

### *Exceptional American women mathematicians*

This file examines the lives and careers of the nine women who earned Ph.D.s at American universities before 1900. The first three graduated from Cornell, a coeducational university.

**Ida Martha Metcalf** (1856-1952), who was born and raised in Texas but moved to the Northeast with her mother and brother after her father died when she was a pre-teen. As a teenager, she taught in small schools and worked in the fields after school. Only later did she enroll in the private, coeducational Boston University, as a special student 1883-1885 and then as a regular student the next year. Two years after earning her Ph.B. degree in 1886, Ida Metcalf matriculated in the graduate program in mathematics at Cornell, obtaining a master's degree in 1889. She returned to Cornell three years later, and during the year 1892-1893 assisted George Jones in preparing exercises for his *Drill-Book in Algebra*. At the end of that year she became the first woman to earn a Ph.D. in mathematics at Cornell for the dissertation "Geometric duality in space." Although James Oliver is generally credited with being her advisor, because he was the chair of her doctoral committee, George Jones probably directed her study, as she had taken his course on projective geometry during that year.

Although Ida Metcalf entered the work force with a Ph.D. in 1893 at age 36, she was unable to secure a university teaching position. Initially she taught at various high schools but by 1910 she left the teaching profession for the public sector. At about that time she became a security analyst at a banking house in New York City. Shortly thereafter she won a job in the Comptroller's Office in the city when she became the first woman to pass a civil service examination. This enabled her to work in the city's finance department until her retirement in 1921 at age 65. From that time until 1939 she worked as a civil service examiner on a per-diem basis. Metcalf died in a nursing home 13 years later at age 96.<sup>1</sup> Ida Metcalf was bitter about being unable to land a suitable teaching position despite earning a Ph.D. from a prestigious university and, as a result, maintained a very cynical view of higher education for women throughout the rest of her life. Considering her accomplishments, the struggle to find a teaching position commensurate with her ability must have been a very hard pill to swallow.

The next two women to earn Cornell Ph.D.s led eerily similar lives. Both were born in Canada, though in different provinces, **Annie Louise MacKinnon** (1868-1940) in Woodstock, Ontario, and **Agnes Sime Baxter** (1870-1917) in Halifax, Nova Scotia. MacKinnon's parents moved to Kansas in the U.S. when she was only two years old so she received her early

education in the American Midwest. She received her bachelor's degree from the University of Kansas in 1889 and master's degree two years later. She taught in high school the next year and then enrolled in the graduate program at Cornell, being awarded a Brooks Fellowship her second year. Annie MacKinnon earned her Ph.D. at the end of that academic year, 1894, for a dissertation written under James Oliver, "Concomitant binary forms in terms of the roots." She published her research in the *Annals of Mathematics* in two parts. In the first part, which appeared the next academic year, she stated that her aim was to bring a direct connection "between root and coefficient symbolic expressions for Covariants and Invariants ... into clearer light [to illustrate] the practical value of German Symbolism in Modern Algebra."<sup>2</sup> Her investigation was mainly based on a book by Gordan, but she also cited four similar works by Clebsch, Burnside and Panton, Salmon, and Faà de Bruno. Clearly this was state-of-the art mathematical research. At the end of the paper MacKinnon promised, "The tables referred to in Part I, Chapter III, will be given in a future number of the *Annals*."<sup>3</sup> However, the second part would not appear for another four years; it began with an introductory page explaining the meaning of certain symbols and ended with a list of errata from the first part, with the remainder consisting of the promised tables.<sup>4</sup>

Perhaps part of the reason for the delay was that Annie MacKinnon had won an ACA Fellowship for European study. In July 1894, the summer after her encounter with Felix Klein at Cornell, she wrote a letter gently reminding him of that meeting and asked for permission to attend his courses, having been encouraged by an article in the *Nation* about Göttingen's decision to admit women. She ended up spending two years there, during which time she presented more lectures at his seminars than any other American member of the Klein Klub, male or female: three in the "Seminar on Number Theory"<sup>5</sup> and one each in the "Seminar on the Foundations of Analysis for Functions of a Single Variable" and the "Seminar on the Foundations of Analysis for Functions of Several Variables." Happily, Mary Winston was studying under Klein at the same time. The accompanying photo shows Winston (on the left) and MacKinnon during this time. They were soon joined by yet a third American woman, Isabel Maddison. All three presented lectures at the two seminars on foundations of analysis. Clearly Felix Klein had become *the* cluster point for American women in Europe.



