A Celebration of Women in Mathematics at MIT

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On Saturday and Sunday, April 12–13, 2008, the Department of Mathematics at the Massachusetts Institute of Technology held a Celebration of Women in Mathematics at MIT. The conference—co-sponsored by the MIT School of Science and the National Science Foundation—was instigated by Susan Landau, a 1983 Ph.D. alumna of the department, who asked mathematics department head Michael Sipser to organize a formal event to recognize MIT's role as a leading educator of women mathematicians. The organizing committee for the conference, headed up by Gigliola Staffilani and Katrin Wehrheim of the MIT math department, included Bonnie Berger—MIT professor of applied mathematics and a 1990 Ph.D. alumna in computer science—together with Susan Landau and three other MIT math alumnae: Lenore Blum (Ph.D. 1968), Ana Cannas da Silva (Ph.D. 1996), and Susan Colley (Ph.D. 1983).

The MIT celebration featured seven colloquium talks on topics in pure and applied mathematics, as well as two panels devoted to the mathematical lives of MIT women alumnae and faculty members: "Life Now: Becoming and Being a Mathematician", and "Life Back Then: Graduates of the Sixties, Seventies, and Early Eighties". In addition, alumnus Ken Fan (Ph.D. 1995) introduced Girls' Angle, a math club for Cambridge-area middle-school girls, on Saturday afternoon; MIT President Susan Hockfield and School of Science Dean Marc Kastner hosted a buffet supper on Saturday evening.

Seeking broader historical context for the mathematical achievements of women at MIT, the conference organizers graciously invited me to give an hour talk at lunch on Sunday. I also agreed to cover the conference for the *Notices* as a participant-observer. Because my only connection

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to MIT comes by way of MIT Press, my account interweaves historical elements from my presentation with my observations as both insider and outsider to the proceedings. Table 1 provides an alphabetical list of speakers and panelists. The full schedule of the conference, including slides and references, is now online at http://www-math.mit.edu/womeninmath/schedule.html.

Women in Mathematics: Doctorate Production at MIT (and elsewhere)

While the conference was ostensibly a celebration of *women in mathematics*, the proceedings largely focused upon women in mathematical *research*. Because the Ph.D. degree is effectively the professional certification for research mathematicians—and because most mathematical research is conducted by university mathematics faculty and their doctoral students—the conference celebrated the role of MIT as a producer of female mathematics Ph.D.'s.

But MIT's leadership in Ph.D. production is a relatively recent phenomenon. Table 2 lists, in chronological order, the first Ph.D.'s awarded to women by each of the Top Ten departments—Berkeley, Caltech, Chicago, Columbia, Harvard, MIT, Michigan, NYU, Princeton, Stanford, and Yale.[1] Columbia was the first among *all* U.S. institutions to award a mathematics Ph.D. to a woman, when it recognized Winifred Edgerton in 1886.[2] Swept along in the tide of first-wave feminism, many other universities steadily followed suit.[3] Among Top Ten departments both Chicago (46) and Yale (13) were leading producers of female mathematics Ph.D.'s prior to 1940 ([6], p. 18). All told, nine of the Top Ten departments—all but Princeton and Caltech—had awarded math Ph.D.'s to women by 1940.[4]

World War II was a turning point in the development of the American mathematical community. Mathematical research came to be seen as

indispensable to national security, and a host of federal programs provided fuel for massive expansion of graduate programs in mathematics—above all the National Science Foundation, which began awarding fellowships in 1952. Paradoxically, however, the immediate result of this expansion was the virtual disappearance of women from mathematics doctoral programs in the 1950s ([14], pp. 21–46).

Table 3 lists the names, degree years, and advisers of the first nine women to earn Ph.D.'s in mathematics from MIT. These are, in fact, *all* the women who earned MIT math Ph.D.'s prior to 1960. Domina Eberle Spencer, the third woman in the list, has been on the mathematics faculty at the University of Connecticut since 1950. At eighty-eight, Spencer was the oldest participant in the MIT celebration—seated front-and-center at each presentation with her chihuahua, Nikki, resting contentedly in her lap.[5]

One of the paradoxical effects of the postwar boom in mathematics was that institutions that

