How Many Women Mathematicians Can You Name?

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Until my last semester as an undergraduate student in 1964, my answer to the question of the title would have been "One: Emmy Noether, the German algebraist." That semester a woman mathematician, Yvonne Choquet-Bruhat, was a visiting professor at my undergraduate institution, Cornell, so my list increased to two! If you restrict your answer to those women who were active by the middle of the twentieth century, you are unlikely to be able to name more than seven: Hypatia (c. 370–415); Gabrielle-Émilie Le Tonnelier de Breteuil, Marquise du Châtelet (1706–1749); Maria Gaetana Agnesi (1718–1799); Sophie Germain (1776–1831); Mary Somerville (1780–1872); Sofia Kovalevskaia (1850–1891), and Emmy Noether (1882–1935).

By the time I got my PhD in 1972, my list of women mathematicians active by mid-century had increased by one, Dorothy Maharam Stone, whom I met when she was visiting Yale. However, there were a number of women on the mathematics faculty of my doctoral institution, the University of Maryland, so I could name a number of women who had become mathematicians in the 1950s and 1960s, including my dissertation advisor, Carol Karp. In the late 1970s I became interested in the history

of women in mathematics and I have been working in that field ever since, collaborating with Jeanne LaDuke of DePaul University. What we learned is that women have been mathematicians for longer, and in greater numbers, than most people, even most mathematicians, realize. The second half of this paper summarizes and updates a paper Jeanne LaDuke and I wrote in 1987, "Women in the American mathematical community: The pre-1940 PhDs." (*Mathematical Intelligencer* 9 no 1: 11–23); it also relies on another of our papers, "Contributors to American mathematics: An overview and selection" (in G. Kass-Simon and Patricia Farnes (eds.), *Women of Science: Righting the Record*, Bloomington: Indiana University Press, 1990).

Rather than repeat the often-told tales of the seven famous women mathematicians, I will start in the late nineteenth century when English-speaking women had already had access to training in mathematics beyond arithmetic for about half a century and some were beginning to receive real training as mathematicians. While it was still unusual for women to receive higher education of any sort, it was not a secret that when they did, they studied mathematics. In fact, in 1894 George Bernard

Shaw wrote about it in his play, *Mrs. Warren's Profession*. In the first act, the following dialogue takes place between a middle-aged gentleman, Mr. Praed, and Mrs. Warren's twenty-two-year-old daughter, Vivie. Vivie has just taken the mathematical tripos, the honors examination in mathematics at Cambridge, and has achieved the same score as the third wrangler, that is the male candidate with the third highest score. Mr. Praed is quite impressed with Vivie's accomplishment but Vivie tells him that she "wouldnt do it again for the same money," explaining that

> Mrs. Latham, my tutor at Newnham, told my mother that I could distinguish myself in the mathematical tripos if I went in for it in earnest. The papers were full just then of Philippa Summers beating the senior wrangler... and nothing would please my mother but that I should do the same thing. I said flatly it was not worth my while to face the grind since I was not going in for teaching; but I offered to try for fourth wrangler or thereabouts for £50. She closed with me at that, after a little grumbling; and I was better than my bargain. But I wouldn't do it again for that. £200 would have been nearer the mark.

One can surmise that Shaw chose to have Vivie Warren study mathematics at Newnham and made reference to Philippa Summers, who is supposed to have beaten the senior or top-scoring wrangler in a previous year, because of a real incident. In 1890 a student at Newnham, Philippa Fawcett, who regularly spent six hours a day studying for the mathematical tripos, did indeed score above the senior wrangler. In fact, she scored thirteen percent higher than the man who received the title of senior wrangler. Her accomplishment was discussed in the English newspapers and even the *New York Times* ran an article, "Miss Fawcett's Honor: The sort of girl this lady Senior Wrangler is," describing her success and the significance it had for the higher education of women.

Although Fawcett's achievement was unprecedented, women from Newnham and Girton, the first two women's colleges at Cambridge, had been formally competing in the tripos since 1881. Previous to that a woman had to obtain special permission to sit for the tripos and had to find an examiner to grade her paper, and even then, her score was officially ignored. The change came because of an incident in 1880 when Charlotte Angas Scott of Girton scored between the seventh and eighth wranglers. Since women were not mentioned at the awards ceremony, the undergraduates who were present shouted her name and cheered her as the true eighth wrangler. In subsequent years the rankings of the women were given separately but relative to the men's rankings and the successful women were awarded a special certificate, though not a degree. Women did not receive degrees from Cambridge until 1948!