The third Cornell graduate, **Agnes Baxter** (1870-1917), came from a family that had immigrated to Nova Scotia from Scotland, an unsurprising heritage in light of the Latin meaning of the name of that province. She was educated in Halifax, culminating in bachelor's and master's degrees from Dalhousie University in 1891 and 1892. Both MacKinnon and Baxter entered Cornell in October 1892.<sup>6</sup> MacKinnon graduated in two years but it took Baxter three years to complete her dissertation, also written under Oliver, "On Abelian integrals, a resume of Neumann's Abelsche integral with comments and applications." Baxter too was awarded an Erastus Brooks Fellowship for her final year of study.

The women both entered the work force in 1896, MacKinnon after a two-year study tour in Göttingen and Baxter after another year at Cornell spent editing the works of their advisor, James Oliver, who died in March 1895 just months before Baxter earned her Ph.D. MacKinnon had won an ACA fellowship for 1894-1895 and a Women's Education Association of Boston Fellowship for 1895-1896. Upon returning to the U.S., MacKinnon became the only mathematics faculty member at Wells College; the *Bulletin* announced, "A vacancy was caused in the department of mathematics at Wells College by the resignation of Miss S. A. Acer. It has been filled by the appointment of Miss Annie L. MacKinnon, Ph.D. (Cornell)."<sup>7</sup> She left Wells after five years to marry Edward Fitch (1864-1946), whom she had met in Göttingen. He had obtained his Göttingen Ph.D. in 1896 and was a professor of Greek at Hamilton College at the time of the marriage. Annie MacKinnon Fitch neither taught after her marriage nor continued the research program she had begun with such promise. However, she joined the AMS in 1897, was a charter member of the MAA when it was established in 1915, and maintained both memberships until about 1930. Throughout her life she was an active member of the League of Women Voters.

Baxter had met her husband while still an undergraduate. **Albert Ross Hill** (1869-1943), also from Nova Scotia, graduated from Dalhousie a year after Baxter and then spent a year studying in Europe before enrolling in the graduate program at Cornell. Both Baxter and Hill received their Ph.D.s in 1895, his in philosophy. They married in 1896 after she had spent the year editing Oliver's works. Subsequently the Hills moved to the University of Nebraska and the University of Missouri, where Albert Hill served as dean of the school of education. Like MacKinnon Fitch, Baxter Hill's subsequent career was typical of the times, following her husband's career and staying home to raise children. When she died of pneumonia shortly after

her 47<sup>th</sup> birthday, Albert Hill donated her large collection of books to Dalhousie and, in appreciation, the university opened the Agnes Baxter Reading Room in the department's reading room in 1988.<sup>8</sup>

As mentioned above, Cornell was coeducational from its founding and these three women are prime examples of the philosophy that Ezra Cornell and Andrew White espoused. Half of the six Ph.D. recipients in mathematics from Cornell during the 1890s were women. This fraction is very high for universities at that time, but it is not surprising due to the significant clustering that took place for women around a few specific advisors, in this case James Oliver. Yet these three exceptional women were not the only ones with sufficient persistence and academic ability to excel in mathematics at the time. **Anna Helene Palmie** (1863-1946) obtained her Cornell bachelor's degree in 1890 and remained two years in the graduate program before accepting a teaching position at the Women's College of Western Reserve University in Cleveland (Case Western today). And **Estella Kate Wentz** (1866-1938) received a master's degree at Cornell in 1894 before moving to Indiana to teach high. Both were active in the AMS.

Cornell was not the first university to confer a doctorate in mathematics on a woman. That honor falls to Columbia, which awarded a Ph.D. to **Winifred Haring Edgerton** (1862-1951) almost a decade earlier, at about the time that the Board of Trustees at Johns Hopkins refused to bestow the earned degree on Christine Ladd. Winifred Edgerton thus became the first American woman to successfully navigate the "process of infiltration." In fact, she was the first woman to earn a degree of any kind from Columbia, whose undergraduate college was all-male. Her determination to obtain this degree in 1886 blazed a trail for the nine who followed in the next decade and the many who traversed this path later, a testament inscribed below her portrait that was hung in Columbia University to celebrate the 50<sup>th</sup> anniversary of her graduation from Wellesley: "She opened the door."

