
Women Becoming Mathematicians

Creating a Professional Identity in
Post-World War II America

Margaret A.M. Murray

*Best wishes,
Margaret Murray*

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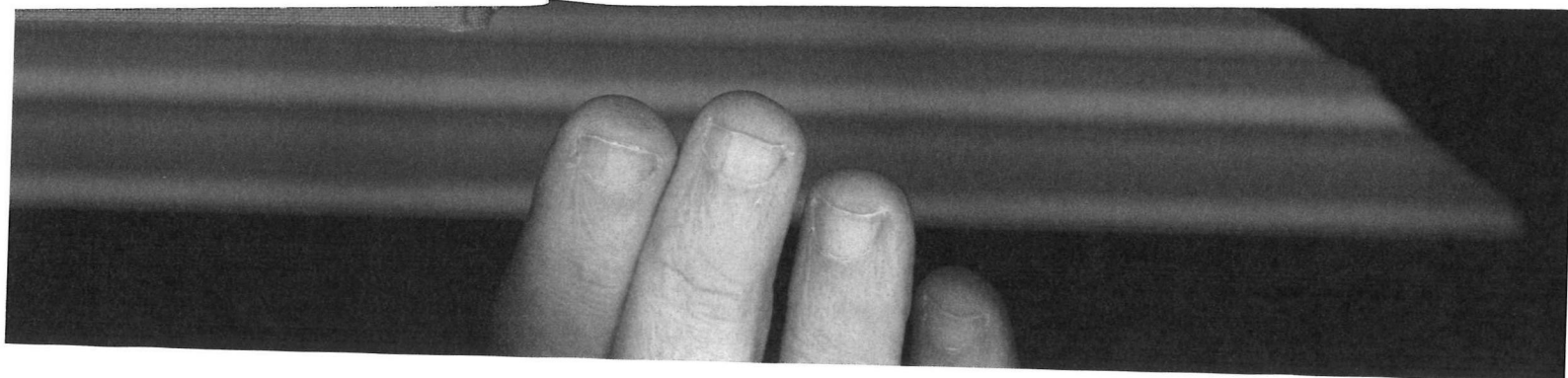
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Preface

In recent years considerable attention has been devoted to the problem of underrepresentation of women in the fields of science and engineering. These fields have tended to attract and retain women in inverse proportion to the degree to which their subject matter is perceived to be difficult, abstract, and inaccessible. Typically, physics and many of the engineering disciplines attract and retain the fewest women, both numerically and proportionally, while the biological and behavioral sciences seem to attract the most. Mathematics has tended to fall somewhere in between, perhaps toward the lower end of the spectrum.¹

Mathematics occupies a unique position among scientific and technical fields. It provides a logical and quantitative framework for the empirical sciences and at the same time has its own independent subject matter. Because the objects of mathematical study are concepts that have been abstracted from common notions of counting, measurement, geometry, and relationship, mathematics is not an empirical science in any ordinary sense of the word. So it is perhaps not surprising that even educated lay persons regard mathematics as difficult, abstract, and inaccessible. But one of the advantages of mathematics as a subject of study for women is precisely this: mathematical objects are portable and can be carried about in the mind, without need for any special equipment. In principle, mathematical inquiry can be carried out anywhere at all.

But meaningful mathematical inquiry does not occur in isolation; it relies on communication between mathematicians and on a community consensus regarding the accuracy, validity, and significance of new discoveries in the field. Similarly, the dissemination of mathematical



knowledge is a social and cultural phenomenon, involving teachers, students, textbooks, and other means of instruction. The historical development of mathematics has been fueled by the resources, support, and encouragement of the larger society: business leaders, scientists, educators, politicians, policymakers. In short, mathematics depends on social relationships—both within its own community and in the larger communities of which it is a part. For women to make meaningful contributions to mathematics, they must establish productive relationships within these communities.

How, then, do women become mathematicians? How do they find satisfying work and earn respect and remuneration in a field that is largely defined and dominated by men? Clearly, the answers to these questions depend on myriad intellectual, social, political, cultural, and personal factors. The history of women in mathematics, as in other male-dominated professions, has followed a cyclic pattern of inclusion and exclusion (Graham 1978). In the United States, women mathematicians have always been in the minority, but they have during two distinct eras gained a substantial foothold in the profession. During the years 1910 to 1939, women earned roughly 14 percent of the mathematics Ph.D.'s awarded in this country, and most of those women went on to substantial careers in research, teaching, or administration. Since 1980, women have earned over 17 percent of the mathematics doctorates and have been more visible and active participants in mathematical life than have any previous generation of women mathematicians in history.

What of the intervening years, then? World War II was the signal event that changed the complexion of women's involvement in the American mathematical community. Through the participation of unprecedented numbers of mathematicians in war-related research, mathematics came to be seen as indispensable to national security. During the postwar years, higher education in general, and mathematics in particular, underwent unprecedented expansion. As mathematics grew in power and prestige, it became particularly attractive to men—men who might otherwise have pursued careers in law, medicine, or another of the sciences. At the same time, the prevailing cultural message for women was that victory in war meant a return to domesticity and femininity: a woman's place was in

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the home, rearing children and providing a comfortable haven for her husband.

While the numbers of women earning doctorates in mathematics remained essentially flat in the 1940s and 1950s, the numbers of men earning these degrees increased more than threefold. The net result was that women were gradually squeezed out of their place in American mathematics. So devastating was the reversal of women's earlier gains in the mathematical community that it took another two decades to recover the ground that had been lost.

During the postwar years, as men joined the mathematical profession in record numbers, a picture emerged of the life course of the ideal mathematician that was well suited to a *man's* life circumstances and particularly to those of a married man whose wife did no work outside the home. I refer to this as *the myth of the mathematical life course*, or simply, *the myth*, and it became the dominant model for the unfolding of mathematical careers in the decades following World War II.

While the economic and political conditions of the forties and fifties made it possible for increasing numbers of men to lead careers in conformity to the myth, its intensification in the postwar years cannot be explained solely in these terms. In her classic study *Men and Women of the Corporation*, Rosabeth Moss Kanter (1977) argues that when women's preponderance in a social group is reduced below a certain critical mass, they assume a token status. She asserts that "tokens are, ironically, both highly visible as people who are different and yet not permitted the individuality of their own unique, non-stereotypical characteristics." Moreover, in the presence of tokens, members of the dominant group seek to clarify for themselves and for others the common characteristics that establish their status and distinguish them from the minority (210–211). Women mathematicians were such a tiny minority of the mathematical community in the forties and fifties that they meet Kanter's criteria for token status; as such they were, indeed, both highly visible and easily stereotyped by many (though not all) of their male colleagues. The postwar intensification of the myth can thus be understood as serving a critical ideological function: to consolidate men's dominance in the mathematical profession.

In her recent book, *Women in Mathematics: The Addition of Difference*, Claudia Henrion (1997) describes in detail the complicated effect that the mathematical community's strongly gendered ideologies have had on recent (especially post-1960) generations of women mathematicians. The women mathematics Ph.D.'s of the forties and fifties, however, were effectively caught in a transition between two cultures. On the one hand, they had many of the women mathematicians of the prewar generation as role models, mentors, and teachers. At the same time, they came to maturity just as the myth of the mathematical life course was gathering momentum.

Faced with a combination of structural discrimination, conflicting cultural messages, and token status, it was indeed difficult for the women mathematicians of the postwar generation to reconcile their mathematical ambitions with the cultural expectations placed upon them. Mary Ellen Rudin, who earned her Ph.D. at the University of Texas in 1949, has characterized her generation of women in mathematics as "the housewives' generation" because they tried at once to meet the cultural expectations of them as women while at the same time maintaining a vital connection to the world of mathematics (Albers, Alexanderson, and Reid 1990: 302). But the reality of the lives and careers of the women mathematics Ph.D.'s of the forties and fifties is much richer and more complex than Rudin's characterization would indicate.