Speaker	Highest Degree (in mathematics unless noted otherwise)	Current position	Title of Talk or Panel
Sami Assaf	Ph.D., UC Berkeley, 2007	Moore Instructor in Mathematics, MIT	*Life Now*
Bonnie Berger	Ph.D., MIT, 1990 (Computer Science)	Professor of Applied Mathematics, MIT	*Comparative Genomics: Sequence, Structure, and Networks*
Lenore Blum	Ph.D., MIT, 1968	Distinguished Career Professor of Computer Science, Carnegie-Mellon University	*Computing Over the Reals: Where Turing Meets Newton*; *Life Back Then*
Anna Marie Bohmann	B.A., MIT, 2005 (Mathematics & Spanish); M.A., NYU, 2006 (Spanish)	Ph.D. Student, Mathematics, University of Chicago	*Life Now*
Ana Cannas da Silva	Ph.D., MIT, 1996	Associate Professor of Mathematics, Universidade Técnica de Lisboa; Senior Lecturer in Mathematics, Princeton University	*Life Now*
Susan Colley	Ph.D., MIT, 1983	Professor of Mathematics, Oberlin College	*Life Back Then*
Lenore Cowen	Ph.D., MIT, 1993	Associate Professor of Computer Science, Tufts University	*Life Now*
Ioana Dumitriu	Ph.D., MIT, 2003	Assistant Professor of Mathematics, University of Washington	*Matrix Computations: How Fast and Accurate Can They Be?*
Tara Holm	Ph.D., MIT, 2002	Assistant Professor of Mathematics, Cornell University	*Dance of the Astonished Topologist, or How I Left Squares and Hexes for Math*
Susan Landau	Ph.D., MIT, 1996	Distinguished Engineer, Sun Microsystems Laboratories	*Life Back Then* (moderator)
Nancy Lynch	Ph.D., MIT, 1972	Professor of Computer Science, MIT	*Life Back Then*
Margaret Murray	Ph.D., Yale, 1983; M.F.A., Iowa, 2005 (Nonfiction Writing)	Development Division, ACT, Inc.; Adjunct Professor of Mathematics, University of Iowa	*Women Becoming Mathematicians: A Look Back (and a Look Forward)*
Ruth Nelson	B.A., MIT, 1963	GTE Government Systems Corporation (retired)	*Life Back Then*
Ragni Piene	Ph.D., MIT, 1976	Professor of Mathematics, University of Oslo	*Life Back Then*
Sarah Raynor	Ph.D., MIT, 2003	Assistant Professor of Mathematics, Wake Forest University	*Life Now*
Linda Rothschild	Ph.D., MIT, 1970	Professor of Mathematics, University of California at San Diego	*Real Geometric Objects that Live in Complex Manifolds*; *Life Back Then*
Brooke Shipley	Ph.D., MIT, 1995	Professor of Mathematics, University of Illinois at Chicago	*Rings Up to Homotopy*
Katrin Wehrheim	Ph.D., ETH Zürich, 2002	Assistant Professor of Mathematics, MIT	*Life Now* (moderator)
Lauren Williams	Ph.D., MIT, 2005	Benjamin Peirce Assistant Professor of Mathematics, Harvard	*Combinatorics and Statistical Physics: A Story of Hopping Particles*

Table 1. Speakers at the Celebration of Women in Mathematics at MIT.

Year	Institution	Recipient
1886	Columbia	Winifred Edgerton (Merrill)
1895	Yale	Charlotte Barnum
1908	Chicago	Mary Emily Sinclair
1911	Berkeley	Annie Dale Biddle
1914	Michigan	Suzan R. Benedict
1917	Harvard (Radcliffe)	Mary Curtis (Graustein)
1928	Stanford	Marie Weiss
1930	MIT	Dorothy Weeks
1939	NYU	Harriet Griffin
1964	Caltech	Lorraine Turnbull Foster
1972	Princeton	Marjorie Leiter Stein Deborah L. Goldsmith Susan Friedlander

Table 2. Year first Ph.D. awarded to a woman in each of the Top Ten departments. Compiled and cross-checked from multiple sources, including *Bulletin* and *Notices* of the AMS, *ProQuest Dissertations & Theses*, *Mathematics Genealogy Project*, [3], [19].

had formerly been friendly to women became chilly, if not hostile, after 1945. The University of Chicago offers perhaps the most dramatic example of climate change ([14], pp. 26–27). But the post-Sputnik expansion of graduate funding—under Title IV of the National Defense Education Act (NDEA) of 1958—improved the situation for women. Statistics indicate that NDEA Title IV funding in the 1960s benefited larger numbers of women than had NSF funding a decade before ([21], pp. 76–79). Title IV funding, combined with second-wave feminism, led to a growing presence of graduate women in mathematics in the 1960s.