Though born in Wisconsin of parentage that can be traced back to the Plymouth Colony, at age two Winifred Edgerton moved with her family to New York City, where she was schooled by private tutors. During this time an increasing interest in astronomy and mathematics impelled her parents to have an observatory built for her in one of their New Jersey homes. Edgerton then entered Wellesley College, which had been opened in 1875. When she graduated in 1883 she moved back home with her parents and became a teacher at a boarding school for "Young Ladies."

Moreover, that year Edgerton calculated the orbit of a comet that further stoked her interest in mathematical astronomy and led her to seek access to the telescope at Columbia College (the University was not established until 1896). This in turn created a strong desire to continue her study of mathematics and astronomy at Columbia so, with the support of her parents and college President Frederick A.P. Barnard, she applied for admission even though Columbia had never granted a degree to a woman. The Board of Trustees opposed admitting women but in a compromise with Barnard agreed that women could be given detailed syllabi and, if they subsequently passed necessary exams, would be awarded appropriate degrees but they were forbidden from attending classes. In early 1884 Edgerton met with Reverend Morgan Dix, one of the more vocal opponents on the Board, and apparently won him over because in February of that year the Board granted permission for her to use the telescope and to study under Professor John Rees.



Yet Winifred Edgerton still had to leap hurdles in her quest to earn a doctorate. For instance, in one class the students, all males of course, requested that the professor assign one of the hardest textbooks in the course, but they had not counted on the fact that she had already read it in one of her Wellesley courses. Undaunted, she continued her work in the observatory and her study of mathematics alone, without any communication with other students, and was awarded her Ph.D. in June 1886 at age 23. The *New York Times* even recorded the historical event: “She was greeted with a terrific round of applause.”<sup>9</sup> Edgerton’s dissertation bore the expansive but descriptive title “Multiple integrals: (1) Their geometrical interpretation in Cartesian geometry, in trilinears and triplanars, in tangential; in quaternions; and in modern geometry. (2) Their analytical interpretation in the theory of equations, using determinants, invariants and covariants as instruments in the investigation.” The dissertation “presents geometrical representations of infinitesimals in several coordinate systems and uses theory involving the Jacobian to derive transformations between multiple integrals in various systems.”<sup>10</sup> Actually Edgerton submitted two dissertations, the other one in astronomy based on the computation of the orbit of the 1883 comet, but official records indicate that her degree was based on the dissertation in mathematics. It was directed by department head John Van Amringe, who two years later played an important role in the formation of the AMS at Columbia and served as its first president. Edgerton, however, never joined the AMS.

Upon graduation Winifred Edgerton was offered a position at Wellesley but turned it down in favor of teaching at the boarding school. One year later, in September 1887, and like two of the Cornell graduates mentioned above, she married a highly educated man, **Frederick Merrill** (1861-1916). She delivered her first child the next year, 1888, when she was also asked to serve on a small committee to form a separate woman's college to be part of Columbia. However, because there were men on the committee and its meetings were conducted in a downtown Manhattan office, her husband objected so she declined to serve. Nonetheless, when Barnard College was founded in 1889, named in honor of the campaigner for women's education, Edgerton-Merrill's name was listed on the request to the Columbia trustees to establish the woman's college.

Frederick Merrill received his Ph.D. from Columbia's School of Mines in 1890 with a degree in geology. He then held various positions in Albany until 1904, when he moved back to New York City as a mining geologist. During that time the Merrills inherited wealth from two of his family members and they began to host lavish social affairs, attracting the likes of Booker T. Washington and Teddy Roosevelt. These parties, however, led to financial difficulties and the family was forced to declare bankruptcy in 1902, which in turn caused Frederick Merrill to resign his position. The strains soon took their toll on the relationship and the Merrills separated in 1904. He left for Arizona in 1907 and six years later for California, where he resided up to his death in 1916. Meanwhile, after 1904 Winifred Edgerton Merrill remained behind in New York City to raise their four children. Initially she was the principal at a girls' school in Yonkers but in 1906 she founded the Oaksmere School for Girls, a boarding school in Westchester County that was eminently successful from its inception; in fact, a Paris branch was opened in 1926. Once again, however, lavish spending, this time on her schools, caused financial difficulties despite exceedingly high tuitions and Oaksmere had to be closed two years later. At that point Edgerton-Merrill moved into an apartment in the Barbizon Hotel in New York City, where she was appointed the librarian for that residence hotel for women. She died in September 1951 just 18 days shy of her 89<sup>th</sup> birthday.

