of land as large as Greenland, extending beyond latitude 81 north and longitude 102 east.

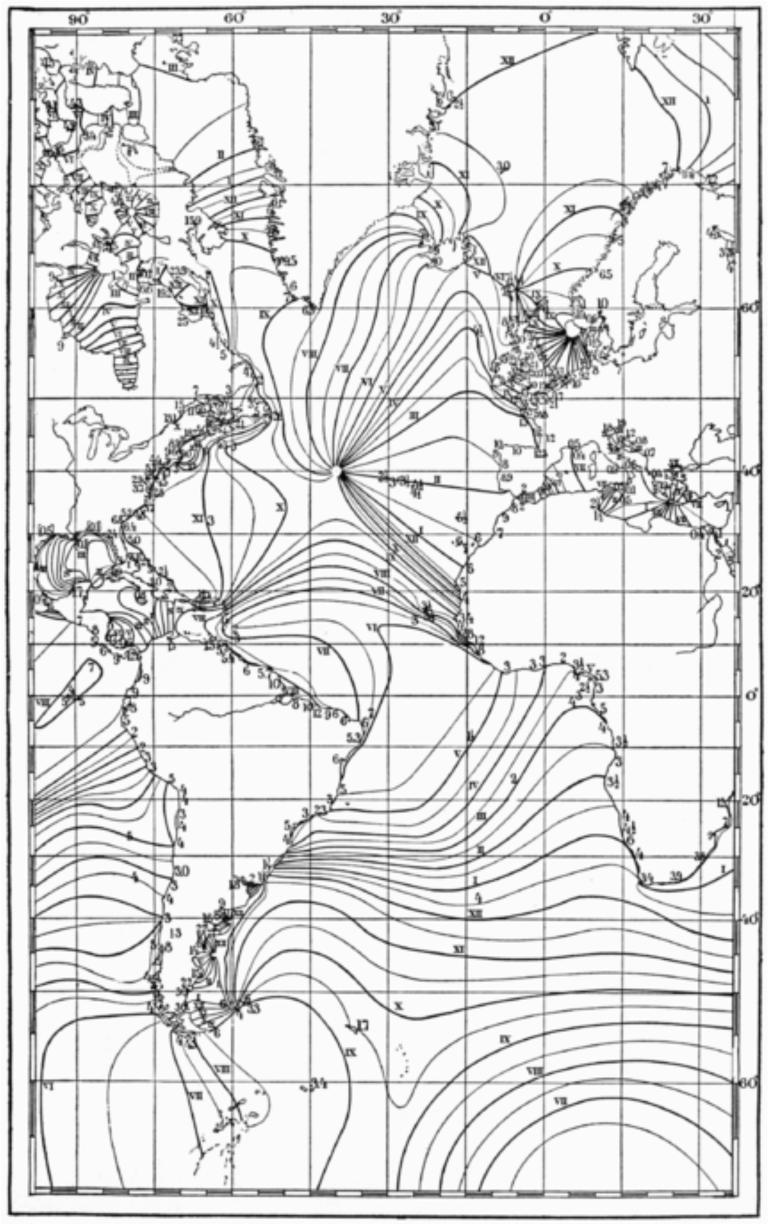
When Vilhjalmur Stefanson started last summer on a three-year expedition into the arctic he described it as an undertaking to test the validity of a theory. That theory, of which Dr. Rollin A. Harris, *the tidal expert of the United States Coast and Geodetic Survey, was the author, was that a body of land about the size of Greenland existed in the unexplored regions north of Canada, Alaska, and Eastern Siberia. The Harris theory, as it is known, was a deduction from tidal movements as observed by arctic explorers for many years back and at many points in the Arctic Circle…*

Through his study of tidal records and his attempts to understand the theory of tides on the basis of geophysical features of the oceans, Harris had arrived at the theoretical conclusion (now known to be erroneous) that a land mass must exist in the arctic.[86] The *New York Times*' article above refers to the Canadian Arctic Expedition of 1913–1916, organized and led by Vilhjalmur Stefansson, originally sponsored by the (US) National Geographic Society and the American Museum of Natural History and later by the Canadian government. Stefanson's expedition is related in detail in the book *Science and the Canadian Arctic: A Century of Exploration, 1818-1918* by Trevor H. Levere, 1993, Cambridge University Press. In 1986, Bernard D. Zetler published *Arctic tides by Rollin A. Harris (1911) revisited*. The abstract reads as follows.

Rollin A. Harris used a few scattered tide observations on the periphery of the Arctic Ocean to contradict Nansen's statement that the Arctic Sea was an open basin of deep water occupying all, or nearly all, of the large unexplored area (in 1911) of the Arctic. Harris concluded that there was either a land mass or some shallow water near the north pole. Fjeldstad disagreed with Harris in 1923, and in 1927, Sverdrup supported Fjeldstad, using additional tide and current observations to reach this conclusion. Later, about 1950, Soviet scientists discovered the Lomonosov and Mendeleyev ridges, and shortly thereafter, U.S. scientists found the Alpha Ridge, all three ridges lying at least partially in what was in 1911 unexplored territory. It appears that Harris' hypothesis was at least partially accurate.

[86] *Arctic tides*, Coats and Geodetic Survey, Washington, 1911, available at https://babel.hathitrust.org/cgi/pt?id=loc.ark:/13960/t08w48g29
Even though there are no land masses above sea level in the artic, there are ridges below sea level that might be connected to Harris' hypothesis.

We end this discussion of Harris' life work by reproducing a text taken from *The Tides: Their Causes and Representation*, an article Harris wrote and published in *Popular Science Monthly*, Volume 74, June 1909.[87] The illustration below is also from that article.



The so-called problem of the tides has for ages engaged the attention of observing and thinking men. Before Newton established the law of universal gravitation, the whole subject was surrounded with an air of mystery, although the fact had long

[87] page 552, https://books.google.com/books?id=RqgWAAAAYAAJ

been recognized by many that in some manner the tides are governed by the moon or the moon and sun. Such views were held by Pytheas of Massilia, Seleucus of Babylonia, Posidonius the Stoic philosopher, Caesar, Cicero, Strabo, Seneca, Pliny the elder, Lucan, Claudianus and Macrobius.

The ancients say little as to the agency whereby the moon is enabled to exert an influence upon the waters of the globe; but winds produced by the moon, vapors surrounding the moon and the special power of the moon to replenish moist bodies, are severally mentioned as being the probable means.

However, before Newton's great discovery, several philosophers had gone so far as to suggest or assert that the tides are due to an attractive force of the moon analogous to magnetic attraction. Among these were Scaliger, Gilbert, the College of Jesuits at Coimbra, Antonio de Dominis, Stevin and especially Kepler.

Of course, not all ancient or medieval theorists admitted the moon to be the cause of the tides. Some of the many other causes brought forward were: The discharging of rivers into the sea; variations in depths and densities of the sea; the surface of the sea not being everywhere upon the same level; the respiration of the earth; submarine caverns; submarine heat; submarine vapors, exhalations, or fermentations; power exerted by a supernatural being; whirlpools and eddies; and the non-uniform motion of the earth or of its various parts.

When Newton had made public his capital discovery, and had shown that the magnitudes or ranges of the tides increase and decrease in accordance with the varying attractions of the moon and sun, the tidal problem was supposed to be nearing a solution. Indeed, Newton thought that he could see in the observed times of tides upon certain shores a justification of his theoretical considerations. His work, however, was only a beginning. Since his time, eminent mathematicians, astronomers and physicists—including Bernoulli, Maclaurin, Euler, Lalande, Laplace, Young, Lubbock, Whewell, Airy, Ferrel, Kelvin, Darwin, Levy and Hough — have addressed themselves to this subject; while others, like Lagrange, Stokes, Rayleigh, Lamb and Poincaré, have dealt rather with the underlying mathematical and physical problems.

CHAPTER IV: THE BIRTH OF THE GRADUATE PROGRAM, 1887-1897.

This drawing[88] is from the thesis *The Library Building of the Cornell University* by Cornell's student Arthur Gibb, 1890. The University Library (now Uris Library) opened in the Fall of 1891.

[88] https://digital.library.cornell.edu/catalog/ss:544465 (Cornell University, Images from the Rare Book and Manuscript Collections)

IV.1 The Rise of a Community

On my return to New York I was filled with the thought that there should be a stronger feeling of comradeship among those interested in mathematics, and I proposed to my classmates and friendly rivals, Harold Jacoby and Edward Stabler, that we should try to organize a local mathematical Society.[89]

The decade 1887-1897 was rich in significant events for the nascent mathematical community of the United States: the birth of the New York Mathematical Society; the openings of Clark University (1889), Stanford University (1891) with Cornell's graduate David Starr Jordan as its first president, and the University of Chicago (1892); and, in 1893, the World's Columbian Exposition and the accompanying Chicago Mathematical Congress and Evanston Lectures.

The American Mathematical Society

The New York Mathematical Society was created in 1888 by a group of mathematicians and actuaries associated with Columbia University. In 1889, the society had 16 members, including Cornell's former student Hiram Messenger. The year 1891 saw a dramatic growth in membership, reaching 174 by June 1891. Members with a Cornell connection at this date include A.R. Bullis, W. Byerly, H.T. Eddy, G.E. Fisher, C.S. Fowler, A.S. Hathaway, E.W. Hyde, G.W. Jones, J. McMahon, H. Messenger, G. Miller, J.E. Oliver, C.A. Van Velzer and L.A. Wait. Six years later, the society changed its name to the American Mathematical Society. The society played a key role in the development of the profession and the mathematical community, and in the emergence of mathematical research in the United States.

Clark University

In January 1887, Jonas G. Clark announced he would found and endow a new University in Worcester, Massachusetts. In 1888, G. Stanley Hall, Professor of Psychology at Johns Hopkins, was appointed the first President of Clark University.