The women mathematicians of the postwar generation were compelled to *improvise*: to create lives and careers that were faithful to their values, talents, and needs by adapting to shifting circumstances and opportunities (see Bateson 1990). Their stories are instructive precisely *because* they do not conform to a set pattern. In the absence of a single, guiding model for how a woman's mathematical life is to be lived, the women mathematics Ph.D.'s of the forties and fifties followed a diversity of paths in the struggle to create a professional identity in post-World War II America.

In the 1990s, women earned mathematics Ph.D.'s at U.S. universities in record numbers. By the mid-1990s, women were receiving approximately one-quarter of the Ph.D.'s awarded each year. If these trends continue, women will rapidly leave behind the token status they have occupied in the mathematical community for over half a century. If women are to have any hope of changing the culture or shaping the direction of the

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Mathematics: The Addition of Differences describes in detail the complicated effects that strongly gendered ideologies have on generations of women mathematicians. Ph.D.'s of the forties and fifties, however, grew up between two cultures. On the one hand, they were the daughters of mathematicians of the prewar generation. At the same time, they came of age when a new mathematical life course was gathering

momentum. Cultural discrimination, conflicting cultural expectations, it was indeed difficult for the women of the postwar generation to reconcile their mathematical expectations placed upon them. Mary Cartwright, at the University of Texas in 1949, described the situation of women in mathematics as "they have tried at once to meet the cultural expectations while at the same time maintaining a separate identity in mathematics (Albers, Alexanderson, and others). The lives and careers of the women of the forties and fifties is much richer and more varied than the statistics would indicate.

The postwar generation were compelled to choose between careers that were faithful to their values, or to accept shifting circumstances and opportunities. These choices are instructive precisely *because* they reveal the absence of a single, guiding model for how a mathematical life is to be lived, the women mathematicians followed a diversity of paths in the postwar environment in post-World War II America. The number of mathematics Ph.D.'s at U.S. universities in the forties and fifties, women were receiving approximately 1,000 each year. If these trends continue, the token status they have occupied in the postwar era for over half a century. If women are to have a significant influence on culture or shaping the direction of the

mathematical community of the future, they will need to understand the struggles of the women who have come before them and to rely on the very improvisational skills that these women brought to the process of becoming mathematicians in the past.

In the pages that follow I examine more deeply the social and cultural background, the lives and careers, of the approximately two hundred women who earned Ph.D.'s in mathematics from American colleges and universities during the years 1940 to 1959. In the first chapter, I discuss the role of women in the development of the American mathematical community and the profound transformation of American mathematics wrought by World War II. The myth of the mathematical life course is fully elaborated, and its emergence in the context of the World War II transition is critically examined in detail.

Chapter 2 provides an introduction to the women mathematics Ph.D.'s of the forties and fifties: their background, education, and accomplishments. Special attention is given to a select group of thirty-six women who agreed to participate in intensive oral history interviewing. The remaining chapters are based on the lives and experiences of the thirty-six interviewees, from childhood through retirement and beyond, with a view to understanding how women become mathematicians in the leanest times, when social and cultural forces are least supportive of their ambitions. It is in these times that women rely most heavily on their own resources and inventiveness to persevere in work they love and care about.

Acknowledgments

This project has been several years in the making and would not have come to fruition without the help and support of numerous individuals and organizations. I am indebted to Roberta Mura of Université Laval, whose sabbatical visit to Virginia Tech during the fall semester of 1990 stimulated my thinking about the social history of women in mathematics. I am deeply grateful to Jeanne LaDuke and Judy Green, whose pioneering work on the American women who earned Ph.D.'s in mathematics prior to 1940 has been an inspiration and a resource for my own. In particular, Jeanne LaDuke has been a continual source of

support, encouragement, and information for many years; it was she who first suggested to me that the post-1940 Ph.D.'s would be an especially fruitful subject of study.

I am also profoundly indebted to two Virginia Tech colleagues, Susan Hagen and Doris Zallen, who prompted and prodded me to learn more about the theory and practice of oral history, and to Pamela Henson of the Smithsonian Institution, who provided me with the resources and information I needed to get the oral history interviewing underway.

As early as 1994, Thomas Brobson was attentive to my plans for this project and helped immeasurably in my quest for funding. Leslie Kay introduced me to Jean Walton and has maintained a steady interest in my work over several years; her extensive feedback on the manuscript has been invaluable. Rita Kranidis helped me to make crucial decisions about the structure of the book and offered careful readings of interview transcripts as well as early drafts of the first few chapters.

This project was made possible in part by grants from the Spencer Foundation of Chicago, the Alfred P. Sloan Foundation, and the Center for Programs in the Humanities at Virginia Polytechnic Institute and State University, for which I express my deepest gratitude. The statements made and the views expressed in this book are, of course, entirely my own responsibility. Dr. Ted Greenwood of the Sloan Foundation, as well as anonymous reviewers at the Spencer Foundation and MIT Press, provided thoughtful and timely criticisms that greatly improved the final manuscript. Thanks go as well to Amy Pierce Brand of MIT Press, without whom this book might never have come to be.

A preliminary report on this research, based on twenty-three of the thirty-six interviews, was presented at the conference on Women Succeeding in the Sciences, held at Sweet Briar College in April 1997. It will appear in the proceedings of the conference, to be published in 2000 by Purdue University Press. I am grateful to Professor Jody Bart of Sweet Briar for her early interest in my work.

Many other colleagues, friends, and relatives have provided assistance, support, encouragement, and feedback at various stages along the way. Among these, my greatest personal debt is owed to Carol McManus. In addition, I offer heartfelt thanks to Susan Anderson, Moira Baker, Ezra Brown, Laura Clark, Peggy DeWolf, Caren Diefenderfer, Peter Duren,

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Thomas Ewing, Deanna Haunsperger, Michael Hughes, Joan Hutchin- son, Stephen Kennedy, Cathy Kessel, Jennifer Livesay, Harriet Lord, Laura Mayer, Elizabeth McManus, Roxe Murray, Terry Murray, Sylvia Nasar, Amy Nelson, Kenneth Pimple, Lynn Reed, Barbara Reeves, Mar- garet Rossiter, Sanford Segal, Sally Sevcik, Daryl Smith, Anita Solow, and Steve Weiss.

Finally, this project would not have been possible at all without the generous participation of the interviewees themselves. I am deeply hon- ored by their willingness to share their lives and stories with me.

A Note on Notation

At various points throughout the text I have found it useful to briefly indicate both the institution and the year in which a specific individual earned her (or his) Ph.D. In such cases I have enclosed the name of the Ph.D.-granting school and the year in which the degree was awarded in parentheses immediately following the name—for example, Mary Ellen Rudin (Ph.D., Texas, 1949). In specific cases I have also indicated the individual's dates of birth and death in the same set of parentheses—for example, Anna Pell Wheeler (Ph.D., Chicago, 1910; 1883–1966).

Citations of oral history interviews are made by giving the last name of the interviewee followed by the page number of the transcript from which the citation is drawn. Two of the interviewees had multiple inter- views (and hence multiple transcripts); in these cases, the last name of the interviewee is followed by the transcript number—Anderson-2, Freitag-3. An alphabetical list of the interviewees, which includes the date and location of each interview and the length of each transcript, is given in appendix B.



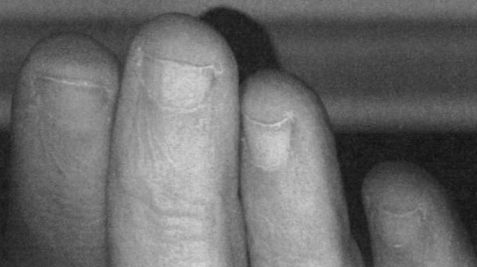
Appendix A

Note on the Methodology of Oral History

This study is based on in-depth, tape-recorded interviews that were conducted during the period from October 1995 through August 1997 with thirty-six women who earned Ph.D.'s in mathematics from American institutions during the years 1940 through 1959. All but one of the interviews was conducted in person. My aim in each interview was to elicit a narrative account of the interviewee's life and career in mathematics. In all but the first few cases, each interviewee was asked to complete a biographical questionnaire in advance of our meeting. Once we finally met in person, I also asked them to provide supporting documents, including photographs, *curriculum vitae*, and other written materials.