**Charlotte Cynthia Barnum** (1860-1934), like Christine Ladd Franklin, was unsuccessful in attempts to obtain Ph.D.s at Johns Hopkins. Barnum was a preparatory-school teacher, human computer, and editor for the eight years after her 1881 graduation from Vassar. She then taught astronomy at Smith College 1889-1890, and was credited with solving three problems in the

*Annals of Mathematics*, an activity that often anticipates success in research mathematics. During that year, she was also granted permission to take courses at the Johns Hopkins, where she remained 1890-1892. But she sought a doctorate so she transferred to Yale in 1892 and three years later became the first woman to receive a Ph.D. degree at the formerly all-male bastion for the dissertation “Functions having lines or surfaces of discontinuity.” No advisor is stated; it is doubtful that it could have been James Pierpont, who became a vital cluster point for women at Yale in the twentieth century, because he had only taken up his Yale position in her final year.

However, upon graduation Barnum’s professional career did not follow a normal academic trajectory, even for a woman mathematician circa 1900. Two actions with the AMS suggest an interest in research-level mathematics that might have followed the earlier problem-solving activity—membership 1894-1922 and attendance at the 1897 AMS summer meeting at the University of Toronto—but such a career never materialized. Except for an instructorship the next year at Carleton College, 1895-1896, Charlotte Barnum worked in applied areas of mathematics and in editorial work most of the rest of her career, as an actuarial computer for insurance companies, a computer for the U.S. Naval Observatory and for the tidal division of the U.S. Coast and Geodetic Survey, an editorial assistant in a biological survey for the U.S. Department of Agriculture, and an editor for Yale University Press. It was not until 1922 that she returned to teaching, but at preparatory schools in New York City and in Massachusetts. Barnum published articles in *Astronomy*, *Astro-Physics*, and *Scientific American Supplement* but apparently, none in mathematics journals. She died in 1934 at age 73.

The remaining woman to earn a Yale Ph.D. before 1900 was **Elizabeth Street Dickerman** (1872-1965), whose life was as similar to Charlotte Barnum’s in much the same way that Cornell graduates Annie MacKinnon and Agnes Baxter were to each other. Dickerman also hailed from an educated family, with both her father and one of her two brothers graduating from Yale and her one sister attending the Yale School of Music. Her father was a Congregational minister with B.A. and B.D. degrees, while her brother ended up earning a doctorate from Halle in Germany after completing his undergraduate studies. Elizabeth Dickerman attended Smith College 1890-1894 upon graduation from high school in nearby Amherst. She entered the graduate program at Yale at once, a rare occurrence for women at that time, so her first year in New Haven overlapped with Barnum’s final year. Dickerman completed her dissertation in just

two years, “Curves of the first and second degree in  $(x, y, z)$  where there are conics having two points in common.” As usual, no advisor is cited.

Like Barnum, Dickerman obtained one collegiate faculty appointment, though it was only as a substitute at College for Women of Western Reserve University in Cleveland and lasted only one year, 1906-1907. During 1896-1904 she had done private tutoring but she also managed to take additional courses at Yale and traveled to Europe twice, where fluency in French, German, and Italian certainly abetted communication. She taught mathematics and psychology in several different private schools 1904-1913 but it appears that she turned attention to literary pursuits for the rest of her life. She may have received earlier inspiration from her mother, a friend of the poet Emily Dickinson. In 1915 Dickerman published *Songs of Brittany*, which she translated into English verse from the original French of Theodore Botrel. During World War I, she translated war poems for a calendar whose proceeds were donated to wounded French soldiers. She also published several translations and other articles in *Poet Lore* between 1917 and 1922, as well as *A Spanish Journey* in verse the next year. We are not aware if she published her dissertation, let alone any other works in mathematics. Moreover, she joined neither the AMS nor the MAA, the two professional organizations for mathematicians. Elizabeth Dickerman died in 1965 at age 92.