Neither the fictitious Vivie Warren nor the real Philippa Fawcett pursued an academic career in mathematics; Vivie, in the play, becomes an actuary and Philippa Fawcett, after about ten years as a Lecturer at Newnham, went to South Africa and helped develop a system of

Charlotte Angas Scott
Courtesy of the Bryn Mawr Library.

farm schools in the Transvaal. She returned to England in 1905 and spent the remainder of her career working for the London County Council first as Assistant to the Director of Education and later as Assistant Education Officer for Higher Education. On the other hand, by the time Philippa Fawcett had distinguished herself in the tripos, Charlotte Scott had come to the United States to Bryn Mawr College in Pennsylvania.

Charlotte Angas Scott was born in 1858 and was educated by private tutors until she enrolled at Girton College, Cambridge, in 1876. Girton had opened seven years earlier as England's first college for women and was located three miles from the Cambridge University. Even the supporters of higher education for women were against their receiving degrees. One such supporter was quoted as saying: "If given the BA, they must next have the MA… [and e]ven the BA would enable them to take 5 books at a time out of the University Library…" Despite the fact that Cambridge was not to grant degrees to women for another seventy-two years, even in 1876 most of the Cambridge professors allowed women to listen to their lectures. Thus the women of Girton had opportunities to obtain a real education and Scott took

advantage of this education. Although she received no official recognition for her achievements at Cambridge, in 1882 the University of London opened all degrees, prizes, and honors to women and Scott received a BSc by examination that year. She served as Lecturer at Girton and continued her mathematical studies at Cambridge, where her main interest was algebraic geometry. In 1885 she received a DSc from the University of London, again based on examinations. She was hired by Bryn Mawr, then a newly founded women's college, to head its mathematics department, and remained there for forty years, retiring in 1925, six years before her death.

Scott's influence on American mathematics was publicly acknowledged in many ways. In 1906 she was ranked by her peers as fourteenth among the top ninety-three mathematicians of the period. That same year Scott served as vice-president of the American Mathematical Society, being the first woman to hold that office and the only one to do so until seventy years later when Mary Gray, one of the founders of the Association for Women in Mathematics (AWM), was elected.

Another Girton-educated Englishwoman, Grace Chisholm Young, also has an important place in the history of women in mathematics. Grace Chisholm was born in 1868, the year before Girton was founded. Like Scott, she did not receive any formal education until she entered Girton in 1889. At the end of her first year she heard Philippa Fawcett of Newnham College announced as "Above the Senior Wrangler." When Chisholm sat for the mathematical tripos two years later, she placed between the twenty-third and twenty-fourth Wranglers. She accepted a challenge to become the first woman to sit for the Oxford Honour exams and received First Class Honours with the highest score on the exam.

Chisholm returned to Girton the following year and then went to Göttingen to be one of three women first officially

Grace Chisholm Young

Courtesy Sylvia Wiegand

admitted to study at the university there. She wrote a dissertation and, in 1895, became the first of the three pioneering women students to receive her PhD. As such, she was the first woman to receive a doctorate as a regularly enrolled student in a university administered by the Prussian government. Although Sofia Kovalevskaia had received a PhD *in absentia* from Göttingen in 1874, she had never taken classes or been enrolled at any German university.

Chisholm returned to England with a doctorate but without a job and started a mathematical collaboration with William Henry Young, one of her Girton tutors. A year later they were married. The following year their first child was born and they moved to Göttingen where they both spent their time doing mathematical research. Although the Youngs were doing very well mathematically at Göttingen, neither of them was earning money, so Will Young eventually had to resume his tutoring duties at Cambridge. He did this part-time while Grace Young and their children remained on the continent. Based on his published work to that time, Will Young received a DSc from Cambridge in 1903 but was still only able to get part-time jobs. Meanwhile, in Göttingen, Grace Young was

studying medicine, raising four children, and doing mathematics. In 1908 the family, now with six children, moved to Switzerland. Will Young didn't get his first regular appointment until five years later, in 1913, and then it was in Calcutta. Grace Young and the children continued to live in Switzerland and finally, in 1919, Will Young got a job closer to his family, in Wales.

Early in their career, the Youngs produced many mathematical works together, but almost all of the papers were published under Will Young's name alone. The first of the works appearing under both their names was a 1905 geometry book intended for elementary school children. In 1914, Grace Chisholm Young started publishing under her own name again, this time on the foundations of the differential calculus.