Each interview was based on a list of twenty-one questions, proceeding more or less chronologically through the interviewee's family background, early education, college and graduate study, and career development. Special attention was paid to the interweaving of personal, family, and career concerns. The interviews themselves were somewhat open-ended. Although I worked in each case from the same set of questions, not all of the questions were actually *asked* of each interviewee, since many of them were able to anticipate the issues I wanted to discuss. Moreover, I endeavored to frame the questions in terms that were as neutral as possible, in an effort to bring out each woman's authentic point of view.

For a variety of reasons, some of the interviews were unusually brief, but typically, each interview went on for a period of one to three hours. The interviews were conducted following the procedural, legal, and ethical guidelines put forth by the Oral History Association. In particular, each interviewee gave her informed consent prior to the interview and



signed a deed of gift afterward, transferring copyright of the interview material to me. The forms used in the interview process were approved for use in this project by the Institutional Review Board at Virginia Tech.

I prepared a verbatim transcript of each interview, and a copy of the transcript was sent to each interviewee for review and revision. At some future point, the tapes and transcripts will be made available to the public in an oral history archive. An alphabetical list of the interviewees, which includes the date and location of each interview and the length of the transcript in pages, is given in appendix B. Because four of the interview transcripts (Bell, Gassner, Hahn, and Morley) are not yet in their final, archival form, quotations from these interviews appear very rarely in the text.

Information gleaned from an interview narrative is highly subjective, reflecting an individual's reaction to and interpretation of life events. With a view to placing the narratives in proper perspective, I have done additional research using primary and secondary sources in an effort to verify the interviewees' factual accounts and to provide a historical, cultural, and mathematical context for their recalled experiences.

For the most part, the interview extracts presented in this book are presented as direct quotations from the interviewees, removed from the context of the interview itself. In particular, the questions that prompted these responses have generally been omitted. In the text, I have endeavored to supply the proper context for such quotations. Moreover, I am keenly aware of the fact that the interviewees and I may have differing views on the interpretation of circumstances and events. (Borland 1991 provides a thoughtful discussion of the problems inherent in attempts to interpret women's oral narratives of the past.)

My attitude throughout has been one of profound respect toward the women who have so generously shared their stories. At the same time, I believe that a retrospective view, informed by the insights of liberal feminist scholarship, can shed new light on the lives of twentieth-century women mathematicians.

As this book goes to press, four of the interviewees are no longer living and a number of others are in failing health. In the text, however, each woman's words are used as if she were speaking in the present, thus preserving a sense of the immediacy and spontaneity of the interview setting.

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Appendix B

Alphabetical List of Interviewees

Each entry in the list contains the following information. The name of the interviewee appears first, followed in parentheses by the Ph.D. institution, year of Ph.D., date of birth, and sometimes date of death. Then the Ph.D. adviser and field of study are listed, followed by information on the interviewee's marital status and children (if any). If the individual held a tenured college or university position at some point in her career, this is noted next. Finally, the interview date(s) and location(s) are given, together with transcript length in pages.

A surname in (parentheses) denotes a married name under which the individual has been known at some time during her career; a surname in **boldface** denotes the name under which the individual has been most recently known professionally; a surname in *italics* denotes the name under which the Ph.D. was awarded.

Anne *Lewis* **Anderson** (Ph.D., Chicago, 1943; born 1919). Adviser: Magnus Hestenes. Field: Calculus of variations. Widowed, no children. Tenured. Interviews: by phone, 18 April 1995, Chapel Hill, N.C. (13 pages); in person, 20 November 1995, Chapel Hill, N.C. (8 pages).

Winifred *Asprey* (Ph.D., Iowa, 1945; born 1917). Adviser: E.W. Chittenden. Field: Analysis. Never married, no children. Tenured. Interview: 24 August 1996, Poughkeepsie, N.Y. (56 pages).

Lida Kittrell **Barrett** (Ph.D., Pennsylvania, 1954; born 1927). Adviser: J.R. Kline. Field: General topology. Widowed, three children. Tenured. Interview: 15 August 1997, West Point, N.Y. (37 pages).

Grace **Bates** (Ph.D., Illinois, 1946; 1914–1996). Adviser: Reinhold Baer. Field: Algebra. Never married, no children. Tenured. Interview: 13 June 1996, Newtown, Pa. (24 pages).

Barbara *Beechler* (Ph.D., Iowa, 1955; born 1928). Adviser: H.T. Muhly. Field: Algebra. Divorced, no children. Tenured. Interview: 23 May 1996, Claremont, Calif. (51 pages).

Janie *Lapsley Bell* (Ph.D., Illinois, 1943; born 1913). Adviser: E.B. Coble. Field: Geometry. Widowed, three children. Not tenured. Interview: 22 May 1997, Monument, Colo. (18 pages).

Anne *Whitney Calloway* (Ph.D., Pennsylvania, 1949; born 1921). Adviser: I.J. Schoenberg. Field: Complex analysis and approximation theory. Married, two children. Not tenured. Interview: 21 October 1996, Kalamazoo, Mich. (23 pages).

Mary Dean *Clement* (Ph.D., Chicago, 1943; born 1914). Adviser: E.P. Lane. Field: Geometry. Never married, no children. Not tenured. Interview: 18 November 1995, Nashville, Tenn. (40 pages).

Jane *Cronin Scanlon* (Ph.D., Michigan, 1949; born 1922). Adviser: E.H. Röthe. Field: Functional analysis. Divorced twice, four children. Tenured. Interview: 12 June 1996, Highland Park, N.J. (49 pages).

Patricia James (*Wells*) *Eberlein* (Ph.D., Michigan State, 1955; 1925–1998). Adviser: Charles P. Wells. Field: Applied mathematics, integral equations. Divorced twice, widowed, seven children (includes step-children). Tenured. Interview: 12 August 1997, Buffalo, N.Y. (18 pages).

Herta Taussig *Freitag* (Ph.D., Columbia, 1953; 1908–2000). Adviser: Howard Fehr. Field: History of mathematics, mathematics education. Widowed, no children. Tenured. Interviews: 28 October, 11 November, and 2 December 1995, Roanoke, Va. (23, 25, and 19 pages).

Betty Jane *Gassner* (Ph.D., NYU, 1957; born 1934). Adviser: Wilhelm Magnus. Field: Algebra. Never married, no children. Not tenured; not employed in academia. Interview: 7 June 1997, New York, N.Y. (8 pages).

Evelyn *Boyd Granville* (Ph.D., Yale, 1949; born 1924). Adviser: Einar Hille. Field: Analysis. Divorced, remarried, no children. Tenured. Interview: 19 May 1997, Tyler, Tex. (28 pages).

Susan Gerber *Hahn* (Ph.D., NYU, 1957; born 1914). Adviser: Peter Lax. Field: Partial differential equations. Widowed, no children. Not tenured; employed in industry. Interview: 6 June 1997, Queens, N.Y. (39 pages).

Violet *Hachmeister Larney* (Ph.D., Wisconsin, 1950; born 1920). Adviser: C.C. MacDuffee. Field: Algebra. Married, no children. Tenured. Interview: 21 May 1996, Mesa, Ariz. (24 pages).

Anneli Cahn *Lax* (Ph.D., NYU, 1955; 1922–1999). Adviser: Richard Courant. Field: Partial differential equations. Divorced, remarried, two children. Tenured. Interview: 5 June 1997, New York, N.Y. (21 pages).

n 1928). Adviser: H.T. Muhly. Tenured. Interview: 23 May 1996, Troy, N.Y. (41 pages).

born 1913). Adviser: E.B. Coble. Not tenured. Interview: 22 May 1996, Troy, N.Y. (41 pages).

vania, 1949; born 1921). Adviser: Robert Cameron. Field: Analysis and approximation theory. Divorced, three children. Tenured. Interview: 21 October 1996, Adrian, Mich. (25 pages).