In 1920 Yale published an account of its alumnae since 1894. The author of the mathematics section, Ernest William Brown, provided thumbnail sketches of the education and professional activities of the ten women who had obtained Ph.D.s in mathematics during this period.<sup>11</sup> Table 1 summarizes Brown’s findings, including the first entry, **Margaretta Palmer** (1862-1924), even though we would categorize her work as astronomy today. In fact, her dissertation carried out a recalculation of the orbit of a comet that had been discovered in 1847 by her undergraduate mentor, Maria Mitchell, who had also played a vital role in the early career of Christine Ladd Franklin. Margaretta Palmer and Charlotte Barnum were in the first group of women admitted to the Yale Graduate School in 1892.

| <b>Name</b>              | <b>B.A.</b>   | <b>B.A.</b> | <b>Ph.D.</b> | <b>Notes</b>     |
|--------------------------|---------------|-------------|--------------|------------------|
| <b>Margaretta Palmer</b> | <b>Vassar</b> | <b>1887</b> | <b>1894</b>  | <b>astronomy</b> |
| Charlotte Barnum         | Vassar        | 1881        | 1895         |                  |
| Elizabeth Dickerman      | Smith         | 1894        | 1896         |                  |
| Leona Peirce             | Smith         | 1886        | 1899         |                  |

|                      |               |      |      |                                 |
|----------------------|---------------|------|------|---------------------------------|
| Ruth Wood            | Smith         | 1898 | 1901 | <i>Annals</i>                   |
| Helen Merrill        | Wellesley     | 1886 | 1903 | <i>Trans.</i> ; Wellesley 1903  |
| Clara Smith          | Mount Holyoke | 1885 | 1904 | <i>Trans.</i> ; Wellesley 1908  |
| Euphemia Worthington | Wellesley     | 1904 | 1908 | Wellesley 1909-1918             |
| Mary Walker          | Missouri      | 1903 | 1909 | Missouri 1909-1911              |
| Ida Barney           | Smith         | 1908 | 1911 | <i>Amer. Journal</i> ; colleges |

**Table 1.** Ten women who had obtained Ph.D.s in mathematics

The “Notes” column in Table 1 highlights two essential differences between the three women who graduated before 1900 (not including Margaretta Palmer) and the remaining six. First, not one of the three published her dissertation, whereas four of the remaining six did. Second, not one in the first group snared an academic position at a college (except in two one-year isolated incidents) whereas three of the six taught at Wellesley and Mary Walker at Missouri until she married the physicist Albert Wallace Hull two years after obtaining her doctorate. Another vital difference separating the two groups, one not indicated in the table, was having a dissertation advisor. In this sense Ruth Wood and Helen Merrill are aligned with the pre-1900 trio with unknown advisors. Merrill is an unusual case. Sometimes she is listed as a student of James Pierpont, probably because he was on her examining committee and signed the official form. However, the problem for her thesis was suggested by Milton Porter, who directed her study but had left Yale in 1902, the year before she received her degree. We supply further details in Chapter 4. Incidentally Helen Merrill was the first woman officer of the MAA when she was elected vice president in 1920; no other woman would be an officer for another 43 years. Nonetheless, we hasten to add that James Pierpont did serve as the advisor for Smith, Worthington, Walker, and Barney, underscoring his role as a significant cluster point for women at Yale. Although the only one in this group we will encounter is Helen Merrill, we should mention that **Ruth Goulding Wood** (1875-1939) created a trust fund ensuring that at least one female mathematics professor would earn the highest salary on the Smith College faculty.

The first dean of Bryn Mawr College was as instrumental in determining the future course of mathematics at the school as Daniel Coit Gilman had been at Johns Hopkins. Both looked to England for a mathematician to thrust the mathematics department into a leading role in the U.S. **Martha Carey Thomas** (1857-1935) graduated from Cornell in 1877 despite the wishes of her father, a trustee at Johns Hopkins. Thomas then enrolled in the graduate program at Johns Hopkins in her hometown of Baltimore, but withdrew when offered only private tutoring rather than being permitted to attend classes. Carey Thomas, as she preferred to be called, next

traveled to Europe, initially pursuing graduate work in Leipzig, but she then moved to Zurich because the University of Leipzig did not grant degrees to women. When she received her Ph.D. in linguistics from the University of Zurich in 1882, she became the first American woman to obtain a doctorate in any field. She moved to Paris for additional study at the Sorbonne before returning to the U.S. In 1885, when Bryn Mawr College opened its doors, she was appointed chair of the English department and the first female dean in the U.S. A suffragist, Carey Thomas became the second president of the college ten years later. During her tenure as dean 1885-1908 and president 1894-1922, she was instrumental in recruiting several notable faculty members. Perhaps none was as successful as her appointment in mathematics.