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89 Thomas Fiske, quoted by R.C. Archibald. *A Semicentennial History of the American Mathematical Society*, *1888-1938. Volume I.*

G.S. Hall organized a university focused on research and graduate studies in a small number of subjects: Mathematics, Physics, Chemistry (temporarily discontinued in 1894), Biology and Psychology. In the book prepared for the Decennial Celebration of Clark University, the choice of these subjects is motivated as follows:

Mathematics is sometimes called the queen of all the sciences. As the latter become exact, they approximate it, and are fructified by its spirit and its methods. Its antiquity, its disciplinary value, its rapid and recent development, makes it obviously indispensable. Physics is the field of the most immediate application of mathematics, and deals with the fundamental forces of the material universe, — heat, sound, light, electricity, — and the underlying problems of form and motion generally, with their vast field of application in such sciences as astronomy and dynamic geology. Chemistry, with its great and sudden development, revealing marvelous order and harmony in the constitution of matter, is rapidly extending its dominion over industrial processes. Biology, which seeks to fathom the laws of life, death, reproduction, and disease, that underlies all the medical sciences, in its broader aspects has taught man in recent decades far more concerning his origin and nature than all that was known before. Psychology, or the study of man's faculties and their education, is a new field into which all the sciences are bringing so many of their richest and best ideas, which is now so full of promise for the life of man.

Jonas G. Clark purchased the land, erected the first buildings and gave funds to sustain the university for the first few years, eventually providing a promised endowment of $700,000. Very quickly, misunderstandings and differences grew between J.G. Clark, the Trustees, and President Hall. Clark wanted an undergraduate College whereas Hall was focused on graduate education and scholarship. At his death in 1900 and through his will, Clark established a separate undergraduate institution, Clark College. The two institutions merged in 1920, only after Hall retired as President of Clark University.

Hall’s vision was one of outstanding scholarship with a focus on research. As Gilman had done five years earlier at Johns Hopkins, Hall tried to attract Felix Klein to Clark, without success. At the opening of Clark University in 1889, the Department of Mathematics comprised W.E. Story, Professor and Chair, assisted by

Oscar Bolza, a German student of Klein, and Henry Taber. All came from Johns Hopkins. They advised six Fellows and Scholars: Henry Benner, L.P. Cravens, Rollin A. Harris, J.F. McCullogh, William H. Metzler and J.W.A. Young. Harris had earned his Ph.D. at Cornell that summer. There were no other students. During the first ten years, the Mathematics Department taught 44 students with an average of 8 students attending each year. At the decennial celebration in 1899, the invited lectures were delivered by Emile Picard (Mathematics), Ludwig Boltzmann (Physics), Angelo Mosso (Psychology), S. Ramon y Cajal (Neuroscience, Nobel Prize 1906) and August Forel (Neuroscience). This list captures accurately the ambitious vision of Clark University's first President.

MATHEMATICS' NEW BEGINNING AT HARVARD

After the death of Benjamin Peirce in 1880, mathematics at Harvard was in the hands of excellent teachers, James Mills Peirce, Benjamin Osgood Peirce and William Byerly, but the impetus for research in mathematics was limited. Things changed for the better with the return in 1890 and 1891 of two Harvard graduates, W. F. Osgood and Maxime Bôcher. They had earned their doctorates in Europe, Osgood with Max Noether, Bôcher with Felix Klein. In time, Osgood and Bôcher established a research department with a strong graduate program.

THE UNIVERSITY OF CHICAGO

The original University of Chicago, supported by the American Baptist Education Society, operated from 1857 to 1886. In 1887/88, The American Baptist Education Society and John D. Rockefeller became engaged in the founding of a new University in Chicago. Rockefeller had pledged an endowment of $600,000 if $400,000 could be raised for land and buildings from other sources. Once this was done, Rockefeller committed an additional $1,000,000 including $800,000 specifically for graduate studies. In 1891, William Rainer Harper, a Semitic languages scholar, Professor at Yale, became the first President of the university. He pursued an ambitious project including both undergraduate and graduate studies with an emphasis on the training of future researchers. The plan included lighter teaching loads for the faculty involved in graduate training. Harper benefited from a rare combination of limited interference from Rockefeller and ample support. (Rockefeller's donations to the University of Chicago under W.R. Harper exceeded 30 million dollars.)

In mathematics, Harper hired a young Yale tutor, Eliakim Hastings Moore, who had received his Yale Ph.D. under H. A. Newton with a dissertation titled *Extensions of*

Certain Theorems of Clifford and Cayley in the Geometry of n dimensions. As Harper was building the Chicago faculty, the financial situation at Clark took a turn for the worse and nine of the eleven permanent faculty resigned. (The resignations were later withdrawn.) Harper visited Clark and raided its faculty, bringing the physicist Albert Michelson and other faculty members to Chicago. In Mathematics, Harper and Moore made an offer to Oscar Bolza who declined at first, suggesting his friend Heinrich Maschke. When Harper and Moore asked Bolza again, he accepted on the condition that they also offer a position to Maschke.

The University of Chicago opened in 1892 with an entering class of 594 students and a faculty of 120. (By comparison, Cornell had open in 1868 with 412 students and a faculty of 26.) In addition to Moore, Bolza and Maschke, two other young faculty members were teaching lower divisions classes. With Moore as Chair and Klein's German students Bolza and Maschke bringing mathematical sophistication that was unmatched anywhere in the United States, the Mathematics Department of the University of Chicago instantly became the most ambitious and best mathematics department in the country.

Among the attending graduate students at the opening of the University of Chicago was John Irwin Hutchinson who had followed Oscar Boza from Clark. His mathematical interests were deeply influenced by Bolza's own work under Klein on hyperelliptic functions. In the summer of 1894, Hutchinson accepted an instructor position at Cornell where he would remain for the rest of his career. In 1896,[90] together with Leonard Eugene Dickson, he earned one of the first two mathematics doctorates awarded by the University of Chicago with a dissertation titled *On the Reduction of Hyperelliptic Functions (p=2) to Elliptic Functions by a Transformation of the Second Degree.*

[90] Some early documents from the University of Chicago give the date of Hutchinson's Ph.D. as 1895. See The President's report, July, 1892-July, 1902. Part II [Publications of the members of the university], page 82. https://catalog.hathitrust.org/Record/011715416

The year following the opening of the new university was marked by the World's Columbian Exposition which took place from May 1 to October 30, 1893, in Chicago. Over 750,000 people attended the fair on October 9.

The International Mathematical Congress, one of the many scientific events organized on the occasion, opened on August 21 with the scientific program[91] taking place August 22-26. From Cornell, James Oliver and James McMahon were present as well as H.T. Eddy and C.A. Van Velzer. Eddy was one of the invited speakers and spoke on *Modern Graphical Developments*. Following the congress, from August 28 to September 9, Felix Klein gave an important series of lectures[92] at Northwestern University in Evanston. The lectures covered the following topics:

I. CLEBSCH
II. SOPHUS LIE
III. SOPHUS LIE
IV. ON THE REAL SHAPE OF ALGEBRAIC CURVES AND SURFACES
V. THEORY OF FUNCTIONS AND GEOMETRY
VI. ON THE MATHEMATICAL CHARACTER OF SPACE-INTUITION, AND THE RELATION OF PURE MATHEMATICS TO THE APPLIED SCIENCES
VII. THE TRANSCENDENCY OF THE NUMBERS, e AND π
VIII. IDEAL NUMBERS
IX. THE SOLUTION OF HIGHER ALGEBRAIC EQUATIONS
X. ON SOME RECENT ADVANCES IN HYPERELLIPTIC AND ABELIAN FUNCTIONS
XI. THE MOST RECENT RESEARCHES IN NON-EUCLIDEAN GEOMETRY
XII. THE STUDY OF MATHEMATICS AT GÖTTINGEN
XIII. APPENDIX (THE DEVELOPMENT OF MATHEMATICS AT THE GERMAN UNIVERSITIES)

The discussions that led to the publication of the proceedings of the congress by the New York Mathematical Society were instrumental in providing the impetus for the society to change its name to the American Mathematical Society. The booklet for the Evanston Lectures lists the two dozen members of the society who were in attendance. They include J. Oliver, J. McMahon, H. Eddy and C. Van Velzer.

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[91] https://catalog.hathitrust.org/Record/005830870

[92] "The Evanston Lectures" are available on line at https://archive.org/details/134256628

IV.2 GÖTTINGEN AND THE MATHEMATICAL CLUB

In 1888, James Oliver married Sarah T. Van Petten, a science teacher at Oswego Normal School.