At the outbreak of World War II Grace Young was visiting in England and Will Young was stranded alone in Switzerland, where he died in 1942 without having seen his family again. Grace Young died two years later in England. The Young's mathematical heritage includes their work as well as a daughter, a son, and a granddaughter who became mathematicians.

As mentioned earlier, Chisholm was one of the three first women to be officially admitted to study at Göttingen. The other two women were Americans, Margaret Maltby, who came to study physics, and Mary Frances Winston, who also came to study mathematics and who received her PhD two years after Chisholm. It is not a coincidence that none of these three women were German and that they had come to Göttingen to study mathematics and physics. At about this time, early in the 1890s, there had been discussion in Germany concerning admission of women to the universities. While the Prussian Minister of Culture was not unsympathetic to the idea, the overseer of the University at Göttingen was firmly against it.

In spite of that, it was decided that foreign women should be admitted to study mathematics. Felix Klein, the mathematician responsible for bringing Chisholm and Winston to Göttingen, explained later,

> Mathematics had here rendered a pioneering service to the other disciplines. With it matters are, indeed, most straightforward. In mathematics, deception as to whether real understanding is present or not, is least possible.

In the summer of 1893 Klein came to the United States with mathematical models to be displayed at the Columbian Exposition in Chicago and to speak at the International Mathematical Congress held in conjunction with the Exposition. In Chicago Klein met Mary Winston, a graduate student at the University of Chicago whose undergraduate degree was from the University of Wisconsin. After teaching for two years in Milwaukee she studied with Charlotte Scott at Bryn Mawr before coming to the University of Chicago in its inaugural year, 1892. Klein agreed to sponsor her admission to the university but could not provide her with financial support.

Five of Felix Klein's students, including Mary Winston and Grace Chisholm, at Göttingen
Courtesy Sylvia Wiegand

Although Winston applied for a European fellowship from the Association for Collegiate Alumnae, she did not receive it and was able to go to Germany only because of the generosity of a woman mathematician, Christine Ladd-Franklin, who personally provided her with a $500 stipend. Mary Winston arrived in Göttingen in the fall of 1893 and waited for Klein to clear the way for her admission to the university. A few weeks after her arrival, Winston wrote her family that the people in Göttingen were very skeptical as to her chances for admission; they were wrong.

Two years after coming to Germany, Winston published a short paper in a German mathematical journal. In a book entitled *A History of Mathematics in America before 1900* (Chicago: Mathematical Association of America, 1934), the authors, David Eugene Smith and Jekuthiel Ginsburg, note that this particular journal contains fifteen articles published by Americans between 1893 and 1897. They then list the authors of fourteen of these articles, omitting only the name Mary Winston. Winston's paper was based on a talk she had given in the mathematics seminar at Göttingen within months of her arrival in Germany. That talk was the first such given by a woman and she wrote her family that the presentation "went off reasonably well.... I do not think that anyone will draw the conclusion from it that women cannot learn Mathematics."

Upon her return to the United States in 1896, Mary Winston took a job teaching high school in Missouri. The following year she received her PhD from Göttingen and became Professor of Mathematics at Kansas State Agricultural College, now Kansas State University. Three years later she resigned and married Henry Byron Newson, a mathematician at the University of Kansas. Henry Byron and Mary Winston Newson had three children born in 1901, 1903, and 1909. Mary Winston was widowed in 1910 when her youngest child was just

Christine Ladd-Franklin
Courtesy of Christine Ladd-Franklin Papers, Rare Book and Manuscript Library, Columbia University

three months old. She moved in with her parents, who were then living in Lawrence. She returned to teaching, but not to mathematical research, a few years later at Washburn College in Topeka, Kansas. Her son reported that she took that job because Topeka was within commuting distance of Lawrence and her parents could care for the children during the week. Newson remained at Washburn until 1921; she spent the rest of her career at Eureka College in Illinois, retiring in 1942.

While Mary Winston Newson was the first American woman to receive a degree from a foreign university, by the time her degree was awarded in 1897 eight American women had been awarded PhDs in mathematics in the United States. The first American woman to earn a PhD in mathematics was Christine Ladd, who is the Christine Ladd-Franklin who provided the $500 that allowed Mary Winston to go to Germany. Ladd graduated from Vassar College in 1869 and during the next ten years she taught school and began publishing mathematics, including several articles that appeared in an American journal and at least twenty mathematical

questions or solutions to questions in a British periodical, *The Educational Times*. She also attended classes at Harvard and, in 1878, she applied to Johns Hopkins University to study mathematics at the graduate level. Since Hopkins was not open to women, her admission was far from routine. The head of the mathematics department, J. J. Sylvester, had read some of her published work and wrote on her behalf both for admission and for the granting of a fellowship. Ladd was admitted, but under the condition that she was to attend only Sylvester's lectures. Although she was not required to pay tuition, she was not given a fellowship. After her first year of attendance, 1878–79, she was voted the $500 stipend of a fellowship for the following year. Despite this, her name was not included on the actual list of fellows but appeared in a footnote. Thus, like Philippa Fawcett and Charlotte Scott, Christine Ladd received the recognition she deserved but not the title.