Like William Rainey Harper at Chicago seven years later, Carey Thomas took a chance on a young, untested, but magnetic figure to head her mathematics department, instead of settling for an older, established mathematician. That figure was **Charlotte Angas Scott** (1858-1931), who in 1876 had entered Girton College, the first residential college for women in England, on scholarship. She graduated with honors four years later. Most of the faculty (22 out of 34) at the prestigious Cambridge University, located nearby, permitted women to attend their lectures, although always with a chaperone. Therefore, Scott received an excellent education. In her final year, she was permitted to take the highly competitive Tripos exam (which allowed students to graduate with honors) on an informal basis. Just taking the exam would test one's fortitude, as it required 50 hours over nine days. Yet Scott placed eighth, an unprecedented achievement for a woman. Nonetheless, due to her sex, she was unable to receive the title "eighth wrangler" and was barred from attending the commencement ceremony where these awards were announced with great pomp and circumstance, a tradition that caused a minor brouhaha among the Cambridge students who interrupted the ceremony. According to a contemporary report on the proceedings:<sup>12</sup>

The man read out the names and when he came to "eighth," before he could say the name, all the undergraduates called out "Scott of Girton," and cheered tremendously, shouting her name over and over again with tremendous cheers and raising of hats.

However, Cambridge did not grant degrees to women until 1948, so Scott remained at Girton as resident lecturer in mathematics for the next four years. During that time, she passed examinations administered by the University of London, which became the first British college to award degrees to women only in 1880. At that time the university was an examining body

only, not a teaching institution. Charlotte Scott was then awarded a bachelor's degree from London in 1882 and a Ph.D. three years later for research conducted under Arthur Cayley. By 1885 Cayley's friend J.J. Sylvester had returned to England from Johns Hopkins with firm knowledge of the collegiate landscape in America, whereupon Cayley, who had been a visiting professor at Johns Hopkins, recommended Charlotte Scott for the opening at Bryn Mawr. The 27-year-old Scott accepted at once and sailed across the Atlantic to establish undergraduate and graduate programs in mathematics. As Table 7 shows, two American women earned Ph.D.s in the 1890s, both with dissertations directed by Charlotte Scott; altogether she directed five others in her 40-year tenure at Bryn Mawr, 1885-1925. Scott and, later, Anna Pell Wheeler were two important cluster points for women in the country. A third leading advisor for women Ph.D.s was Aubrey Landry of Catholic University, but the bulk of her students graduated in the 1930s.

The program at Bryn Mawr has always been relatively small, though not to the extent of Scott's first three years, when only three undergraduates and one graduate student who were seriously interested in mathematics enrolled in her classes. But by 1894 the number of graduate students had quadrupled, most likely due to fellowships the college offered; two of those four ended up being successful doctorate candidates. Like J.J. Sylvester, Scott returned to England for many summers, mainly to avoid the humidity that engulfs the Philadelphia area. She too went back to the motherland one year after retirement in 1924, remaining at Bryn Mawr that year to supervise the completion of her final student's doctoral dissertation (Marguerite Lehr). Back in England she settled into a house midway between Girton and Cambridge. Over her tenure Charlotte Scott was a tireless researcher who was especially active with the AMS; she was the only woman elected vice president of the AMS until 1976.<sup>13</sup> But her role as dissertation advisor concerns us directly here so we discuss the education and career of the two doctoral students she directed before 1900. In her role as mentor she initiated the Bryn Mawr College Mathematics Journal Club, the equivalent of the seminars that had been so successful for taking graduate students from learners to creators abroad at Göttingen and at home at Johns Hopkins and Chicago.

Scott's two ultimately successful 19<sup>th</sup>-century graduate students were different in many ways. **Ruth Gentry** (1862-1917) came from an Indiana farming family. She began teaching at age 16, two years before being certified officially when she graduated from Indiana State University (then a "normal" school, meaning that its mission was to train prospective teachers).

She held various teaching positions during 1880-1890, including a two-year stint at Stetson University 1886-1888 (founded as Deland Academy and College) to save money to pay for college. She also attended the University of Michigan for one year before and two years after her brief tenure at the Florida school, resulting in a Ph.B. degree in 1890. She then accepted a fellowship to Bryn Mawr College for 1890-1891; the next year she won a two-year ACA Fellowship for study in Europe. Her experience on the continent showed that women faced as many hurdles abroad as at home despite persistent efforts, as she was unsuccessful in her attempts to attend courses as an auditor in Berlin in spite of support by Lazarus Fuchs. She then wrote to Felix Klein in Göttingen asking if he would provide private lessons, only to be totally rebuffed once again. Frustrated with Germany, she ended up moving to Paris to study at the Sorbonne. Bryn Mawr rewarded her effort with yet another fellowship upon her return for the next year, and she completed all requirements for the college's first Ph.D. in mathematics in June 1894. Several sources date that degree to 1896, an error now ascribed to the two-year delay in printing her dissertation.<sup>14</sup> AMS membership records confirm the earlier date; she joined the Society in 1894 and maintained membership for the rest of her life. The topic of Gentry's dissertation was her advisor's specialty, algebraic geometry. Titled "On the forms of plane quartic curves," its aim was to characterize curves of order four in the plane.