In 1889, James and Sarah Oliver departed for Europe where they stayed fourteen months. It seems likely that this European journey was made possible by the establishment of sabbatical leaves in the early years of President Adams' administration. The Olivers started in Cambridge where James attended lectures by Cayley and Stoke. Next, they went to Göttingen. Cornell's former student B.W. Snow who later became Professor of Physics at the University of Wisconsin, had attended Klein's lectures the previous year and had given Oliver a very positive report. Oliver attended Klein's lectures on Lamé functions, together with fellow Americans Henry White and Maxim Bôcher.[93] In the National Academy memorial celebrating Oliver's life, G. W. Hill[94] writes

> *At Göttingen he [James Oliver] found a congenial friend in Professor Klein. In a note written from there he says: my work here is likely to be of great service to me, including the trains of thought and plans it suggests, no very radically new plans, only as to the spirit, the aims, and the details of my Cornell work.*

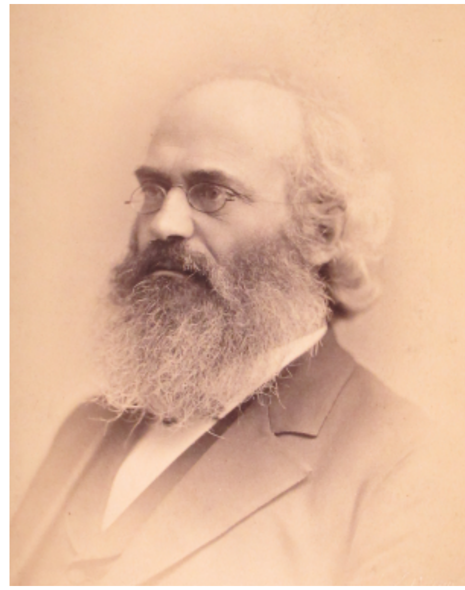
A few years later, when Klein visited America to attend the Mathematical Congress organized in Chicago on the occasion of the Colombian Exhibition of 1893, he paid a visit to his friend Oliver in Ithaca. Several sources note that the two couples, Klein and his wife, Anna (Hegel) Klein, granddaughter of the philosopher, and Sarah and James Oliver, who hit it off. Anna and Sarah were independent, well educated women and the two couples were strong supporters of women's access to higher education, including for the pursuit of research and scholarship. After her husband's death in 1895, Sarah earned a Bachelor of Science at Cornell (1897) and took charge of Natural Study at Oswego Normal School. She soon had to resign because of poor health. She left for California in 1902 and passed away in 1912

[93] *The Emergence of the American Mathematical Research Community*, 1876-1900: J. J. Sylvester, Felix Klein, and E. H. Moore. Karen Hunger Parshall and David E. Rowe, A co-publication of the AMS and the London Mathematical Society, 1994, page 213.

[94] The mathematician G.W. Hill was mentioned in Chapters I-III. He and Oliver had spent years as colleagues at the Nautical Almanac Office.

Upon his return to Cornell in 1890, Oliver started[95] the Cornell Mathematical Club. The first regular meeting of the Club took place on January 24, 1891 and Mr. Charles S. Fowler spoke on the Riemann Plan.

During the first year, the members were as follows: Professors: Oliver, McMahon, Hathaway; Instructors: Mr. Folwer, Rappleye, Studley; Students: Miss Palmié, Davis, Gibbs, Miller, Hawley; Mr. Kerr, Michaelson, Nichols, Pawling, Rogers, Royse, Saurel, Shearer, Shoemaker, Snyder, Tanner. During the second year: Professors: Oliver, McMahon; Instructors: Mr. Fowler, Rappleye, Tanner, Shoemaker; Students: Miss Miller; Mr. Fite, Bedell, Crehore, Saurel, Shearer, Snyder, Pawling, Root, Banks.



James Edward Oliver

These lists offer a window into the life of the department at the time. A.S. Hathaway moved to Rose Polytechnics in the summer of 1891, leaving Oliver and McMahon as the two Cornell professors involved in mathematical research. Here is some information concerning the other early members of the Cornell Mathematical Club.

Charles Summer Fowler, AB ’88, was an Instructor in the department, 1888-95. He was an early member of the New York Mathematical Society (1891) and later worked for the Civil Service Commission, New York State. Walker Glazier Rappleye, BS ’82, was an Instructor, 1889-94. He later taught at the State Normal School, Oswego. Duane Studley, BS ’81, was an Instructor, 1887-92 and later taught at Wabash College. All three were also graduate students. None of them received a doctorate.

Anna Helene Palmié, Ph.B. ’90, was a graduate student supported by the Erastus Brooks Fellowship in Mathematics 1890-91. She pursued further graduate studies at Chicago and Göttingen, and later became Professor at the Flora Stone Mather College, the women's College of Western Reserve University in Cleveland (Case-Western University).

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[95] Felix Klein is often credited as one of the first to organize regular weekly meetings at which mathematical research were discussed (the precursor of todays seminars). Oliver’s mathematical club was built on Klein’s own version that Oliver had attended during his stay at Göttingen.

Eunice Maria Davis, BS '91 with Special Mention in Mathematics, was from Binghamton. She was an undergraduate senior supported by a Sage Scholarship for Women. She later was a mathematics teacher, Union School, Batavia, NY, 1891-95. Kate Francesca Gibbs was an undergraduate special student in mathematics, also from Binghamton. Katharine Moncrief Miller was from New York City, an undergraduate special student in mathematics, 90-92. Sarah Ellen Hawley, AB '91, came from Brandon, Vt. and was an undergraduate senior. She later taught at Northfield Seminary, Mass., 1891-93 and the State Normal School, Albany, NY, 1893-95.

Irvine Jay Kerr, BS '91, was an undergraduate senior from Ithaca studying natural history. Joseph McConnechy Michaelson, CE '92, came from Geneva, NY, and was an undergraduate junior in Civil Engineering supported by the Sage Scholarship. John Henry Tanner, BS '91, was an undergraduate senior supported by the Cornell scholarship. He graduated on the Honor List and with Special Mention in Mathematics with a thesis *The Geometry of the Straight Line and Plane, treated by pure Quaternion Methods; together with a Brief Discussion of some Plane Curves and Surfaces of the Second Order.* In 1891-92, he was an Instructor and graduate student. He became Assistant Professor at Cornell in 1894, studied at Göttingen 1894-96, and became a pillar of the department. Louis Carroll Root was an undergraduate senior who earned his BA in 1892. He became a banker and economist. William Benjamin Fite was an undergraduate senior who graduated Ph.B. in 1892 and would later return to Cornell to earn a Ph.D. He became Professor of Mathematics at Columbia.

John Sandford Shearer, from Homer, was an undergraduate student. He graduated BS in 1893 and received a Ph.D. in Physics from Cornell in 1901. His obituary reads as follows. "*In the death of Professor John Sandford Shearer, Cornell loses one of her most loyal and capable educators and alumni. For twenty-nine years a member or the instructing staff of the University he has labored ardently and faithfully in the fulfillment of his work. Devoting his attention to the physics of the X-Ray, Professor Shearer had become one of the foremost scientists in this field in the country.*"

Jesse Jr. Pawling (AB, Philadelphia) BS '93, was enrolled as a graduate student not candidate for a degree, 1890-94. He later worked at the US Naval Observatory. Daniel Royse (BME, Purdue University), MME '91, was a graduate student in Mechanical Engineering supported by the Sibley Fellowship. He later was editor of *Street Railway Review*. William Ross Shoemaker (BS, Iowa State College) was a graduate student in Mathematics, 1890-94. He became a Clergyman. Virgil Snyder

(BS, Iowa State College) was in his first year as a graduate student in Mathematics and Physics at Cornell. He later earned his Ph.D. at Göttingen under Felix Klein, returned to Cornell, and had for a brilliant career in Mathematics. He will figure prominently in later chapters. John Edwin Banks (BCE, Iowa Agricultural College) was a graduate student specializing in Bridge Engineering.

Ernest Fox Nichols (BS, Kansas Agricultural College) was a graduate student in Mathematics and Physics. He received an MS in 1893 and a Science Doctorate in 1897. Nichols was a professor of physics at Colgate College (1892-1898), Dartmouth College (1898-1903), Yale University (1916), and Columbia University (1903-1916). He was President of Dartmouth from 1909-16 and President of the Massachusetts Institute of Technology 1921-22. He was a member of the National Academy of Sciences and died while delivering a speech at the academy in 1924. Frederick Bedell (AB Yale) was a graduate student in Physics and Electrical Engineering. In 1892, he received the first Ph.D. awarded by the Cornell physics department and was immediately appointed Assistant Professor. He served Cornell for 45 years. His title was Professor of Applied Electricity. His most important contributions in Electrical Engineering were in experimental investigations and theoretical studies in connection with alternating currents.

Albert Cushing Crehore (AB Yale) was a graduate student in Physics and Electricity who, like Bedell, received his PhD in 1892. Bedell and Crehore wrote a book together *Alternating Current, Analytical and Graphical Treatment* which was, for many years, a standard text on the subject. Crehore became a popular writer and inventor. He taught at Cornell and at Dartmouth College, and is the author of "The Atom" (1920) and "Electrons, Atoms, Molecules" (1946). Bedell married Crehore's sister, Mary Louise Crehore (MS '95). Frederick John Rogers (BS, Kansas State Agricultural College) was a graduate student in Mathematics and Physics and received a Science Master in 1891. In 1900, after being a member of the Department of Physics at Cornell for eight years, he left for Stanford where he stayed until his retirement in 1929.

Paul Louis Saurel served as the first secretary of the Mathematical Club. He had graduated BS in 1890 from the College of the City of New York and enrolled as a graduate student in Mathematics at Cornell 1890-96, serving as instructor 1892-96. He returned to the College of the City of New York in 1896, serving successively as tutor, instructor, Assistant Professor, Associate Professor, Professor and Head of Mathematics from 1919 until his retirement. In 1900, he obtained a Science Doctorate with a thesis titled *"Sur l'équilibre des systèmes chimiques"* at Université de Bordeaux, France, under the supervision of Pierre Duhem. During his career, he published regularly in the *Annals of Mathematics*, the *Bulletin of the AMS* and the *Journal of Physical Chemistry*. He died while vacationing in Paris after his retirement in 1934.

THE FIRST GRADUATE STUDENTS

The *Cornell Register* was an annual publication providing information about the courses of study offered at Cornell, including the list of "Elective Work" proposed that year in mathematics. For 1892/93, it reads as follows. The order is that of the register. Subjects not offered that year are omitted.