43; born 1914). Adviser: E.P. Jackson. Field: Analysis. Never married, no children. Tenured; later, U.S. government employee. Interview: 21 July 1997, St. Paul, Minn. (28 pages).

1949; born 1922). Adviser: E.H. Morawetz. Field: Applied mathematics. Married, four children. Tenured. Interview: 4 June 1997, New York, N.Y. (28 pages).

Michigan State, 1955; 1925–1997). Adviser: Antoni Zygmund. Field: Harmonic analysis. Married, no children. Not tenured. Interview: 13 August 1997, Ithaca, N.Y. (25 pages).

1953; 1908–2000). Adviser: Vera Stepen Pless. Field: Algebra. Divorced, three children. Tenured. Interview: 16 July 1996, Oak Park, Ill. (29 pages).

1953; 1908–2000). Adviser: Joan Raup Rosenblatt. Field: Mathematical statistics. Married, no children. Not tenured; U.S. government employee. Interview: 2 October 1996, Gaithersburg, Md. (23 pages).

1953; 1908–2000). Adviser: Jean Hirsh Rubin. Field: Logic. Married, two children. Tenured. Interview: 15 July 1996, West Lafayette, Ind. (16 pages).

1953; 1908–2000). Adviser: Mary Ellen Estill Rudin. Field: General topology. Married, four children. Tenured. Interview: 17 July 1996, Madison, Wis. (28 pages).

1953; 1908–2000). Adviser: Alice Turner Schafer. Field: Geometry. Married, two children. Tenured. Interview: 1 October 1996, Arlington, Va. (31 pages).

1953; 1908–2000). Adviser: Augusta Schurrer. Field: Complex analysis. Never married, no children. Tenured. Interview: 20 July 1996, Cedar Falls, Iowa (34 pages).

1953; 1908–2000). Adviser: Domina Eberle Spencer. Field: Tensor analysis. Widowed, one child. Tenured. Interview: 26 August 1996, Boston, Mass. (42 pages).

Edith Hirsch *Luchins* (Ph.D., Oregon, 1957; born 1921). Adviser: Bertram Yood. Field: Functional analysis. Married, five children. Tenured. Interview: 14 August 1997, Troy, N.Y. (41 pages).

Dorothy *Maharam Stone* (Ph.D., Bryn Mawr, 1940; born 1917). Adviser: Anna Pell Wheeler. Field: Measure theory. Married, two children. Tenured. Interview: 28 August 1996, Boston, Mass. (15 pages).

Margaret *Owchar Marchand* (Ph.D., Minnesota, 1950; born 1925). Adviser: Robert Cameron. Field: Analysis. Divorced, three children. Tenured. Interview: 22 October 1996, Adrian, Mich. (25 pages).

Margaret *Martin* (Ph.D., Minnesota, 1944; born 1915). Adviser: Dunham Jackson. Field: Analysis. Never married, no children. Tenured; later, U.S. government employee. Interview: 21 July 1997, St. Paul, Minn. (28 pages).

Cathleen Synge *Morawetz* (Ph.D., NYU, 1951; born 1923). Adviser: Kurt O. Friedrichs. Field: Applied mathematics. Married, four children. Tenured. Interview: 4 June 1997, New York, N.Y. (28 pages).

Vivienne Brenner *Morley* (Ph.D., Chicago, 1956; born 1930). Adviser: Antoni Zygmund. Field: Harmonic analysis. Married, no children. Not tenured. Interview: 13 August 1997, Ithaca, N.Y. (25 pages).

Vera Stepen *Pless* (Ph.D., Northwestern, 1957; born 1931). Adviser: Alex Rosenberg. Field: Algebra. Divorced, three children. Tenured. Interview: 16 July 1996, Oak Park, Ill. (29 pages).

Joan Raup *Rosenblatt* (Ph.D., North Carolina, 1956; born 1926). Adviser: Wassily Hoeffding. Field: Mathematical statistics. Married, no children. Not tenured; U.S. government employee. Interview: 2 October 1996, Gaithersburg, Md. (23 pages).

Jean Hirsh *Rubin* (Ph.D., Stanford, 1955; born 1926). Adviser: C.C. McKinsey and Patrick Suppes. Field: Logic. Married, two children. Tenured. Interview: 15 July 1996, West Lafayette, Ind. (16 pages).

Mary Ellen *Estill Rudin* (Ph.D., Texas, 1949; born 1924). Adviser: R.L. Moore. Field: General topology. Married, four children. Tenured. Interview: 17 July 1996, Madison, Wis. (28 pages).

Alice *Turner Schafer* (Ph.D., Chicago, 1942; born 1915). Adviser: E.P. Lane. Field: Geometry. Married, two children. Tenured. Interview: 1 October 1996, Arlington, Va. (31 pages).

Augusta *Schurrer* (Ph.D., Wisconsin, 1952; born 1925). Adviser: Morris Marden. Field: Complex analysis. Never married, no children. Tenured. Interview: 20 July 1996, Cedar Falls, Iowa (34 pages).

Domina Eberle *Spencer* (Ph.D., MIT, 1942; born 1920). Adviser: Dirk J. Struik. Field: Tensor analysis. Widowed, one child. Tenured. Interview: 26 August 1996, Boston, Mass. (42 pages).

Maria *Weber Steinberg* (Ph.D., Cornell, 1949; born 1919). Adviser: William Feller. Field: Partial differential equations. Married, no children. Tenured. Interview: 25 May 1996, Pacific Palisades, Calif. (21 pages).

Ruth Rebekka *Struik* (Ph.D., NYU, 1955; born 1928). Adviser: Wilhelm Magnus. Field: Algebra. Divorced, three children. Tenured. Interview: 21 May 1997, Boulder, Colo. (39 pages).

Jean *Walton* (Ph.D., Pennsylvania, 1948; born 1914). Adviser: Hans Rademacher. Field: Analytic number theory. Never married, no children. Employed as college dean. Interview: 24 May 1996, Claremont, Calif. (37 pages).

Tilla Savanuck (*Klotz Milnor*) *Weinstein* (Ph.D., NYU, 1959; born 1934). Adviser: Lipman Bers. Field: Complex analysis and geometry. Divorced twice, remarried, two children. Tenured. Interview: 11 June 1996, Metuchen, N.J. (44 pages).

Margaret *Willerding* (Ph.D., St. Louis, 1947; born 1919). Adviser: Arnold Ross. Field: Number theory. Never married, no children. Tenured. Interview: 26 May 1996, La Mesa, Calif. (13 pages).

Joyce White *Williams* (Ph.D., Illinois, 1954; born 1929). Adviser: Walde-mar Trjitzinsky. Field: Integral equations. Widowed, five children. Tenured. Interview: 27 August 1996, Lowell, Mass. (20 pages).

Marie *Wurster* (Ph.D., Chicago, 1946; born 1918). Adviser: Lawrence Graves. Field: Calculus of variations. Never married, no children. Tenured. Interview: 9 June 1997, Swarthmore, Pa. (20 pages).

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Notes

Introduction

1. One measure of women's participation in scientific disciplines is given by the proportion of women among the Ph.D.'s awarded in each field. For detailed statistics on Ph.D.'s awarded in the United States, by field of specialization and gender, during the years 1920 to 1974, see Harmon 1978. Aggregated U.S. statistics for the years 1920 to 1989 are effectively presented and discussed in Stephan and Kassis 1997. For other measures of women's participation in science in America, see Rossiter 1982, 1995.

Chapter 1: Women Mathematicians and the World War II Transition

1. Sally Gregory Kohlstedt (1978) argues that nineteenth-century women in American science comprise three distinct generations: the "independents," who studied science with private support; the "educators and popularizers," who served as science teachers and authors of textbooks; and finally, the "professionals," who sought to join the scientific community and to achieve social recognition for their work. The participation of nineteenth-century women in mathematics in the West roughly follows this pattern.