Upon receiving her degree in 1894, Ruth Gentry accepted an instructorship at Vassar as the first faculty member holding a Ph.D. However, she resigned her position after eight years, likely due to ill health. In 1902 she became associate principal and head teacher at a private school for girls in Pittsburgh, where she remained for only two years. From that time on she mostly lived in her Indiana hometown, where she died of breast cancer at age 55. During the period 1904-1917 she served as a volunteer nurse but also managed to travel extensively throughout the U.S. and Europe despite that enervating illness.

Charlotte Scott's second Ph.D. student, **Ada Isabel Maddison** (1869-1950), was, like her, born in Great Britain. Isabel Maddison attended schools in Wales that prepared her to pass the matriculation exam for the University of London at age 16. Recall that London was then an examining body, not a teaching institution. Like Scott, Maddison attended Girton College, 1889-1892, and was given permission to attend Arthur Cayley's lectures at Cambridge. Maddison and her classmate, Grace Chisholm Young, both passed the Tripos exam with first-class honors in the spring of 1892.

Isabel Maddison was awarded a fellowship to Bryn Mawr College for 1892-1893, no doubt due to the Cayley-Scott connection. She also won the first Mary E. Garrett Fellowship for study abroad the following year, and ironically used it to attend lectures by Felix Klein and David Hilbert at Göttingen instead of England. We mentioned above that she lectured twice in Klein's seminars on the foundations of analysis during her year abroad, when she also published a paper in the respected *Quarterly Journal of Pure and Applied Mathematics*. Upon her return to Bryn Mawr she accepted a position as secretary to President Carey Thomas and completed two major projects. One was a translation for the *Bulletin* of a Felix Klein lecture presented to the Royal Academy of Sciences of Göttingen while she was there.<sup>15</sup> The other, much more significant, was her dissertation, "On singular solutions of differential equations of the first order in two variables and the geometrical properties of certain invariants and covariants of their complete primitives," published in the British *Quarterly Journal of Mathematics*. This work reeks of Klein much more than Scott, and it seems possible that, like with Frank Cole at Harvard in 1886, Klein assigned the topic and gave his imprimatur on the results, whence the home institution awarded the Ph.D. in 1896.

With degree in hand, one might expect Maddison to have sought a teaching position at a women's college, perhaps at one of the Seven Sisters, since similar positions in England were out of the question for women even more so than men. Instead, Maddison remained at Bryn Mawr for the rest of her career. Although she, like Sylvester and Scott before her, generally took summer vacations (which she would have called holidays) in England, she remained in Bryn Mawr even beyond retirement in 1926. During her tenure, she held two positions during 1896-1910, one administrative (first, secretary, and then assistant to President Thomas) and the other academic (reader and then associate in mathematics). However, she dropped the mathematics position after that, becoming a dean in the college and assistant to the president.

Isabel Maddison remained connected with the American mathematical community over her career, maintaining membership in the AMS the whole time. She also attended annual meetings held at Columbia University in New York City in Decembers of 1899, 1901, 1903, and 1906. The *Bulletin* announced her promotion to recording dean in 1910, but it appears she did not attend any AMS meetings after that time.<sup>16</sup> That journal also carried her announcement of an April 1922 meeting at Bryn Mawr "in honor of Professor C.A. Scott, on the completion of her

thirty-seventh year as Head of the Department of Mathematics.”<sup>17</sup> The principal speaker at the conference was Scott’s longtime friend, the philosopher Alfred North Whitehead.