- 10. Analytic Geometry and Calculus (Professor Oliver)
- 11. Geometric, Algebraic and Trigonometric Problems with Applications; including something of Probabilities and Insurance, and of Spherical Astronomy. (Assistant Professor Jones)
- 12. Advanced work in Algebra, including Determinants and the Theory of Equations. (Mr. Tanner)
- 13. Advanced work in Trigonometry including Hyperbolic Functions. (Mr. Fowler)
- 14. Advanced work in Analytic Geometry of two and three Dimensions
  (a) First year, Lines and Surfaces of First and Second Orders. (Assistant Professor Jones)
  (b) Second year, General Theory of Algebraic Curves and Surfaces. (Assistant Professor McMahon)
- 15. Modern Synthetic Geometry, including Projective Geometry. (Assistant Professor Jones)
- 19. Advanced work in Differential and Integral Calculus.
  (a) In Differential Calculus. (Mr. Rappleye). Will include a short course in Differential Equations given in the Spring term by Professor Wait.
  (b) In Integral Calculus. (Professor Wait)
- 20. Theory of Quantics, based upon Salmon's Modern Algebra. Requires courses 8 or 10, 12, 14 (a), and preferably also 11, 13, and 19. (Assistant Professor McMahon)
- 22. Theory of Functions (Professor Oliver)
  (a) First year; General Function Theory.
  (b) Second year; Elliptic, Abelian, and Automorphic Functions.

- 23. Finite Differences, Factorials, and Difference-Equations, with applications to Practical Computation. (Professor Oliver)
- 29. Theory of Numbers. (Professor Oliver).
- 31. Theory of Probabilities and Least Squares, with some applications to philosophy, sociology, and metric science. (Professor Oliver)
- 32. Non-Euclidian Geometry. (Professor Oliver)
- 16. Descriptive and Theoretical Astronomy.
  (a) Descriptive Astronomy, requiring but little mathematics. (Mr. Shoemaker)
  (b) Physical and Mathematical Astronomy, requiring the equivalents of course 3, and 7 or 8, and of course 1 or 2 in Physics. (Mr. Shoemaker)
  (c) Celestial Mechanics, requiring the equivalent of courses 10 and 16 (a), and preferably also of 16 (3), 21, 24, 26, and 27. (Professor Oliver)
- 24. The Potential Function and Spherical Harmonics. (Professor Oliver)
- 26. Rational Statics, or 27, Rational Dynamics. (Professor Wait)
- 28. Molecular Dynamics, and Physical Optics, based upon Sir Thompson's lectures. (Assistant Professor McMahon)
- 43. Mathematical Theory of Sound (according to Rayleigh). (Assistant Professor McMahon)
- 44. Mathematical Theory of Electricity and Magnetism, based upon Maxwell. (Professor Oliver)
- 17. Mathematical Pedagogy. (Professor Oliver) Course 17 is required for the Teacher's Certificate in Mathematics.
- 18. Mathematical Essays and Theses. (Professor Oliver)
- 33. The Reading and Discussion of the Mathematical Journals. (Professor Oliver)
- 34. Higher Algebra. Seminary work. (Assistant Professor Jones)

Six doctorates were awarded in mathematics at Cornell between 1886 and 1895 to three men, J.I. Messenger (1886), R. A. Harris and C. E. Linthicum (1888), and to three women, I.M. Metcalf (1893), A.L. MacKinnon (1894) and A.S. Baxter (1895). The thesis work of R. Harris and A. MacKinnon were both published in the *Annals of Mathematics*.

Charles Worthington Comstock earned a Master in Civil Engineering in 1894. He was an instructor in Civil Engineering until 1897 when he left Cornell for a position at the Colorado State School of Mines. He earned his Ph.D. in 1898, in absentia, with a dissertation titled *The Application of Quaternions to the Analysis of Internal*

Stress. Between 1895 and 1900, at the same time as graduate studies emerged as a force in many areas, at Cornell and at other institutions in the United States, Cornell produced no other mathematics doctorates. This is, no doubt, the result of James Oliver's untimely death in 1895. Nevertheless, Oliver's tireless efforts were not in vain. The younger faculty he helped bring to Cornell, notably James McMahon, Virgil Snyder and John Irwin Hutchinson, would become the pillars of the department and its graduate program during the first two decades of the twentieth century.

In 1893-95, Virgil Snyder, who had enrolled at Cornell as a graduate student in 1891, was at Göttingen working under Felix Klein with the support of a Cornell graduate fellowship. In 1894/95, under Oliver's leadership, the department made a determined effort to strengthen its faculty. The Canadian Daniel Alexander Murray joined the department as Instructor in 1894, having earned his Ph.D. with a thesis titled "*Associate Equations of Linear Differential Equations*" at Johns Hopkins in 1893. He was the first faculty member holding a Ph.D. since W. Byerly (1873-76). He stayed until 1901 when he moved to Dalhousie University and later to McGill. That same year, Bolza's student, John I. Hutchinson, accepted an instructorship. He received his Ph.D. from the University of Chicago two years later, in 1896, and stayed at Cornell for the rest of his career. John Henry Tanner, a brilliant Cornell student who had been retained as an Instructor, was promoted to Assistant Professor and sent to Göttingen to attend Klein's and Hilbert's lectures. In addition, Tanner was given the mission to convince a young German mathematician to accept a Professorship at Cornell.

During the decade 1890-1899, Cornell enrolled about 30 graduate students with interest in mathematics. There were also a number of students listing Physics or Chemistry as a primary subject and Mathematics as a secondary interest. In some cases, for example Virgil Snyder, the order changed over the years. To help make sense of the interests, goals and quality of these students, we arrange the list in three distinct categories based on what we know about their subsequent career.

Students who later obtained a doctorate and/or held a Professorship at a College or University:

- Anna Helene Palmié, Erastus Brook Fellowship 1890/91, Professor, the Women's College of Western Reserve University in Cleveland.
- Paul Louis Saurel, Erastus Brook Fellowship 1891/92, D.Sc. Bordeaux 1900, Professor of Mathematics and Chair, CUNY.

- Ernest Fox Nichols, switched to Physics, D.Sc. Cornell, 1897, Professor of Physics, Columbia University.
- Virgil Snyder, Erastus Brook Fellowship 1892/93, Ph.D. Göttingen, 1895, Professor of Mathematics at Cornell.
- John Henry Tanner, Professor of Mathematics at Cornell, Ph.D. New Hampshire College, 1901.
- Anna Louisa MacKinnon, Erastus Brook Fellowship 1893/94, Ph.D. 1894, Postgraduate studies at Göttingen, Professor at Wells College.
- Ida Martha Metcalf, Ph.D. 1893, Security Analyst, Statistician, Office of The Controller of the City of New York.
- Frank Edward Millis, President White Fellowship 1893/94, switched to Physics, Ph.D. 1896, died in 1903.
- Caroline Willard Baldwin, Physics D.Sc. 1895, first woman to earn a physics doctorate at an American university.
- Agnes Sime Baxter, Erastus Brook Fellowship 1894/95, Ph.D. 1895. Married Albert Ross Hill who earned his Ph.D. in Philosophy the same year. Hill was later, successively, Dean of the College of Arts and Sciences at Cornell and President of the University of Missouri. At his wife's death, Hill stated[96] that she had given her life "to assist in my educational work instead of making an independent record for herself."
- Mary Cass Spencer, MS 1895, Professor of Mathematics, H. Sophie Newcomb Memorial College, Tulane University.
- Arthur Ranum, Erastus Brook Fellowship 1895/96, Ph.D. Chicago 1906, Professor of Mathematics at Cornell.
- Paul Arnold, University Fellow 1895/96, Erastus Brook Fellowship 1896/97, Professor of Mathematics at the University of Southern California.
- Murray MacNeill, University Fellow 1896/97, Erastus Brook Fellowship 1897/98, Professor of Mathematics at McGill and Dalhousie (also known in the sport of Curling.)
- Peter Fields, University Fellow 1897/98, Erastus Brook Fellowship 1898/99, Ph.D. 1901, Professor of Mathematics and Chair, the University of Michigan.
- Elting Houghtaling Comstock, University Fellow 1897/98, Professor of Mathematics at the University of Minnesota.
- Harry Waldo Kuhn, University Scholar 1898/99, Erastus Brook Fellowship 1899/1900, Ph.D. 1902, Professor of Mathematics and Chair, The Ohio State University.

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[96] http://www.biographi.ca/en/bio/baxter_agnes_sime_14E.html

- William Benjamin Fite, University Scholar 1898/99, University Fellow 1899/1900, Ph.D. 1902, Professor of Mathematics at Cornell and, later, at Columbia University.

Students who earned a Master's degree:

- Frederick John Rodgers, switched to Physics, AM 1891, career at Stanford University.
- Estella Kate Wentz, MS 1894, Instructor in Mathematics, Manual Training High School, Indianapolis, Ind., Mathematics teacher, West Lafayette, Ind.
- Charles Howard Phelps, AM 1894, Business.
- Wendell Melville Strong, AM 1894, Actuary.
- Frank Rounsefell Higgins, AM 1896, State Normal School, Terre Haute, Ind.
- Hallie Schoedde Poole, AM 1897, Teacher, Lafayette High School, Buffalo, NY, computer, US Coast and Geodetic Survey.
- Claude William Leroy Filkins, MCE 1894, Civil Engineer.
- Edwin Haviland, AM 1899, University Station, Seattle.