2. Although the awarding of doctorates of various kinds dates back to the early medieval University of Bologna, the doctor of philosophy degree seems to have been a much later German creation (Simpson 1983). I have been unable to determine when and where the first Ph.D. in mathematics was awarded, but Carl Friedrich Gauss earned one in Germany as early as 1799. Early Ph.D.'s were frequently awarded by universities for work completed elsewhere; Gauss, for example, was a student at the University of Göttingen but submitted his research and was awarded the Ph.D. *in absentia* at the university at Helmstedt (Hall 1970: 43). Kovalevskaya studied privately in the 1870s with Karl Weierstrass, a professor at the University of Berlin, who submitted her research to the University of Göttingen for the Ph.D. (Koblitz 1993: 123).

3. Etzkowitz et al. (1994) have elaborated the notion of "critical mass for women in science." A minority group is said to have achieved "critical mass" in a population when it reaches a size sufficient to "insure its survival from within and effect a transition to an accepted presence"—a proportion of about 15 percent (51).
4. Uta Merzbach (1989) writes that the statement of historical-critical purpose appeared on the masthead of the *Bulletin* until 1931, when it was quietly dropped (642–643, 653–654).
5. Two of the early presidents of the MAA, Florian Cajori and David Eugene Smith, were not trained as research mathematicians at all but made their reputations as scholars, teachers, and popularizers of the history of mathematics (Merzbach 1989). A third, Herbert Ellsworth Slaught (Ph.D., Chicago, 1898), was among the many MAA members who were instrumental in the founding of the National Council of Teachers of Mathematics (NCTM), an organization devoted to precollege mathematics teaching, in 1920 (Bliss 1938; Cairns 1938).
6. The contributions of women are evident on even casual browsing in the early volumes of the *Monthly*. For a discussion of women in the leadership of the MAA, see Green and LaDuke 1989: 386.
7. The Institute was established with a \$5 million gift from Louis Bamberger and Caroline Bamberger Fuld, who had sold their New York retail business just before the 1929 stock market crash. For more on the Institute and its founding, see Institute for Advanced Study 1980; Bers 1989; Borel 1989.
8. Short biographies of Mina Rees and Grace Murray Hopper are found in Grinstein and Campbell 1987. For more on Rees, see Albers and Alexanderson 1985: 255–267; Green et al. 1998. On Hopper, see Rossiter 1995: 268–269 and the references there.
9. On the other hand, at universities that failed to secure a V-12 or ASTP contract, enrollment crises threatened the shutdown of academic programs and the dismissal of faculty. In her interview for the present study, Domina Spencer describes just such a crisis at American University in 1943. The only aspect of the V-12 program in which the university was able to participate was a small program for the training of future military chaplains, which had only "a minimal impact on enrollment" (Amy Robertson, American University Library Archives, e-mail communication, December 1998).
10. In her interview for the present study, Barbara Beechler recalls that she served as a teaching assistant in physics while still a sophomore at the University of Iowa in 1946.
11. On the G.I. Bill, women's colleges, and women's enrollments, see Olson 1974 and Rossiter 1995: 31. The G.I. Bill generally hastened coeducation at women's colleges; in a comparatively rare turnabout, however, "Colgate [in New York State] . . . authorized the wives of veterans to attend its formerly all-male classes" (Olson 1974: 35).

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12. Despite considerable social pressure to the contrary, women entered the workforce in increasing numbers in the fifties, though not in high-status jobs; see Kaledin 1984: 61–80.

13. In a 1975 survey of 350 women mathematicians, the spouses of nearly half of those who were married were also mathematicians (Luchins and Luchins 1980: 9). In a similar study of mathematicians in Canada, 45.4 percent of women mathematicians were married to mathematicians (Mura 1990: 77).

14. Claudia Henrion (1997) argues persuasively, for example, that there is no clear correlation between youth and mathematical achievement for either men or women (110–113).

15. See, for example, interviews with male mathematicians in Albers and Alexanderson 1985 and Albers, Alexanderson, and Reid 1990; the memoirs of Paul Halmos (1985); reminiscences, anecdotes, and informal histories found in Duren, Askey, and Merzbach 1989; personal reminiscences of Richard Courant and Jerzy Neyman (Reid 1976, 1982); and the vivid depiction of mathematical life at Princeton, NYU, and MIT in the 1950s, in the recent biography of John Nash by Sylvia Nasar (1998). The legendary connection between youth and mathematical achievement has been given official sanction through the institution of the Fields Medals, regarded in the mathematical community as "the equivalent of the Nobel Prize for mathematics." Established in 1932 and awarded at four-year intervals, recipients may be no more than forty years of age (Tropp 1976).

Chapter 2: Women Mathematics Ph.D.'s of the 1940s and 1950s

1. Julia Robinson's life and accomplishments have been recounted in several different publications by her sister, Constance Reid (for example, Reid 1996). Both Cathleen Morawetz and Mary Ellen Rudin have been the subject of numerous interviews and profiles in the popular mathematical press (for example, Albers, Alexanderson, and Reid 1990; Henrion 1997; Morrow and Perl 1998).

2. The first woman elected president of the MAA was Dorothy Bernstein (Ph.D., Brown, 1939), who served in 1979–80. The third woman president of the MAA, Deborah Tepper Haimo (Ph.D., Harvard, 1964), was elected to a two-year term beginning in 1993.

3. After Marjorie Lee Browne earned her doctorate in 1950, the next three African American women to earn Ph.D.'s in mathematics did so in 1960, 1961, and 1962. During the years 1965 to 1981, sixteen more African American women earned the degree (Kenschaft 1981). For more on Granville and Browne, see Kenschaft 1981; Grinstein and Campbell 1987; Morrow and Perl 1998.

4. Karen Uhlenbeck, at Chicago for a brief period in the 1980s, was, after Logsdon, the next tenured woman in the department (Henrion 1997).

5. Marie Wurster (Ph.D., Chicago, 1946), who earned bachelor's and master's degrees in mathematics at Bryn Mawr in 1940 and 1943, respectively, reports that Wheeler—herself a Chicago Ph.D.—strongly influenced her decision to go

to Chicago for the doctorate. Moreover, Wurster decided against attending Radcliffe in part because she would be denied a Harvard degree.

6. For more on Neyman and his support of women as colleagues, collaborators, and students, see Reid 1982. Both Neyman and Scott are profiled in Johnson and Kotz 1997. In addition to Julia Robinson, Tarski's female Ph.D. students at Berkeley include Louise Hoy Chin Lim (1948), Wanda Szmielew (1950), and Anne Davis (1953); see Henkin et al. 1974. Esther Seiden, who shifted her mathematical interests from logic to statistics, describes her experiences at Berkeley and her relationship with Tarski, Neyman, Scott, and others in Samuel-Cahn 1992.

7. The terms *Courant Institute* and *Courant's institute* will be used throughout the book to refer to the graduate center in mathematics founded by Courant in the 1930s. The official name of the graduate center has, however, changed several times over the years. For more on the early history of the Courant Institute, see Morawetz 1989; on Courant's life and work, aspects of his personality, and reminiscences of his friends and colleagues, see Reid 1976.

8. Lipman Bers (1914–1993) was the Ph.D. adviser for a total of sixteen women students over the course of his career at Syracuse, NYU, and Columbia. One of his students, Linda Keen (Ph.D., NYU, 1964), has written an appreciative memorial to him (Keen 1994). See also the interview with Bers in Albers, Alexanderson, and Reid 1990. Wilhelm Magnus (1907–1990) supervised the doctoral dissertations of fourteen women at NYU; he is remembered by nine of his sixty-two doctoral students in Birman and Struik 1991.

9. The 1960s and 1970s saw a proliferation in the literature on sex differences in mathematical abilities (for example, Macoby and Jacklin 1974; Fausto-Sterling 1985; Benbow and Stanley 1992). It is interesting to speculate as to whether, under the influence of this literature, women may have been *directed* into fields—discrete mathematics, for example—deemed better suited to the particular talents of their gender. For a provocative discussion of how social perceptions shape women's performance in mathematics, see Eccles and Jacobs 1992.