At the beginning of her career Isabel Maddison published three book reviews for the *Bulletin*. The first one from 1897 contrasted two texts on elementary geometry “that have appeared recently [and] rise above the general level,”<sup>18</sup> one of which was by Klein Klub member Henry Dallas Thompson. A second review described a textbook on analytic geometry that “differs greatly in the choice and arrangement of material from the standard English textbooks on analytic geometry, and clearly shows the influence of Briot and Bouquet’s *Géométrie Analytique*.”<sup>19</sup> The third review provided a short sketch of the contents of an advanced book by Rudolf Sturm on Jacob Steiner’s 1866 lectures on synthetic geometry; her review supplied details for an audience not fluent in German.<sup>20</sup> During this time Maddison also used both of her European experiences in a short note on the four-color problem that added an early source on the problem due to Möbius in 1840 to a paper that had appeared in the *Quarterly Journal of Mathematics*, where her dissertation had appeared. Given this interest in geometry, Maddison offered advanced courses at Bryn Mawr titled “Analytic geometry of space” and “Analytic geometry of three dimensions.”

## Endnotes:

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<sup>1</sup> See Green/LaDuke *Pioneering Women*, especially p. 248 for additional information on Ida M. Metcalf. She is also cited for taking in an eight-year-old ward who later became very successful.

<sup>2</sup> On pp. 97-98 of Annie L. MacKinnon, Concomitant binary forms in terms of the roots, *Annals Math.* **9** (1894-1895), 95-157.

<sup>3</sup> On pp. 157 of Annie L. MacKinnon, Concomitant binary forms in terms of the roots, *Annals Math.* **9** (1894-1895), 95-157.

<sup>4</sup> Annie L. MacKinnon, Concomitant binary forms in terms of the roots, *Annals Math.* **12** (1898-1899), 95-109.

<sup>5</sup> The enrollment in Klein’s number theory course was 13, including four women, three of which were the American women mentioned here. One of the men was the Johns Hopkins graduate J.C. Fields, for whom the Fields Medal is named.

<sup>6</sup> It seems relevant here to point out that no Canadian university granted a Ph.D. to a woman until 1930, so Baxter was forced to go to the U.S. for graduate study.

<sup>7</sup> On p. 124 of Notes, *Bulletin Amer. Math. Soc.* **3** (1896), 122-124.

<sup>8</sup> See Green and LaDuke *Pioneering Women*, for additional information on these women, pp. 174-175 for Annie MacKinnon Fitch, and pp. 201-202 for Agnes Baxter Hill. [Endnote 1.]

<sup>9</sup> As quoted on p. 506 of Susan E. Kelly and Sarah A. Rozner, Winifred Edgerton Merrill: “She opened the door,” *Notices Amer. Math. Soc.* **59** (2012), 504-512.

<sup>10</sup> *Ibid*, p. 504. An analysis of this dissertation is given on pp. 506-508 of this reference.

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- <sup>11</sup> Ernest William Brown, Mathematics, pp. 52-55 in *Alumnæ, Graduate School, Yale University, 1894-1920*, Yale Univ.: New Haven, 1920.
- <sup>12</sup> Quoted on p. 194 of Patricia Clark Kenschaft, "Charlotte Angas Scott (1858-1931)," in Louise S. Grinstein and Paul J. Campbell (editors), *Women of Mathematics: A Biobibliographic Sourcebook*, New York: Greenwood Press, 1987, pp. 193-203. This is my main source for information on Scott.
- <sup>13</sup> Mary W. Gray was elected vice president of the AMS in 1976. Julia Robinson was the first woman president of the Society, serving in this capacity 1983-1984.
- <sup>14</sup> For details on Gentry's life, including the correcting of the record on the date of her degree, see p. 180 of Green and LaDuke, *Pioneering Women*, pp. 180-181. [Endnote 1.]
- <sup>15</sup> Felix Klein, The arithmetizing of mathematics, *Bulletin Amer. Math. Soc.* **2** (1896), 241-249.
- <sup>16</sup> On p. 158 of Notes, *Bulletin Amer. Math. Soc.* **17** (1910), 154-159.
- <sup>17</sup> On p. 72 of Notes, *Bulletin Amer. Math. Soc.* **28** (1922), 72-82.
- <sup>18</sup> On p. 253 of Isabel Maddison, Two books on elementary geometry, *Bulletin Amer. Math. Soc.* **3** (1897), 253-255.
- <sup>19</sup> On p. 234 of Isabel Maddison, Shorter notices, *Bulletin Amer. Math. Soc.* **4** (1898), 234-235.
- <sup>20</sup> Isabel Maddison, Shorter notices, *Bulletin Amer. Math. Soc.* **6** (1899), 113-115.