Other graduate students (1890-1899):

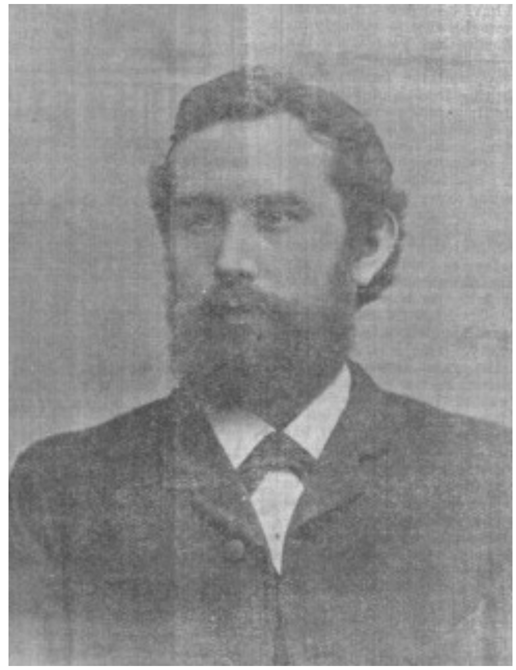
- Charles Summer Fowler, Civil Service Commission, Albany, NY.
- Walter Glazier Rappleye, Teacher, Oswego State Normal School.
- William Ross Shoemaker, Clergyman.
- James Harrison Dysinger, Teacher, Los Angeles, California.
- Charles Albert Stiles, Founder and Principal of the University Preparatory School in Ithaca, 1900-1909.
- Edward Candee Townsend, Draughtsman, Olympia, Washington.
- William Henry Pierce.
- Arthur Evan Rommel, CE 02, Railroad engineer and later, County Engineer of Mahaska County, Iowa.

IV.3 THE DEATHS OF JAMES OLIVER AND ERNST RITTER

For the academic year 1894/95, James Oliver was set to teach courses on Non-Euclidean Geometry, Mathematical Theory of Electricity and Magnetism, Mathematical Pedagogy and a seminar on Mathematical Methods applicable to certain Economic and Social questions. Oliver fell ill in early 1895 and passed away on March 27 1895. In his Report for the year 1894-95, President Shurman wrote the following.

The University has sustained a grievous loss in the death of Professor James Edward Oliver. On the 27th of March he succumbed to an illness by which he had been prostrated for several weeks. Professor Oliver had been connected with the University for twenty-four years. Appointed assistant professor of mathematics in 1871, he was in 1873 raised to the full professorship in succession to Professor Evans. With a rare genius for mathematics, Professor Oliver not only maintained his department at a high level, but it is not too much to say he made the University a center of mathematical influence for this continent. A master of demonstrative reasoning he presented to the public only a small portion of the materials of the lectures which he gave his students; he was restrained from publishing by his modesty, his inexorable self-criticism, the many-sidedness of his intellectual interests, and his unfailing readiness to give aid to others, many of whom he knew only through the problems they propounded to him by correspondence. By nature, an inquirer demanding liberty of thought yet judicial and reverent, Professor Oliver was an embodiment of that spirit of free and impartial search after truth which is the vital principle of a university, and as such he was a model and an inspiration to all members of Cornell. Frank, simple, and hopeful, full of the most inspiring earnestness and enthusiasm, he was also a man of the highest moral qualities, scrupulously veracious, just, patient, guileless, generous and kindhearted to a fault. No wonder that when the end came, admiration of his greatness was hushed in the affection which friends, colleagues, and students cherished for his sweet and simple goodness…

Ernst Ritter was appointed Assistant Professor of Mathematics. Taking the most advanced classes of the late Professor Oliver, Professor Ritter will have nothing to do with students in the undergraduate courses. If the graduates who make up his classes desire it, some of the instruction may be given in German, though Professor Ritter is able to lecture in English.



The last paragraph announces the arrival at Cornell of the German mathematician Ernst Ritter, a student of Felix Klein. Simply put, although Ernst Ritter was still very young (twenty-eight), he was, without a doubt, one of the best trained and most brilliant European mathematicians to emigrate to the United States before 1900. Oscar Bolza and Heinrich Maschke, the German stars of the newly created University of Chicago, both also students of Felix Klein, had left Germany because they could not find a university position at all. Ernst Ritter was a Privatdozent at Göttingen and the closest associate of Felix Klein when he accepted the Cornell position. His work had been featured in some of the Evanston Lectures given by Klein in 1893 and would find an important place in the two volume treaty *Vorlesungenuber die Theorie der automorphen Funktionen published by Klein and Fricke* in 1897 and 1912.

In a sad turn of events, Ritter died upon his arrival in New York and never made it to Ithaca. Felix Klein himself relates the events in Ritter's obituary[97] reproduced below.

From New York we received the sad news, that our member Ernst Ritter died there of typhus. He got his habilitation in Göttingen a year ago and had received a job offer from Cornell University in Ithaca. It was a research position which was supposed help Cornell to catch up other famous American universities where mathematics is developing rapidly and he gladly accepted this job. With his clarity and his extended mathematical knowledge, he seemed to be particularly well suited to this task. But it should come differently. Ritter was not feeling well, when he started his journey to the United States 4 weeks ago; due to his strong constitution he paid no attention to this. Immediately upon arrival in New York he was

[97] Jahresbericht der Deutschen Mathematiker Vereinigung, vol. 4, page 52 (translation by Birgit Speh).

admitted to the Government Hospital on Ellis Island, where he then passed away, on the new continent, surrounded by all the care which his American mathematical friends could muster.

Ernst Ritter was born in Waltershausen (Thüringen) on January 9,1867; starting in 5th grade he attended the gymnasium in Gotha where he graduated in spring 1885. He continued his studies for 2 years in Jena and after that for 4 years in Göttingen. In fall 1890 he obtained his Staatsexamen (teacher's license) and, in spring 1891, his doctorate in mathematics, He started in fall 1891 the two years of practical teacher training, which everyone in Prussia has to do, in Cassel and then continued in Frankfurt. In fall 1893, he returned to Göttingen as an assistant in the mathematics department and at the end of summer 1894 he obtained his "habilitation".

Apart from an article which discusses the movements of 2 particles according to Weber's law and which was published in Schlömilch's Zeitschrift 3, his research concerns the theory of functions in one complex variable. I would like to mention here the 3 long articles in Mathematische Annalen volumes 41, 44 and 45, which will be followed by a fourth article in volume 47. In these Ritter developed the foundations of function theory, His point of view is similar to the one which I suggested earlier, but he develops this theory in great depth. Without doubt his work is a great advance in the theory of functions on Riemann surfaces. I want to mention here just his use of homogenous variables, multiplicative forms and the continuity of functions under continuous change of the Riemannian surface and from his as yet unpublished article the general theorems about linear differential equations in a Riemannian class. The spirit of strength and clarity, which one finds in these articles, is characteristic of Ritter. This could be observed earlier in his life. I have been told that Ritter was always the best student in school and that he passed brilliantly all his exams at the university.

May he rest in peace.

Göttingen, September 25, 1895.

Felix Klein

Here is the perspective of Salomon Bochner,[98] mathematician, Professor at Princeton and himself a German émigré, who wrote on these events years later.

Now, in my search for an understanding of the Riemann-Roch theorem, I have been looking at the references in the footnotes of Weyl's book (Die Idee der Riemannschen Fläche/The Concept of a Riemann Surface). There, on pages 136 and 137 (of the English edition) there is a reference to one E. Ritter who in 1894 was one of the first who, except for one relatively minor flaw, gave a proof of the Riemann-Roch theorem even for so-called fractional divisors. And later on in Weyl's book, in a footnote to page 147, this E. Ritter is even credited with formulating an extension of the entire Riemann-Roch theorem from system of differentials and functions that are univalent on the closed Riemann surfaces to such differentials and functions that are defined on the covering space of the Riemann surface, but are reproduced by the elements of the Poincaré monodromy group by a fixed multiplicative character of the group. And Weyl adds that in a later paper in 1896 (Math. Annalen, vol. 47), E. Ritter even further generalizes this to solutions of certain types of differential equations on the Riemann surface. This sounded to me like the work of a very good mathematician, and I wondered why I had not heard from Ritter otherwise. So, one day I decided to look up the last quoted paper, and I had a surprise. The very last sentence of the paper announces a continuation, but there is a sad footnote by the editor attached, stating that, alas, there will be no such continuation. The author, Dr. Ernst Ritter, had accepted a call to Cornell University at Ithaca, but on the way to Ithaca, in New York, he succumbed to a typhus attack, on September 23, 1895. Also, the footnote announced a detailed obituary in the Jahresbericht der Deutschen Mathematiker Vereinigung.

This obituary was done by F. Klein, and is, oddly enough, dated September 25, 1895. It made me doubly unhappy for Cornell and the U.S.A. in general, for having missed out on such a gifted mathematician. Ritter had been born in January 9, 1867, and thus

98 Bochner's Collected work, Part 4, Mathematical Reflections, page 833.

was only 28 ½ years old when he died. He had become a Privatdozent at Göttingen only two terms before receiving the call from Cornell. It was meant to be a big, purely scientific position by which Cornell wanted to become aligned with other mathematically forward-striding great American universities. Klein added that at sailing time Ritter did not feel well, but having a robust constitution ignored it. Immediately on arrival he was taken to the Government hospital at Ellis Island, where he passed away, surrounded with all the care which friendly American mathematicians could show him. I have been unhappy for American mathematics since.

The deaths, in less than six months, of James Oliver and of the young Ernst Ritter who had been hired to replace him was, indeed, a terrible blow to the establishment of a major graduate program in mathematics at Cornell. As we shall see, the program survived and grew nonetheless. But one may forever wonder what would have happened if Ernst Ritter had established himself at Cornell.

IV.4 Mathematics and Cornell's Founding Ideas

The Importance of Mathematics

In view of the strong emphasis on mathematics during the early years at the Johns Hopkins University, Clark University and the University of Chicago, one is led to observe that the founders of Cornell University were preoccupied by much different areas and issues than mathematics. The bold and ambitious ideal, "*Any Person, Any Study,*" and the varied interest of Andrew Dickson White did not foster a particular emphasis on Mathematics.