Just as the Nineteenth Amendment in 1920 was the culmination of American first-wave feminism, the signing of Title IX in 1972 was the culmination of American feminism's second wave ([21], 361–382). Title IX of the Educational Amendments Act of 1972—which bans discrimination on the basis of sex in all educational institutions receiving federal funding—has had a revolutionary impact on the gender balance of American mathematical research. And in the Title IX era, MIT has been a leading provider of graduate mathematics education to women.

In the 1980s, for example, MIT led the Top Ten in overall percentage of math Ph.D.'s to women (15%), and led *all* U.S. departments in total numbers (32) of female math Ph.D.'s [8]. From 1995–96 to 2002–03, MIT ranked fifth among all departments in total numbers of Ph.D.'s awarded to women in math: 37 out of 174 total, about 21%. Among the Top Ten departments only Berkeley ranked higher in total numbers (39), although it was lower in percent (16%).[6]

Women in Mathematics at MIT: Faculty Presence

But in terms of women on the graduate faculty, progress in the MIT math department is a much more recent development. According to departmental records for the period 1945–2007 [18], MIT's mathematics faculty was all male until 1968, when the department hired its first woman C.L.E. Moore Instructor, Karen Uhlenbeck. While women held a handful of untenured faculty positions during the decade that followed, Michèle Vergne—affiliated with MIT during 1977–1988—was MIT's first and only tenured woman in mathematics until 1999.

As a general matter, increases in women's faculty presence generally lag behind increases in doctoral production ([11], 127–130). According to the most recent CBMS survey, women account for about 15% (1,651/11,332) of the tenured, doctoral mathematics faculty at U.S. colleges and universities, and about 30% (926/3,120) of those deemed "tenure-eligible" ([12], p. 96). By contrast, women's representation among the tenured faculty at Top Ten institutions remains right around 5% [9]. But there have been clear signs of change in several Top Ten mathematics departments in recent years—including Michigan, Princeton, and MIT.

The revolution at MIT began in the summer of 1994, when biologist Nancy Hopkins joined with fifteen (of sixteen) other tenured women in the School of Science to petition then-Dean Robert Birgenau to establish a committee to investigate the status of women faculty at MIT. The committee, formed in 1995, included tenured women from every department in the school—*except* mathematics, which had no tenured women—and issued its final report in 1999 [4]. The report urged Dean Birgenau and then-President Charles M. Vest to improve conditions and ensure equity for both junior and senior women, and to increase women's faculty presence in each of the six departments of the School of Science.[7]

The transformation of MIT's mathematics faculty has been roughly concurrent with these developments. Bonnie Berger joined the department as an untenured assistant professor in 1992; she was tenured in 1999 and made full professor

Name	Ph.D. Year	Dissertation Adviser
Dorothy Weeks	1930	Norbert Wiener
Martha Plass	1939	Dirk Struik
Domina Eberle Spencer	1942	Dirk Struik
Helen Beard	1943	Dirk Struik
Miriam Lipschütz-Yevick	1948	Witold Hurewicz
Violet Haas	1951	Norman Levinson
Phyllis Fox	1954	C. C. Lin
Evelyn Bender	1954	Irvin Cohen

Table 3. Mathematics Ph.D.s awarded to women at MIT before 1960. Compiled and cross-checked from multiple sources, including *Bulletin* and *Notices* of the AMS, *ProQuest Dissertations & Theses, Mathematics Genealogy Project.*

in 2002. Gigliola Staffilani arrived as an associate professor in 2002, was tenured, and made full professor in 2006. Katrin Wehrheim arrived as a tenure-track assistant professor in 2005, and JuLee Kim arrived as a tenured associate professor in 2007. Women now account for 6.5% (3/46) of the tenured and 14.3% (1/7) of the tenure-eligible faculty. With the ascent of Susan Hockfield to MIT's presidency in 2004, many expect that these numbers and proportions will continue to rise.