10. The sociologists Gaye Tuchman and Nina Fortin (1980) have observed similar patterns of gender inclusion and exclusion in the arts and humanities as well: [W]hen a field or occupation is not socially valued, women and other minorities will populate it heavily. If the field grows in prestige, (white) men may push women (and other minorities) out. Conversely, as a field loses social value . . . men may decamp and leave the field to women. (309)

11. In fact, one of the most blatant cases of discriminatory antinepotism involves Josephine Mitchell (Ph.D., Bryn Mawr, 1942). Regrettably, I was unable to conduct a formal interview with her for this study. As a tenured associate professor at the University of Illinois in the early 1950s, Mitchell married Lowell Schoenfeld (Ph.D., Pennsylvania, 1944), who was at that time an untenured assistant professor in the same department. Citing antinepotism rules, Illinois chose to terminate *her* contract rather than that of her untenured husband (Rossiter 1995: 125).

12. The word *single* here is somewhat misleading, since many of these unmarried women enjoyed long-term partnerships with other women.

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13. Included among the sixteen are Marie Wurster, who joined the faculty of Temple University before it had really achieved research university status; Violet Larney, who joined the faculty of the New York State Teachers College at Albany and remained there through its growth and metamorphosis into the State University of New York at Albany; and Anneli Lax, who was tenured at NYU but whose responsibilities were primarily in undergraduate teaching at Washington Square College.

14. Josephine Mitchell (Ph.D., Bryn Mawr, 1942; see note 11) held professorships at *seven* different colleges and universities before she and her husband were offered tenured professorships at Penn State in 1958. She made these frequent moves in an effort to find an institution where her research would be supported and valued (personal communication, September 1994).

15. Julia Robinson provides the most dramatic example of "sudden tenure." She taught in the Berkeley mathematics department—where her husband, Raphael M. Robinson (Ph.D., California/Berkeley, 1935; 1911–1995), had tenure—on an occasional, as-needed basis for nearly thirty years. When, in 1976, she became the first woman mathematician elected to the National Academy of Sciences, she was made a full professor, essentially overnight (Reid 1996).

16. Among the women mathematics Ph.D.'s of the forties and fifties, Katharine Hazard (Ph.D., Chicago, 1940), Jane Cronin Scanlon (Ph.D., Michigan, 1949), Helen Nickerson (Ph.D., Radcliffe, 1949), Joanne Elliott (Ph.D., Cornell, 1950), and Tilla Weinstein (Ph.D., NYU, 1959) have all held tenured faculty positions at Rutgers University.

17. This is a question she raises explicitly in her interview but more guardedly in Larney 1973.

Chapter 3: Family Background and Early Influences

1. Vivian Eberle Spencer (Ph.D., Pennsylvania, 1936; 1907–1980) wrote a dissertation on Chebyshev polynomials under the direction of Shohat.

2. Ruth Ramler Struik (1894–1993) was perhaps the first woman to earn a Ph.D. in mathematics from Charles University in Prague, where she completed a dissertation in geometry under Georg Pick in 1919. Dirk Jan Struik (born 1894), also a geometer (and later an historian of mathematics) earned his Ph.D. at Leiden in 1922. Her parents met at a mathematical conference in Germany in 1921 and were married two years later (Struik 1994; Rowe 1994).

Joan Rosenblatt's parents, Robert Bruce Raup (1888–1976) and Clara Eliot (1896–1976), met when both were graduate students at Columbia University and married in 1924. They earned Ph.D.'s from Columbia—he in psychology, she in economics—in 1926, the same year in which Joan, their first child, was born.

3. While her sister Vivian had no formal schooling until she entered Oberlin, Domina Spencer did attend a Quaker high school in Philadelphia for four years prior to college.

4. Samuel Karlin (Ph.D., Princeton, 1947) has won numerous awards and honors for his work in mathematical analysis, probability and statistics, operations research, and mathematical biology. He was awarded the National Medal of Science in 1989.

Chapter 4: High School and College

1. The mathematician Karl Menger (1994) has described Vienna in the twenties as “an intellectually lively city” where, in addition to a vibrant artistic and cultural life, one could find

[an] unusually large proportion of professional and business people interested in intellectual achievement. Many members of the legal, financial, and business world; publishers and journalists; physicians and engineers took intense interest in the work of scholars of various kinds. They created an intellectual atmosphere which, I have always felt, few cities enjoyed. (9)

2. Karl Menger (Ph.D., Vienna, 1924; 1902–1985) was a member of the celebrated Vienna Circle of mathematicians and philosophers. He took a professorship at the University of Notre Dame in 1937 and moved to the Illinois Institute of Technology in Chicago in 1948, where he remained until his retirement (Menger 1994; Kass 1996).

3. Seven of the women interviewed—Calloway, Schurrer, Lax, Rubin, Gassner, Luchins, and Weinstein—attended New York City public schools for all or part of their precollege education. In contrast to Violet Larney’s experiences in Chicago, female students—particularly those with talent or interest in the sciences—seem to have been taken much more seriously in the New York schools.

4. The term *Hutchins College* refers to University of Chicago president Robert Maynard Hutchins, who believed that “the best time in a student’s life to acquire a ‘general, higher education’ is during the four years between ages sixteen and twenty” (Ward 1992: 82).

5. Born in the Netherlands, Arnold Dresden (Ph.D., Chicago, 1909; 1882–1954) came to the United States in 1903 and taught at Swarthmore from 1927 until his death. A naturalized citizen of the United States, Dresden was a strong supporter of émigré mathematicians during the thirties and forties (Dresden 1942) and a good friend to women in mathematics throughout his career.

6. Larew and Wiggin did their doctoral work in calculus of variations with Gilbert Ames Bliss. When Anderson went to Chicago for the Ph.D., she did her graduate work in the same field with Magnus Hestenes, a student of Bliss. I am grateful to Jeanne LaDuke and Judy Green for information about the pre-1940s Ph.D.’s mentioned in this section.

7. Carlson was the first woman to earn a Ph.D. in mathematics at the University of Minnesota. She worked under the direction of Dunham Jackson, who was later Martin’s adviser.

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8. Born and educated in Ireland, the mathematician John Lighton Synge (1897-1995) was a prolific researcher in geometry and mathematical physics and held a succession of prestigious university positions in the United States, Canada, and Ireland (Florides 1996). Cecilia Krieger was the first woman to earn a Ph.D. in mathematics at a Canadian university (Anand and Anand 1990).

9. Margaret Young Woodbridge (Ph.D., NYU, 1946) was a doctoral student of Courant; she had previously earned a J.D. from NYU in 1931. Borofsky, Prenowitz, Richardson, and Boyer all earned Ph.D.'s at Columbia in the 1930s and joined the staff of the newly established Brooklyn College soon afterward. Singer earned his Ph.D. at Princeton in 1931.

10. Hubert Evelyn Bray (Ph.D., Rice, 1918) was a Rice Ph.D. and headed the department there for many years. Szelem Mandelbrojt (1899-1983), born into a Jewish family in Poland, moved to France as a child. He earned a Sc.D. in mathematics at the University of Paris in 1923 and was among the founding members of the French mathematics collective, Bourbaki. Mandelbrojt had a lengthy association with Rice and was a full-time member of the department there during World War II. His nephew, Benoit Mandelbrot, is also a mathematician who has gained fame for his work with fractals (Dresden 1942: 428; Corry 1996: 295-304).

11. For more on William LeRoy Hart (Ph.D., Chicago, 1916; 1892-1984), see Price 1986. On Dunham Jackson (Ph.D., Göttingen, 1911; 1888-1946), see Hart 1948. Warren Simms Loud (Ph.D., MIT, 1947; born 1921) earned all of his university degrees at MIT and spent his entire career on the faculty at Minnesota. Neal McCoy's support of women in mathematics is due, in no small part, to the fact that his older sister is also a professional mathematician. Both Neal (born 1905) and Dorothy McCoy (born 1903) earned Ph.D.'s in mathematics under E.W. Chittenden at the University of Iowa in 1929 (see note 14).