Of mathematics, Andrew Dickson White had little to say, especially for a man who had much to say about many things. In his biography, he notes that school geometry was the only mathematical study he ever loved for its real applications and the beauty of its reasoning. He seems to have had little contact with more advanced mathematics. (From what H.T. Eddy tells about his Yale experience, this is not much of a surprise.) White was an intellectual and humanist, with a strong interest in history and politics. He was fascinated by the experimental sciences. He brought Agassiz and Goldwin Smith to Cornell, not Sylvester nor Peirce.

White understood the role of mathematics in general education and as a language for science. In his extensive writings regarding science and religion —*The Warfare of*

Science (1876) and *A History of the Warfare of Science with Theology in Christendom* (1896)—White discusses the mathematics involved in the discoveries of Copernicus, Galileo and Kepler and, of course, Newton. Nevertheless, White seems strangely unaware of the fact that the gulf separating the United States and the old world with respect to education, scholarship and research, was more pronounced in mathematics than in almost any other subject. He seems similarly unaware of the specific needs or the potential for progress in mathematics in the United States. When, during the difficult period of 1879-81, as Henry Sage and the Trustees were considering a faculty purge, the question came up whether or not the Chair of Mathematics, James E. Oliver, should be retained, White's written answer from Berlin was, "Oliver was a great mathematician, but let him go." [99] It would have been extremely difficult, if not impossible, to replace Oliver by someone of similar standing and quality.

The first professor elected by the Cornell's Trustees—on White's suggestion—was Evan W. Evans, as Professor of Mathematics. Evans was an acquaintance (perhaps a friend) of White and, by the standards of the time, a great scholar, noted at Yale for his strength in mathematics and as a writer. At the time of his appointment, he had left a professorship at Marietta College to pursue a career as a mining engineer, perhaps for health reasons. (He suffered from tuberculosis and died from his illness in 1874.) To gauge Evans' stature and his level of interest and scholarship in mathematics, we can compare him to his contemporary and fellow Yale graduate Hubert A. Newton. Newton must have been known to both White and Evans. He graduated at Yale in 1850, a year before Evans and two years before White. He served as a Tutor at Yale (as Evans did) and went to study Geometry in Paris with Michel Chasles while on a leave of absence. After returning to Yale and becoming Professor of Mathematics, he worked mostly on Astronomy while retaining an interest for Geometry. Today, Newton is best known for having supervised the graduate work and doctorate of E.H. Moore,[100] who was the first Chair of Mathematics at the University of Chicago. By comparison, Evans never displayed much interest for advanced study or original work in mathematics.

Most striking is the fact that A. D. White did prefer Evans (and Assistant Professor Ziba Potter, a medical doctor) to James Oliver. Carl Becker reports[101] that Oliver had been recommended to Ezra Cornell and A.D. White, certainly by Benjamin

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[99] *A History of Cornell*, Morris Bishop, page 205.
[100] Notices of the AMS, Volume 55, Number 3, March 2008, The Father of the Father of American Mathematics, by Steve Batterson.
[101] Cornell University: Founders and the Founding, page 125.

Peirce. W.T. Hewett[102] remarks that B. Peirce always said that “Jimmy Oliver was the best mathematician who had ever come under his notice.” In 1867, Oliver had resigned from his position at the Nautical Almanac, a position he had never enjoyed. Oliver lectured at Harvard both during and after his appointment at the Nautical Almanac, in particular, in 1863-64, 1866-68 and 1869-1871. In 1861, he had been elected as a Fellow of the American Academy of Arts and Science. Before calling J. Oliver to an assistant professorship position in 1871, A. D. White hired two military men, W. Arnold and W. Hamilton, as well as the young Harvard graduate, Lucien Wait, to teach mathematics. None of these men had any real standing in mathematics nor any interest for mathematical research. Later, Oliver himself, then the Chair of the Department, described the position of mathematics at Cornell as follows.

The number taking the various electives as undergraduate, graduate, or special students has about kept pace with the general growth of the university; though the splendidly equipped technical courses on the one hand and the admirable scientific and humanistic work done here on the other hand, offer strong counter attractions. For, in the community at large, mathematics is still thought of merely as a good logical drill, and a key to the physical sciences, with their applications. One great mission of the mathematical department here, as elsewhere, is to show that in healthily developing the geometric and philosophic imagination, in awakening an intelligent interest in the grand systems of worlds amid which our own is placed, as well as a sense of the beauty of purely intellectual relations, in adding definiteness to certain metaphysical concepts; and in that correlation of the abstract with the concrete and with the certain which will help to cure the prevalent distrust of ideals, mathematical studies have peculiar educational and even religious values that could ill be spared.

The details we just described and the comparison with the extraordinary efforts made, ten years later, by Daniel C. Gilman to attract James J. Sylvester to Johns Hopkins, seem to indicate that A. D. White had only a limited appreciation for the place of scholarship and research in mathematics and the expanding role of the subject with respect to higher education in general and science in particular.

[102] Cornell University: A History, pages 141–143.

THE MATHEMATICS DEPARTMENT AND CORNELL'S FOUNDING IDEAS

Another interesting question to consider here concerns the views of the early Cornell mathematics faculty with regards to Cornell's founding ideas. Cornell was founded on several bold ideas: "*Any Person, Any Study,*" of course, but also an unusual and novel mix of respect for classical studies (Greek, History, Mathematics, Philosophy, etc,) alongside the pursuit of new subjects such as Literature, Physics and Chemistry, Architecture, Engineering, and Agriculture. In addition, Cornell was non-sectarian and co-educational, and it supported the development, throughout the disciplines, of a curriculum leaving large open spaces for electives. Finally, after the first fifteen years and following the example set by Johns Hopkins University, Cornell University embraced research, scholarship and graduate studies as key elements of its vision of higher education.

By all accounts, it appears that the Cornell Mathematics faculty were staunch supporters of the institution's foundational ideas and innovative views on education. The early Cornell mathematicians were deeply engaged in the education of the Cornell students attracted by the courses in science and engineering offered by the new university. They were supporters of the elective system and of the curricular innovations. In his biography, Andrew White remembers the contributions of Evans and Oliver to his efforts to establish a course in literature.[103]

The effort to promote that element in the general culture of the student body which comes from literature, ancient and modern, gained especial strength from a source usually unpromising—The mathematical department. Two Professors highly gifted in this field exercised a wide and ennobling influence outside it. First of these was Evan William Evans, who had been known to me at Yale as not only one of the best scholars in the class of 1851, but also one of its foremost writers. Later, he developed a passion for modern literature, and his influence was strongly felt in behalf of the humanities. His successor was James Edward Oliver, a graduate of Harvard, a genius in his chosen field, but always exercising a large influence by virtue of his broad, liberal, tolerant views of life

[103] Autobiography of Andrew White, Volume I, page 365.

which were promoted by study of the best thoughts of the best thinkers of all times.

Support for the non-sectarianism and the overall social liberalism underlying Cornell founding ideals almost made James E. Oliver and George W. Jones lose their professorships during the period 1879-1881. Oliver was not irreligious. (Born in a Quaker family, he was part of the Unitarian Church in Ithaca.) He was a tolerant free thinker, as noted in the above quote from A.D. White.[104] He was, from early in his youth, an abolitionist. According to Morris Bishop, Oliver's troubles in 1880 were related to the fact he had been announced as a co-speaker at a certain event with Robert G. Ingersoll, a famous lawyer and orator nicknamed "The Great Agnostic."

The department courses attracted many women who appear to have been very welcome by the Mathematics faculty. James Oliver's youngest sister, Mary Ellen, attended Cornell and graduated with a Bachelor in Philosophy in 1878. (She died in 1888.) Lena Hill, B. Science and Letters '79, published—fifty years after her graduation—a version of her Honors Thesis in which she thanks her teacher, Lucien Wait. The fifth graduate fellowship ever offered by the Department was given to Anna Widman (she declined), and the Mathematical Club created by James Oliver in 1891 included several female members from its very beginning. Of the 29 Special Honors in Mathematics awarded between 1883 and 1900, 11 went to women while women represented at most 15% of the Cornell undergraduates during this period. Of seven mathematics doctorates awarded to graduate students at Cornell before 1900, three went to women. The first of these three women, Ida Metcalf, worked closely with G. W. Jones, who thanks her for her help in the preface for his *Drill Book on Algebra*. She was only the second American woman to earn a Ph.D. in Mathematics. The second, Annie MacKinnon, went on to spend two years in Göttingen after earning her Ph.D. She first met F. Klein at a reception held at Professor Oliver's residence. She is the third American woman to earn a mathematics Ph.D. Upon her return from Europe, MacKinnon taught at Wells College for several years before marrying E. Fitch, a Greek scholar who had also been at Göttingen. He was Professor and Dean at Hamilton College. Agnes Baxter was the last of Oliver's Ph.D. students and graduated in 1895. This tradition in support of women continued long after Oliver's death in 1895: fourteen of the forty-three doctorates supervised by Virgil Snyder in the department from 1900 to 1938 were awarded to women.

[104] See the article dedicated to James Oliver in "The Free Thought Magazine" Vol 13, 1895.

In a letter to "The Freethinker Convention" of 1878, held at Watkins Glen, N.Y., and which he could not attend, Oliver laid down his philosophical views as follows.[105]

Dear friends,

Will you receive a written testimony from one who is unable to be present with you? As Freethinkers, our mission is two fold. First we must maintain the right and duty of absolute freedom in thought and in discussion, providing always, that what we say is true, courteous and decent, appealing to the intellect and not the passions; and that each of us endeavors to be kind and noble in his thought. Secondly, we must use this freedom for discovering the spirit of truth and especially of such truth as appertains to religious or social science and is likely to benefit mankind. Upon each of these topics I would submit a few ideas for your consideration.