During her four-year stay at Johns Hopkins, Ladd did not confine her studies to those she could pursue with Sylvester, but also attended classes given by other members of the mathematics faculty. She also continued her contributions to mathematical journals. By 1882 she had written a dissertation under the direction of the logician Charles S. Peirce. However, she did not receive the PhD she had earned simply because Hopkins was unwilling to grant degrees to women. The following year she married a member of the Johns Hopkins mathematics faculty, Fabian Franklin; they had two children, a son who died in infancy and a daughter who was born in 1884. Starting about 1887 Ladd-Franklin began a second research career in the physiological optics of color vision. She later served as a lecturer in logic and psychology at Hopkins and then at Columbia. Actually Ladd had originally wanted to study physics but switched to mathematics, what she called "the next best subject," because

Wellesley Mathematics Department faculty
1927– 1928: (Merrill, Smith, Comygs, Young,
Stark, Curtis, Copeland)
Courtesy of Wellesley College Archives.

physics laboratories were not open to women.

In 1926, Johns Hopkins offered Ladd-Franklin, then seventy-eight years old, an honorary doctorate in recognition of her work in color vision. Ladd-Franklin convinced Hopkins to award her the PhD in mathematics that she had earned forty-four years earlier. *The New York Times* reported that the ovation she was accorded was "one of the outstanding features of the day."

In 1886 Winifred Edgerton became the first American woman to be *awarded* a PhD in mathematics when Columbia University granted her the degree. In order for Edgerton, an 1883 graduate of Wellesley, to study at Columbia, which, like Hopkins, admitted only men, the trustees had to approve her request to study mathematics and astronomy. While the request was eventually granted, it took several meetings of the trustees. In 1982 one of her sons reported "that a condition of her admission was to dust the astronomical [instruments] and so comport herself as not to

disturb the men students.... When working alone in the observatory she would arrange dolls around the room to keep her company. If she heard someone coming she hid them in a window box."

By the spring of 1886 Edgerton had written a dissertation and the trustees voted to award her the degree of Doctor of Philosophy *cum laude*. Her degree was both the first PhD in mathematics awarded to an American woman and the first degree of any kind that Columbia awarded to a woman.

For two years after the receipt of her doctorate, Edgerton taught at a school for girls in New York. In 1887 she married Frederick James Hamilton Merrill, a geologist who did not approve of her involvement in the movement to increase the availability of education for women. They soon had four children. Although she participated in the founding of Barnard College, her husband objected to her attendance at meetings that were held in a man's office and she resigned her position on Barnard's original Board of Trustees. In 1890 she moved to Albany, New York, where her husband worked for the State of New York. In 1904 the family returned to New York City and two years later she founded a school for girls in Greenwich, Connecticut, where she taught for 20 years. She was honored in 1933 when Columbia hung her portrait in what was then the woman's graduate clubroom in Philosophy Hall; its inscription reads: "She opened the door."

Although they were the first two American women to be awarded PhDs in mathematics, neither Ladd nor Edgerton emerged from an intellectual vacuum. Ladd had studied with the astronomer Maria Mitchell at Vassar, and Edgerton was a product of the entirely female mathematics department of Wellesley College. Wellesley's mathematics faculty stayed entirely female for many years and later most of the faculty had doctorates from among the best known schools in the country: Harvard, Johns Hopkins,

the University of Chicago, the University of Pennsylvania, and Yale.