12. There have been numerous studies of the life and work of R.L. Moore (Ph.D., Chicago, 1905; 1882-1974). See, in particular, Traylor, Bane, and Jones 1972; Wilder 1976.

13. Students who were not particularly confident to begin with normally did *not* do well with Moore. Although Moore was a teacher whose style suited *her* temperament perfectly, Rudin is quick to add:

I wouldn't for anything have let my children go to school with Moore! That is, I think that he was destructive to anyone who didn't fit exactly into his pattern; he did not succeed in giving the people that worked with him an education. It's a mistake to go to school under those circumstances in general. (Rudin: 22)

As a rule, Moore's students (such as Wilder at Michigan and Rudin herself) were far more compassionate practitioners of the Moore method than Moore himself.

14. E.W. Chittenden (Ph.D., Chicago, 1912; 1886-1977) did research on the boundary between analysis and general topology. In 1918 he joined the faculty at Iowa, where he remained for thirty-six years. Vital and vigorous well into old

age, he worked in a federal laboratory for nine years after his retirement from Iowa and died at the age of ninety-one (Aull 1981).

Gustav Bergmann (Ph.D., Vienna, 1928; 1906–1987), like Karl Menger, had a doctorate in mathematics from Vienna and was a member of the Vienna Circle (see note 2). In 1935 he earned a law degree and practiced law until 1938. In 1939 he left Austria and joined the faculty in philosophy at the University of Iowa, where he remained until his death (Dresden 1942: 423; Brown, Collinson, and Wilkinson 1996: 65).

15. Before earning his Ph.D. in mathematics, Jean van Heijenoort (Ph.D., NYU, 1949; 1912–1986) was active in radical politics and served for a time as Leon Trotsky's bodyguard (Feferman 1993).

The William Lowell Putnam Mathematics Competition, endowed by a wealthy and well-connected Harvard family, is a competitive exam administered annually (with a brief hiatus during World War II) since 1938 by the MAA. The contest is open to individuals and to three-member teams from undergraduate colleges and universities in Canada and the United States. The problems on the examination are fantastically difficult. Monetary prizes are awarded to the top-ranking individuals and teams, and many of the top finishers also win graduate fellowships to Harvard (Birkhoff 1965; Bush 1965; Nasar 1998: 43–44).

16. Every year the *American Mathematical Monthly* reports the results of the Putnam exam. According to the *Monthly*, NYU did not field a Putnam team in 1954 or 1956, but the 1955 Putnam team—consisting of Donald Fredkin, Charles Kahane, and Tilla Weinstein (then Tilla Klotz)—placed among the top eight teams and received honorable mention. No one on the NYU team placed among the top fifteen individuals, so it seems likely that Weinstein and her teammates all performed with roughly equal distinction.

17. For more on Lipman Bers, see chapter 2, especially note 8.

18. The Works Progress Administration (WPA) was a federal jobs program begun in 1935 as part of the New Deal. During its eight years of operation, the WPA created millions of new jobs in construction, education, and the arts (Badger 1989). Max Wertheimer (1880–1943) was born in Czechoslovakia, educated there and in Germany, and came to the New School in New York in 1933. He is best known as the founder of Gestalt psychology but is highly regarded in philosophical circles. His interest in science and mathematics formed the basis of his long association with Albert Einstein (Brown, Collinson, and Wilkinson 1996: 832–833; Kohler 1944).

Chapter 5: Graduate School and the Pursuit of the Ph.D.

1. For a discussion of comparative marriage rates during the Depression, World War II, and the early postwar years, see Hartmann 1982: 164–165; for a thoroughgoing analysis of the interplay of marriage, work, and family in the 1930s, see Scharf 1980.

nine years after his retirement from (1981).

1906–1987), like Karl Menger, had been a member of the Vienna Circle and practiced law until 1938. In 1938 he moved to the University of Wisconsin in 1942: 423; Brown, Collinson,

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Competition, endowed by a wealthy competitive exam administered annually since 1938 by the MAA. The member teams from undergraduate colleges in the United States. The problems on

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Monthly reports the results of the NYU did not field a Putnam team in 1981—consisting of Donald Fredkin, Gilla Klotz)—placed among the top 10. No one on the NYU team placed 1st. It is likely that Weinstein and her team-injection.

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rates during the Depression, World War II (Hartmann 1982: 164–165; for a thorough, work, and family in the 1930s,

2. Beginning in the spring of 1944 and continuing into the early postwar years, “graduate work in mathematics was carried on only by women students, men classified as IV-F, and men in war industry who carried on graduate work in the evening” (Kline 1946: 123).

3. Oxtoby and Maharam Stone subsequently became very good friends and colleagues; Oxtoby (1989) wrote a tribute to Maharam Stone and her husband on the occasion of their retirement from the University of Rochester.

4. Katharine Hazard died in the early 1990s, just before the interviewing phase of this project was begun. She had bachelor’s and master’s degrees from Purdue University, where her father, C.T. Hazard, was on the mathematics faculty (but did not have a doctorate). I was unable to schedule a formal interview with Janet McDonald, although we spoke informally by telephone in December 1994, and she supplied me with written information about her mathematical life and work. She earned a master’s degree from Tulane University in 1929 and came to Chicago after many years of small college teaching and administration in her home state of Mississippi. I also spoke informally by telephone with Florence Jacobson during the spring of 1995, not long before her death. A native of Chicago, she began graduate study at the University immediately on the completion of her bachelor’s degree there. While she never completed her Ph.D., she went on to a distinguished teaching career at Albertus Magnus College in New Haven, Connecticut.

5. All four of the Chicago advisers had themselves earned Ph.D.’s at Chicago: Graves (Ph.D., 1924; 1896–1973?) and Hestenes (Ph.D., 1932; 1906–1991) were students of G.A. Bliss; Lane (Ph.D., 1918; 1886–1969) was a student of C.J. Wilczynski; Albert (Ph.D., 1928; 1905–1972) wrote a dissertation with L.E. Dickson. See MacLane 1989.

When Florence Dorfman was already fairly far along in her dissertation research, she met her future husband, Nathan Jacobson, when he came to a conference at Chicago. They married in 1942, and she moved with him to the University of North Carolina without completing the Ph.D. Some years later, she did publish the main results of her thesis in a paper written jointly with her husband (Jacobson and Jacobson 1949).

6. Anderson was the only Southern woman among the doctoral students at Chicago in the early forties who did *not* work with Lane.

7. Lane’s brand of geometry was regarded with disrespect, perhaps even with derision, by some of his contemporaries. “Lane and his students carried on the study of projective differential geometry using rather crude analytical methods,” recalls W.L. Duren (Ph.D., Chicago, 1929). “We who were not Lane’s students tended to look on it with disdain.” At the same time, Duren adds, “Lane was honest about the shortcomings of the methods, though he did not know how to overcome them” (Duren and Huston 1989: 179).

8. For an especially vivid description of teatime at Princeton in the early 1950s, see Nasar 1998: 63–65. Saunders MacLane lists teatime as among the indispensable ingredients of a “great department of mathematics” (MacLane 1989: 149).

9. Reinhold Baer (Ph.D., Göttingen, 1925; 1902–1979) emigrated from Germany in 1933 and obtained a permanent position at Illinois in 1938. He returned to Germany in 1956 and in the mid-1960s moved to Zurich, where he remained until his death (Gruenberg 1981). Christine Williams Ayoub (Ph.D., Yale, 1947) and Aileen Hostinsky (Ph.D., Illinois, 1949) were among his other female doctoral students.