1st. That thought and speech should be free. But are they free? If anyone whether Atheist, Calvinist, or Romanist, whether Communist or Tory, is ostracized or even unkindly ridiculed for opinions which he faithfully or conscientiously holds, then, in the name of Free Thought, let us protest against this offense, whether it happens to be committed against ourselves or against our opponents. Distinct from, yet in spirit akin to, free thought and free speech is the complete secularity of the State—the fundamental law. The levying of taxes, the precious weekly holiday, the yet more precious public schools should be utterly without bias for or against any combination of religious sects. The State cannot undertake to bolster up a slowly dying faith, and a live faith is better without its corrupting patronage. The State will best promote the highest interests of mankind by not prejudging questions upon which the best and wisest cannot, as yet, agree, and which hitherto have been treated chiefly by mere appeals to emotion and conflicting authorities. This is, it seems to me, complete as a Liberal creed. Whoever believes earnestly in freedom, fellowship of character, in every one's duty of fearlessly seeking and uttering the

[105] The letter was published seventeen years later, on the occasion of Oliver's death, by the "Free Thought Magazine" of H.L. Green, Vol. 13, 1895.

truth, and in holding the State to a policy of strict non interference in religious matters, he is a Liberal and Freethinker, and belongs with us, no matter what may be his faith concerning God or Christianity. Can't we stand consistent upon this ground? Good men and women will at least unite with us, and the battle of Freethought will be won. But the battle is not yet won. As long as good men say in confidence. "Your demands are just, but if I join with you in urging them, I shall grieve or alienate my friends—injure my worldly prospects," so long have Liberal leagues and Freethought associations a work to do. With cheerfulness and dignity, let us accept and live down the odium which others are afraid to share with us.

2nd. Our second duty is earnestly, fearlessly, and carefully to seek for truth and to make known to others whatever truths we think are most needed and most certain. This duty rests directly upon us as individuals, and we are not committed by one another's utterances. Great problems are before us. Let every one contribute his mite toward the solution of some problem, though it be but a single fact or suggestion, and let us be content to hasten our work in every way until the doubt of its soundness is no longer possible. That is the method of science, and it succeeds. Probably never until now in the World's history could the same method be applied to religion. Thought cannot be scientific until it is free. The overshadowing authority of the Church and Bible, the fear of hell, the notion that credulity is a virtue and skepticism a sin, have for centuries made religious science in America and Europe almost impossible. The very foundations can be hardly recognized lying underneath the rubbish, deep in the permanent needs and adaptations of the human soul.

Besides the religious, science has had to wait for the emancipation of woman. Many of its data are connected with the affections and with moral idealism, and therefore can best be studied by her. But her mind must first be free from superstition and accustomed to the scientific methods. Even now these studies must be slow, partly because one cannot well pursue them except in connection with his own maturing character, for the materials which we are to lift by scientific methods must be largely gathered from within ourselves. Nor can the result as yet be fully seen. It may confirm whatever is *most consoling and inspiring in the old religion. Some of the deeper analogies of science seem to point in this direction, while the popular notion that science has already answered the questions of God and the future life, in the materialistic sense, I think equally unfounded.*

All this will come in time, but first let us deal with the urgent problems of today, such as, how to rescue man from drunkenness and vice, and lead him to a higher life; how to purify trade, politics, and civil service and stop the success of fraud and demagogism; how to raise the condition of the laborer; how best to educate our children; and how to inspire woman with an interest in all that concerns the public Welfare, so that her advent into politics—instead of being feared as a new danger—shall be held as a deliverance. Nor shall we be meanwhile without a religion. We have or may have a religion of unselfish devotion to others and to our own highest ideals; a religion of character, of abiding enthusiasm for humanity, and of complete intellectual honesty. Into our little human lives it will bring something of the grandeur of these infinite surroundings, a high purpose amid which and for which we live. This religion the world needs now; and it may be providential that until its results are learned, no certain knowledge of any future life is given us to divert our thoughts from the duties of this.

SCHOLARSHIP AND RESEARCH

On his return from Berlin and before resigning the presidency at Cornell in 1885, President A.D. White started to promote graduate studies and research as an essential component of Cornell's model of higher education. On February 1881, White stated

The number of Cornell's students will be determined largely by its reputation for research as well as for instruction.

In pursuing this new goal, White had no stronger supporter than James Oliver. When, at the end of 1883, J. J. Sylvester left Johns Hopkins to return to England, Oliver immediately sensed there was an opportunity for Cornell to fill the void created by Sylvester's departure. He then embarked on developing a solid graduate program.[106] In pursuing this long-term goal, the challenges the department faced were, retrospectively, quite obvious.

In 1890, Cornell enrolled 1,390 students (including 157 women and about 80 graduate students) and had a faculty counting 60 Professors (all ranks) and 45 Instructors. The Mathematics Department counted 3 Professors, Jones, Oliver and Wait; two Assistant Professors, Hathaway and McMahon, and 3 Instructors, Fowler, Studley and Rappleye. Eight graduate students were studying mathematics, including the 3 Instructors.

Johns Hopkins had 42 Professors (all ranks) and 29 Instructors and Lecturers. It enrolled 276 graduate students and 141 undergraduates. The Johns Hopkins Mathematics Department had 3 Professors, Newcomb, Craig and Franklin and one Assistant. Twenty graduate students were studying mathematics.

The Clark University Mathematics Department had 3 Professors, Story, Bolza and White, and two docents, Taber and de Perott. They taught 8 graduate students. There was no undergraduate program.

Harvard enrolled 1,339 undergraduates plus 90 students in the Lawrence Scientific School and 110 graduate students. It had 110 permanent faculty members and its mathematics department had 4 Professors, W. Byerly, J.M. Peirce, B.O. Peirce and C.J. White; 2 Instructors, James Lee Love and William Fogg Osgood, and one Assistant. There were 8 graduate students in mathematics. Harvard also had an important Department of Astronomy.

The University of Chicago opened in 1892 with an entering class of 594 students taught by a 120 strong faculty. The Mathematics Department had 3 Professors, E.H. Moore, Bolza and Maschke; 2 Assistants, J.W. Young and H. Hancock; and a Docent, J.I. Hutchinson. There were 4 Fellows in Mathematics.

Confirming the reality conveyed by these numbers, most references to Ernst Ritter's appointment and sudden death in 1895 –including the obituary by Felix Klein

[106] See *"The Teaching and History of Mathematics in the United States"* by Florian Cajori, *"A case study of the emergence of the American mathematical community"* by Gary Cochell, and "*The Emergence of the American Mathematical Research Community 1876-1900: James Joseph Sylvester, Felix Klein"* by Karen Hunger Parshall and David E. Rowe.

reproduced in translation earlier– pointed to the need for Cornell Mathematics to catch up with the other top American mathematics programs of the time. Overall, the Cornell academic environment, which required long hours of teaching of its mathematics faculty, did not facilitate the pursuit of research alongside undergraduate instruction.[107]

On September 26 1895, President Schurman addressed the student body on questions of general interest. His speech, reported by the *Cornell Daily Sun*, includes the following remarks.[108]

A large number of you will regret the loss of Professor Oliver, the student and distinguished mathematician. There was no abler mathematician in America than Professor Oliver. It was a severe loss to us when he was taken from us, and his memory will long be cherished in this University. It gives me great regret and pain to announce that the gentleman who was to take the advanced work and graduate work which Prof. Oliver had, has died on his way from Germany to this University, —Dr. Ernst Ritter, one of the most renowned of German professors, and only twenty-eight years of age. Stricken with typhoid fever on the journey, he was taken to the Government Hospital in New York, died on Sunday and was buried Monday. None of us, except a few who had studied under this distinguished gentleman at Göttingen, knew him personally. The trustees have already taken the first steps towards securing a successor to Dr. Ritter, and my hope is that some time during the present term announcement of his successor may be made[109].

The fulfillment of James Oliver's dream of a strong graduate program would have to wait until the twentieth century.

[107] *The Emergence of the American Mathematical Research Community*, 1876-1900: J. J. Sylvester, Felix Klein, and E. H. Moore. Karen Hunger Parshall and David E. Rowe, A co-publication of the AMS and the London Mathematical Society, 1994, page 269-271.
[108] http://cdsun.library.cornell.edu/cgi-bin/cornell?a=d&d=CDS18950927.2.2
[109] John Henry Tanner, still in Göttingen at the time, tried unsuccessfully to find another German mathematician to take the position. The young Virgil Snyder, a Cornell graduate student who, under the recommendation of Prof. Oliver, had moved to Göttingen to work under Felix Klein, received his Göttingen Ph.D. that year and return to Cornell as Assistant Professor.

REFERENCES

ABOUT ITHACA

Landmarks of Tompkins County, New York: including a history of Cornell University, by W.T. Hewett, Edited by John H. Selkreg, 1894. https://archive.org/details/landmarksoftompk00hewe

Ithaca, by Henry Edward Abt, 1926.

Ithaca: A Brief History, by Carol Kammen, 2008.

ABOUT CORNELL UNIVERSITY

Accounts of the Proceeding of the Inauguration at Cornell University, 1869. https://archive.org/details/cornelluniversit00corn

The Cornell University. What it is and what it is not. 1872. https://catalog.hathitrust.org/Record/009122634

Cornell University, A History, by Waterman Thomas Hewett, 1905, 4 Volumes.
Volume 1 https://archive.org/details/cornelluniversit01hewe
Volume 2 https://archive.org/details/cornelluniversit02hewe
Volume 3 https://archive.org/details/cornelluniversit03heweuoft
Volume 4 https://archive.org/details/cornelluniversit04heweuoft

A History of Cornell, by Morris Gilbert Bishop, 1962.

Cornell University: Founders and the Founding, by Carl Becker, 1967 (based on lectures delivered in 1943). https://ecommons.cornell.edu/handle/1813/184

Women at Cornell, The Myth of Equal Education, by Charlotte Williams Conable, 1977.