Celebration—and Circumspection

The seven colloquium speakers were chosen—deliberately, I suspect—to represent three distinct academic generations. Lenore Blum and Linda Rothschild are veteran full professors, who completed their doctorates well after Sputnik but before Title IX. Bonnie Berger and Brooke Shipley are recent full professors, who earned Ph.D.'s roughly two decades *after* Title IX. Tara Holm, Ioana Dumitriu, and Lauren Williams are new assistant professors with twenty-first century doctorates; the ink had already dried on Title IX by the time they were born!

All seven speakers endeavored to communicate the excitement of research to a mathematically diverse audience; collectively, they illustrated the broad spectrum of women's work in pure and applied mathematics. Shipley and Rothschild gave classic colloquia, emphasizing internal connections among the disciplines of pure mathematics. Tara Holm took a step—or several—away from her pure-mathematical proclivities, joining with members of MIT's Tech Squares in a dynamic illustration of the topology of square dance. While Lauren Williams described how the problems of science inspire pure mathematics, Bonnie Berger emphasized how pure mathematics adapts to solve the problems of science. Finally, Ioana Dumitriu and Lenore Blum

explored the realm of computation—the inevitable meeting ground of theory and application.

When it came time for panel discussion, the organizers wisely chose to begin with the younger generation. The "Life Now" panelists told uplifting tales of early career success. The youngest panelist, Anna Marie Bohmann, is still working on her Ph.D.; she gave a brief but intriguing account of how she came to choose mathematics over Spanish as her academic specialty. Likewise, Sami Assaf had a dual major in mathematics and philosophy as an undergraduate at Notre Dame. These women exemplify a growing trend among a younger generation of scholars, drawn into the serious study of several disciplines at once [10]. Yet despite these Renaissance aspirations, the women of the "Life Now" panel seemed remarkably united in their desire for conventional careers in academic mathematics. All seemed to regard the conventional trajectory from Ph.D. to postdoc to tenure-track to tenure as both normative and desirable. Sami Assaf, Lenore Cowen, Ana Cannas da Silva, and Sarah Raynor told personal stories of the two-body problem, and of balancing marriage and childbearing with the timetables of promotion and tenure.

All this discussion of the "two-body problem" led to one of the more surprising moments of the conference. I asked the panelists if anyone would be willing to comment on the "one-body problem": the potential isolation of being a single woman in a coupled-up academic world.[8] This question led panel moderator Katrin Wehrheim, who had kept mum up until then about her own personal life, to come out as a single tenure-track faculty member—and to come out as lesbian, too. Wehrheim's revelation was greeted with lengthy applause. It seems that there's still something radical about coming out as a gay or lesbian mathematician—even in Massachusetts!

Despite themes common to both the panels, the "Life Back Then" panelists had generally grimmer tales to tell. Ruth Nelson, for example, worked on a Ph.D. in mathematics at MIT for four years in the 1960s before she was, in essence, ushered out of the program without so much as a master's degree. Devastated, she left MIT convinced that she would never do mathematical research. Years later, however, with a corporate career well underway, Ruth Nelson published original research in computer science.

While Linda Rothschild, Lenore Blum, Susan Landau, and Nancy Lynch all managed to complete their Ph.D.'s at MIT, their subsequent careers have involved heroic feats of academic perigrination. The youngest of the old-time panelists, Susan Colley and Ragni Piene, have had rather more-settled careers, earning tenure in their first job post-Ph.D. All in all, the older generation of panelists, though content with their hard-won successes, seemed to counsel vigilance: Blum warned against "making important decisions naïvely", while Lynch advised that a mathematician's first allegiance is to research, rather than to any institution or local community.

In this respect, both panels seemed to buy into at least a modified version of what I have elsewhere described as "the myth of the mathematical life-course" ([14], pp. 15–18). Indeed, at one point Sami Assaf asked the heartfelt question, "What happens when life doesn't conspire to help us?"

An Outsider's Perspective: Problems and Prospects

The MIT Celebration of Women in Mathematics showed that MIT can be a wonderful place for women to prepare for a career in research mathematics. But the match between a doctoral student and his or her department varies from student to student, and I know some women Ph.D.'s from MIT whose experiences in the department were not wholly positive and whose later careers were not so stellar as those showcased at the conference. Even so, that the conference could bring together so many talented women who have earned MIT doctorates and successfully joined the professorial ranks is a clear indication that MIT is doing many things right.