With many women PhDs on the mathematics faculty at Wellesley, it is clear that Ladd and Edgerton did not lack for successors, although it did take another seven years, until 1893, for the second PhD in mathematics to be awarded to a woman in this country. However, by the end of the nineteenth century Edgerton and Winston had been joined by eight women who had received PhDs in mathematics: three from Cornell, three from Yale, and two from Bryn Mawr College, both under the direction of Charlotte Scott. Even counting Christine Ladd-Franklin, the number eleven sounds quite small by modern standards. However, one must bear in mind that the PhD was a far-less-common degree then than it is now and only about 150 American men had received PhDs in mathematics by the turn of the century.
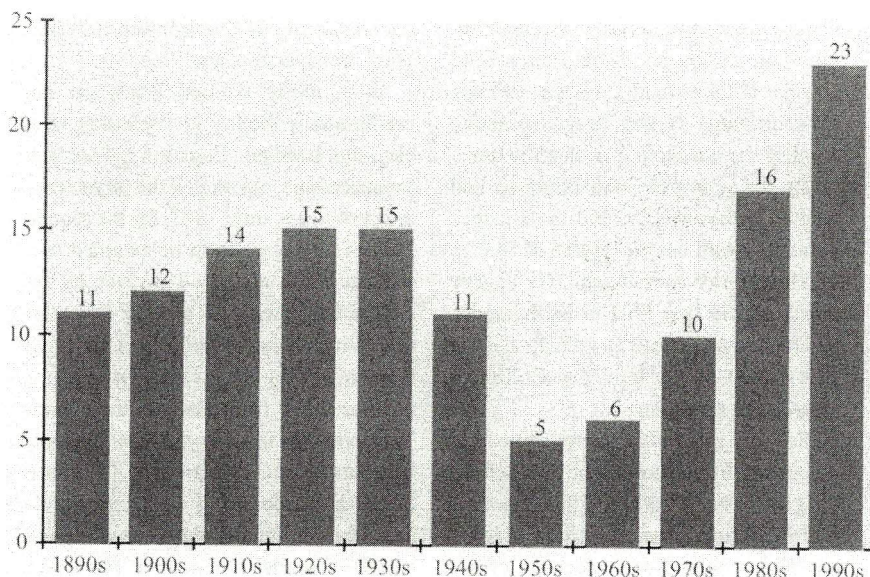
After the turn of the century, the number of American women entering the field of mathematics began to increase and by the mid 1930s was sufficiently established to motivate a study of the history of American women in mathematics by Helen Owens, a 1910 Cornell PhD in mathematics. The percentage of women receiving PhDs also increased from the 1890s through to the 1930s.

Courtesy of Wellesley College Archives. Photo by Pach Bros.

Winifred Edgerton

Approximate Percentage of US Mathematics PhDs Earned by Women

Bar chart values: 1890s: 11, 1900s: 12, 1910s: 14, 1920s: 15, 1930s: 15, 1940s: 11, 1950s: 5, 1960s: 6, 1970s: 10, 1980s: 16, 1990s: 23

growth continued into the 1980s, but at a slower rate. Since the 1990s, the numbers have been consistently above 200 PhDs being granted annually to women by schools in the United States. In 1999 the number exceeded 300 for the first time when 318 women received PhDs in mathematics in the United States; these women made up twenty-eight percent of all the PhDs granted in this country. If this growth continues, the visibility of women in mathematics should increase to the point where it will soon seem absurd to ask how many women mathematicians you can name.

If you would like to find more information about women in mathematics, consult the section on "Women in Mathematics" in *The History of Mathematics from Antiquity to the Present: A Selective Bibliography, edited by Joseph W. Dauben*, revised edition on CD-ROM edited by Albert C. Lewis, in cooperation with the International Commission on the History of Mathematics (Providence, RI: American Mathematical Society, 2000). This bibliography lists specific articles and books on most of the women referred to here. For more information on American women mathematicians see the articles cited in the second paragraph; for information on Fawcett and the education of women in England see *Philippa Fawcett and the Mathematical Tripos* by Stephen Sikos (Cambridge: Newnham College, 1990). ■

However, starting in the mid-1930s the percentages began to drop and by the mid-1940s they had dropped below ten percent, lower than at any time in the first four decades of the century. Although the drop ended in the post-Sputnik boom, it took until the 1980s to reach the level of the 1930s and it took until 1991 to surpass twenty percent.

While the percentages of women were dropping during the late 1930s through around 1960, the numbers dropped only from the mid-1930s through the mid-1940s. Furthermore, the increase from the 1960s to the 1970s in the percentage of women getting PhDs does not show the dramatic growth in the 1970s in the numbers of women getting PhDs. This

Number of Mathematics PhDs Earned by Women at US Schools

Bar chart values: 1890s: 8, 1900s: 17, 1910s: 35, 1920s: 51, 1930s: 113, 1940s: 89, 1950s: 113, 1960s: 390, 1970s: 1094, 1980s: 1304, 1990s: 2561

Markov Process
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