Cornell University, First general announcement, 1868. https://archive.org/details/firstgeneralanno00corn

Proceedings and addresses at the twenty-fifth anniversary of the opening of Cornell University, 1893. https://archive.org/details/proceedingsaddr00corn

History of the agricultural college land grant act of July 2, 1862. Devoted largely to the history of the "land scrip" which under that grant was allotted to the State of New York and afterwards given to Cornell University, by Samuel D. Halliday, 1905. https://archive.org/details/historyofagricul00hallrich
Ten-year book, Cornell University. 4 Volumes.
Volume 1: 1868-1878, https://archive.org/details/cu31924005731470
Volume 2: 1868-1888, https://archive.org/details/tenyearbookofcor02corn
Volume 3: 1869-1898, https://archive.org/details/tenyearbookofcor03corn
Volume 4: 1868-1908, https://archive.org/details/tenyearbookcorn00univgoog

Annual report of the President of Cornell University, 1881, 1884—1922
https://catalog.hathitrust.org/Record/000056219
https://catalog.hathitrust.org/Record/009040484

The Register, Cornell University, 1868/69—1910
https://catalog.hathitrust.org/Record/000527041

Proceedings of the Board of Trustees of Cornell University, 1865—
https://ecommons.cornell.edu/handle/1813/23361

Cornell in Pictures: 1868—1954. Compiled by Charles Van Patten Young, 1954.

Cornell in Pictures: The First Century: Compiled by Charles Van Patten Young; New edition by H.A. Stevenson, 1965.

The days of a man: being memories of a naturalist, teacher, and minor prophet of democracy / by David Starr Jordan. 1922.
https://catalog.hathitrust.org/Record/000483531

ABOUT EZRA CORNELL

“True and Firm”: Biography of Ezra Cornell, Founder of the Cornell University, by Alonso Cornell, 1884. https://archive.org/details/trueandfirmbiog00corngoog

The Builder: A Biography of Ezra Cornell, by Philip Dorf, 1952.

A memorial address, 1875, by Rufus P. Stebbins,
https://archive.org/details/memorialaddressd00steb

My Reminiscences of Ezra Cornell, 1890, by A.D. White, https://archive.org/details/myreminiscenceso00whitrich

Final Judicial Settlement of the Estate of Ezra Cornell; 1892. https://books.google.com/books?id=AFeqUlsVaZkC

About Andrew Dickson White

The Autobiography of Andrew Dickson White, by A. D. White, 1905.
Volume 1: https://archive.org/details/autobioandrew01whitrich
Volume 2: https://archive.org/details/autobiographyofa00whit

Andrew Dickson White: Educator, Historian, Diplomat, by Glenn C. Altschuler. Cornell University Press, 1979.

A history of the warfare of science with theology in Christendom, by Andrew Dickson White, 1896.
Volume 1 and 2: https://catalog.hathitrust.org/Record/008895246

About Mathematics and Mathematicians

The teaching and history of mathematics in the United States, by Florian Cajori, 1890. https://archive.org/details/teachingandhist03cajogoog

A History of Mathematics in America Before 1900, by Eugen Smith David and Jekuthiel Ginsburg, 1934. https://archive.org/details/historyofmathema033032mbp

Life of Sir William Rowan Hamilton, Andrews professor of astronomy in the University of Dublin, and Royal astronomer of Ireland, including selections from his poems, correspondence, and miscellaneous writings; Robert P. Graves and Augustus De Morgan, 1882-1889.
Volume 1: https://archive.org/details/lifeofsirwilliam01gravuoft
Volume 2: https://archive.org/details/lifeofsirwilliam02gravuoft
Volume 3: https://archive.org/details/lifeofsirwilliam03gravuoft

The life of William Thomson, baron Kelvin of Largs, by Silvanus Philips Thomson, 1910.
Volume 1: https://archive.org/details/lifeofwilliamtho01thomuoft

Volume 2: https://archive.org/details/lifeofwillthom02thomrich

Baltimore lectures on molecular dynamics and the wave theory of light, by William Thomson. 1904.
https://archive.org/details/baltimorelecture00kelviala

The Emergence of the American Mathematical Research Community (1876–1900): J. J. Sylvester, Felix Klein, and E. H. Moore, by Karen Parshall and David E. Rowe, AMS/LMS Series in the History of Mathematics, vol. 8, 1994.

James Joseph Sylvester: Life and Work in Letters, by Karen Parshall, Oxford University Press, 1998.

James Joseph Sylvester: Jewish Mathematician in a Victorian World, by Karen Parshall, Johns Hopkins University Press, 2006.

Josiah Willard Gibbs: The History of a Great Mind. By L.P. Wheeler, Yale University Press, 1952

E.H. Moore and the Founding of a Mathematical Community in America: 1892–1902, Karen Parshall, Annals of Science 41 (1984), 313-333; reprinted in A Century of Mathematics in America–Part II, ed. Peter Duren et al. (Providence: American Mathematical Society, 1988), pp. 155-175.

American Mathematics Comes of Age: 1875–1900, by Karen Parshall and David E. Rowe, in *A Century of Mathematics in America–Part III*, ed. Peter Duren *et al.*(Providence: American Mathematical Society, 1989), pp. 1-24.

Pioneering Women in American Mathematics: The Pre-1940 PhD's, by Judy Green and Jeanne LaDuke, 2008, American Mathematical Society, History of Mathematics, vol. 34. With additional material at
http://www.ams.org/publications/authors/books/postpub/hmath-34

The Bicentennial Tribute to American Mathematics 1776–1976. Mathematical Association of America.
https://www.maa.org/sites/default/files/pdf/ABOUTMAA/History/Bicentennial_Tribute.pdf

A Semicentennial History of the American Mathematical Society, 1888-1938 Volume 1, by Raymond Clare Archibald:

Part I: 1865-1898

http://www.ams.org/publicoutreach/math-history/hmreprint-index
Volume II: http://www.ams.org/publicoutreach/math-history/procsemi-index

A Century of Mathematics in America, Edited by Peter Duren.
AMS History of Mathematics.
Part I: http://www.ams.org/publicoutreach/math-history/hmath1-index
Part II: http://www.ams.org/publicoutreach/math-history/hmath2-index
Part III: http://www.ams.org/publicoutreach/math-history/hmath3-index

The Early History of the Cornell Mathematics Department: A Case Study in the Emergence of the American Mathematical Community, by Gary G. Cochell. Historia Mathematica 25 (1998), 133–153.
http://www.math.cornell.edu/m/General/History/historyP1

A History of Mathematics in the United States and Canada: Volume 1: 1492–1930, by David E. Zitarelli: Temple University, AMS-MAA, Spectrum
Volume: 94; 2018; 768 pp (to appear)

About Chicago, Clark, Harvard, Johns Hopkins And Yale

University of Chicago

Quarterly announcements of the University of Chicago, 1893-
https://catalog.hathitrust.org/Record/100180272

General register of the officers and alumni, 1892-1902. University of Chicago.
https://catalog.hathitrust.org/Record/001974948

Register of doctors of philosophy of the University of Chicago, 1922.
https://catalog.hathitrust.org/Record/009577882

The decennial publications of the University of Chicago, 1902-1908.
Issued in commemoration of the completion of the first ten years of the University's existence. https://catalog.hathitrust.org/Record/000049469

The President's report, July, 1892-July, 1902.
Part II [Publications of the members of the university] Chicago, The University of Chicago Press, 1904. https://catalog.hathitrust.org/Record/011715416

CLARK UNIVERSITY

Register and official announcement; Clark University, 1889-1920. https://catalog.hathitrust.org/Record/012466464

Clark University, 1889-1899, decennial celebration. https://catalog.hathitrust.org/Record/001974964

Clark University 1887 – 1987. By William Koelsch, Clark University Press, 1987.

HARVARD UNIVERSITY

The Harvard University catalogue. https://catalog.hathitrust.org/Record/006923722

Quinquennial catalogue of the officers and graduates of Harvard University. https://catalog.hathitrust.org/Record/008694565

http://www.math.harvard.edu/history/index.html

Mathematics: 1870-1928, by J.L Coolidge. In *"The Development of Harvard University since the Inauguration of President Eliot, 1869-1929."* Edited by Samuel Eliot Morison. http://www.math.harvard.edu/history/coolidge/0001a.html

Biography: Benjamin Peirce, by F. P. Matz. The American Mathematical Monthly Vol. 2, No. 6 (Jun., 1895), pp. 173-179.

JOHNS HOPKINS UNIVERSITY

The Johns Hopkins university from 1873 to 1893. By Daniel Coit Gilman, 1893. https://catalog.hathitrust.org/Record/001975176

The Life of Daniel Coit Gilman, by Fabian Franklin, 1910. https://archive.org/details/lifedanielcoitg01frangoog

University register, Johns Hopkins University. https://catalog.hathitrust.org/Record/005805378

YALE UNIVERSITY

Obituary record of graduates of Yale University, 1860-1920. https://catalog.hathitrust.org/Record/000525767

Catalogue of the officers and graduates of Yale University, 1890-1920. https://catalog.hathitrust.org/Record/008922840

Catalogue of the officers and graduates of Yale University. https://catalog.hathitrust.org/Record/100607756

Catalogue of the officers and graduates of Yale university in New Haven, Connecticut, 1701-1895. https://catalog.hathitrust.org/Record/001975658

Doctors of philosophy of Yale University, with the titles of their dissertations, 1861-1915, https://archive.org/details/doctorsofphiloso00yalerich

MISCELLANY

The First Century of the Republic: A Review of American Progress. New York, Harper & Brothers, 1876. https://catalog.hathitrust.org/Record/000329551