But in the words of a recent National Research Council report, women have "entered academia in increasing numbers at a time when opportunities for obtaining more permanent and prestigious faculty positions [have] begun to decline" ([11], pp. 148–9). In some disciplines, the casualization of the academic workforce has reached crisis proportions [1]. To paraphrase Sami Assaf: what indeed, happens, when circumstances do not conspire to create the academic life we have envisioned?

I cannot help but respond to this question from my own perspective, as a Top Ten Ph.D. graduate who has strayed far from the mythical course. For me, creating a life—mathematical and otherwise—has been an act of faith and a great work of the imagination. In another venue, in another time, I offered some advice to graduate students and new Ph.D.'s:

> It is quite unlikely that you will lead the same kind of professional lives that your professors did. But this should not be reason for despair. You need always to remember that you have unusual training and skills. The world—*both inside and outside of mathematics*—is waiting for you, full of problems to be solved. ([5], p. 51)

Perhaps the best way for women to celebrate our achievements is to begin the work of envisioning the mathematical community of the future.

Notes

1. Top-ten rankings are issued periodically by the National Research Council and *U.S. News and World Report.* I offer the name *Top Ten* by analogy to the eleven-member Big Ten.

2. While Edgerton was the first woman to *receive* a U.S. mathematics Ph.D., she was not the first woman to actually *earn* one. That distinction goes to Christine Ladd-Franklin, student and collaborator of C. S. Peirce, who earned a Ph.D. at Johns Hopkins in 1882 but did not actually receive it until 1926 ([2], p. 133; [22], p. 123).

3. While women did not "officially" earn Ph.D.'s from Harvard until 1963, a Ph.D. from Radcliffe was a Harvard degree in all but name ([20], pp. 44, 169; [23]). Stanford's appearance in the list is delayed until 1928, owing perhaps to peculiar circumstances which strictly limited women's enrollment there until 1933 ([24], p. 59). Graduate programs in mathematics at MIT and NYU blossomed only in the 1930s, which explains their comparatively late entries in the table.

4. Caltech and Princeton were extremely slow to admit women to graduate study in any discipline ([21], p. 85; [16]; [25]). At Princeton, however, women held visiting memberships in the School of Mathematics at the Institute for Advanced Study throughout the 1930s [7]. For the early history of mathematics at Princeton, see [17].

5. Spencer's adviser, Dirk Struik, is just one among many notable émigré mathematicians who were especially welcoming to female doctoral advisees during the pre-war years. He advised fully one-third of MIT's pre-1960 women Ph.D.'s. For more on both Spencer and Struik, see [14].

6. In view of the fact that women received 26% of all mathematics doctorates during those years, however, all the Top Ten schools lagged behind the national average somewhat.

7. President Vest subsequently convened a meeting in 2001 at which MIT joined with eight other universities—Berkeley, Caltech, Harvard, Michigan, Penn, Princeton, Stanford, and Yale—in pledging to work toward creating a faculty "that reflects the diversity of the student body" [13]. All the Top Ten institutions were represented at the meeting—save Chicago, Columbia, and NYU.

8. At the 1993 Joint Mathematics Meetings in San Antonio, I was invited to speak on an AWM panel entitled, "Is Geography Destiny?" While the stated purpose was to discuss the effects of geography on academic careers in mathematics, I was the only panelist to speak on the topic assigned; everyone else talked about the employment problems that face a heterosexually-married couple of mathematicians. At the time of my appearance on the panel, I had recently come out as lesbian and entered into a long-term relationship with another woman after several years of singleness. None of this personal history is evident in the short essay I was asked to write in the aftermath of the panel [15].

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Noticed

The November 2008 issue of the *Notices* carried a study about the representation of females in high-level mathematics competitions. The study found that there are numerous girls who do well in such competitions but their participation is highly dependent on culture. In particular, United States girls participate in far fewer numbers than girls from some other countries. This article received widespread coverage in newspapers and magazines all over the world. A Reuters story was reprinted in many newspapers, and byline stories also appeared in the *Boston Globe*, the *Los Angeles Times*, *New Scientist*, the *New York Times*, *Newsweek*, *Science News*, and the *Neue Zürcher Zeitung*.