10. For more about Warren Ambrose (1914–1995), see Halmos 1985; Singer and Wu 1996.

11. Hans Rademacher (Ph.D., Göttingen, 1916; 1892–1969) emigrated to the United States from Germany in 1934, joining the faculty of the University of Pennsylvania the following year. His twenty-one doctoral students include four women, one in Germany and the other three—Ruth Goodman (Ph.D., 1944), Walton, and Leila Dragonette Bram (Ph.D., 1951)—at Penn. Walton experienced Rademacher as imperious and demanding, but reminiscences of Rademacher by his male colleagues (for example, Berndt 1994) praise his talents as a mathematician, teacher, and humanitarian. One such reminiscence, however, provides an illuminating insight: Rademacher insisted that his wife learn to drive so that he would not have to be bothered with doing so himself (Niven 1989: 217).

12. In fact, Wisconsin awarded no Ph.D.'s to women in mathematics during the 1940s. Caroline Lester earned her Ph.D. at Wisconsin under MacDuffee in 1937; it would be thirteen years before Violet Larney completed her Ph.D. with the same adviser in 1950. In addition to Larney and Schurrer, only one other woman, Anna Chandapillai (1954), would earn a Wisconsin mathematics Ph.D. in the 1950s.

13. Jeanne LaDuke and Judy Green have verified that Dorothy McCoy was the only woman to earn a Ph.D. in mathematics at Iowa prior to 1940. The Ph.D. students of Chittenden are listed in Aull 1981.

14. Rebekka Struik's father, Dirk Struik, also fell afoul of the authorities during the McCarthy era (Schrecker 1986; Rowe 1994).

15. Hans Freistadt had political problems of his own. At the University of North Carolina in the 1940s, he did graduate work in physics with fellowship support from the Atomic Energy Commission. At the same time, he was active in the Communist Party. When his political activities came to light, he lost the fellowship in a politically charged, high-profile case (Schrecker 1986: 289–290).

16. In fact, Barrett was filling the vacancy created by the departure of Josephine Mitchell, who had accepted a job at what is now Oklahoma State University. See chapter 2, notes 11 and 14.

17. A total of fifty students completed Ph.D.'s with R.L. Moore from 1916 through 1969; six of them were women. The first of these, Anna Mullikin, received her Ph.D. from Pennsylvania in 1922, although she moved with him to Texas in 1919 and actually completed her studies there (Traylor, Bane, and Jones 1972: 89–90, 196). The other five, all of whom earned Ph.D.'s at Texas, are Harlan Miller (1941), Mary Ellen Rudin (1949), Mary-Elizabeth Hamstrom (1952), Blanche Baker (1965), and Nell Stevenson (1969).

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18. J.R. Kline (Ph.D., Pennsylvania, 1916; 1891–1955) was R.L. Moore's first doctoral student. The transfer of Lida Barrett from Moore to Kline was just one example of an established procedure between Moore and his earliest Ph.D. students:

There [developed], across the years, an association between Moore at Texas, Kline at Pennsylvania, Whyburn at Virginia, as well as others which would allow students to move from one place to another, either during their graduate study or following the formal completion of it. . . . Moore or one of his early doctoral students would describe to another the student's capability by naming a certain difficult theorem he had proved. (Traylor, Bane, and Jones 1972: 103)

19. The McCarran-Walter Act (the Immigration and Nationality Act of 1952) was passed in June 1952 over President Truman's veto. It was one of several pieces of legislation from the late 1940s and early 1950s that imposed severe immigration restrictions in an effort to contain the Communist threat from abroad (Loescher and Scanlan 1986).

20. Courant's failure to give proper credit to coauthors—whether male or female—is legendary. The dispute between Courant and Herbert Robbins over the authorship of *What Is Mathematics?* has been debated for years in the mathematical press (see Reid 1976).

Chapter 6: Interweaving a Career and a Life

1. On research opportunities for women in mathematics in the twenties and thirties, see Green and LaDuke 1989: 386–387. Women were regularly on the roster of visiting members in mathematics at the Institute from its inception (Institute for Advanced Study 1980). Margaret Rossiter (1982: 22–24) argues that the women's colleges were themselves complicit in bringing women's research careers in science to an early end.

2. Indeed, with the exception of Marie Wurstler, *all* of the women who earned Ph.D.'s in mathematics at Chicago in the 1940s landed their first academic jobs through the old-boy/old-girl network.

3. Dorothy Manning came from an unusual mathematical family with strong ties to Stanford University. Her father, W.A. Manning (Ph.D., Stanford, 1904), earned the first Ph.D. in mathematics ever awarded at Stanford and remained on the faculty there for several decades (Royden 1989: 241–242). Indeed, W.A. Manning may well have been Dorothy Manning's adviser. Her younger sister, Rhoda Manning Wood (Ph.D., Stanford, 1941) completed her Ph.D. at roughly the same time as Clement and thus would have been a natural candidate to succeed her sister at Wells, but she went instead to a position at Oregon State College in the fall of 1941.

Dorothy Manning had an NRC postdoc at Chicago in 1937–38, and spent 1938–39 at the Institute in Princeton before joining the faculty at Wells, but held no further professional positions after her marriage in 1941. She did, however, coauthor two papers with her husband in the early 1960s. Malcolm Smiley

(1912–1982) was Bob Blair's dissertation adviser at Iowa (chapter 5). Smiley's personal experience—having a mathematician wife who gave up her professional career when she married—no doubt affected his interactions with Blair and Barbara Beechler at Iowa.

As in previous chapters, I am indebted to Jeanne LaDuke and Judy Green for detailed information regarding the pre-1940 Ph.D.'s.

4. The mathematics faculty at Vassar normally consisted of at least one faculty member in analysis, one in geometry, and one in algebra. When Asprey joined the Vassar mathematics department in 1945, the other tenure-line faculty—all of them Chicago Ph.D.'s—were Abba Newton (Ph.D., 1933) and Janet McDonald (Ph.D., 1943), both students of E.P. Lane, in geometry; Frances Baker (Ph.D., 1934), a student of Dickson, in algebra; and Wells (Ph.D., 1915), a student of E.H. Moore, in general analysis. Although Asprey was the lone non-Chicago Ph.D., she did have a Chicago connection: her adviser, E.W. Chittenden, had earned his Ph.D. at Chicago under E.H. Moore just three years before Wells (Aull 1981).

5. At the University of Miami, the postwar enrollment surge was particularly dramatic. In the fall of 1945, enrollment at Miami stood at two thousand students. In the fall of 1947, Mary Dean Clement was among *seventy-three* new University of Miami faculty hired to teach a student population of just over eight thousand (Tebeau 1976).

6. The Bateman Manuscript Project, funded by the Office of Naval Research, was a compilation of integral transforms and special functions that built on the work of Harry Bateman (Ph.D., Johns Hopkins, 1913; 1882–1946), a British-born mathematician who spent much of his career at Caltech (Askey 1989). The five volumes associated to the project were published during the years 1953 to 1955. Arthur Erdelyi was the project's director; Wilhelm Magnus, Fritz Oberhettinger, and Francesco Tricomi served as research associates; David Bertin, W.B. Fuls, A.R. Harvey, D.L. Thomsen, Jr., Maria A. Weber, and E.L. Whitney were listed at the front of each volume as research assistants.

7. Paul Franklin Douglass (1904–1988) was a man of diverse accomplishments. As a young man he worked for a time as a newspaper reporter, earned a Ph.D. in political science from the University of Cincinnati (in 1931), worked as an attorney, and won election to the Vermont state legislature while serving as a Methodist pastor. His first real academic appointment was as president of American University, a position he held from 1941 to 1951 (*Who Was Who in America*, volume 9, *s.v.* "Douglass, Paul"). For more on the wartime enrollment crisis at American University, see chapter 1, note 9.

8. Leonard Carmichael, president of Tufts College from 1939 to 1952, sought to transform Tufts into a research institution (Freeland 1992: 179–185). As Spencer relates it, Carmichael wanted to replace the physics department chair with someone more sympathetic to his goals. Spencer found herself on the wrong side of Carmichael when she sided with the chair, who had hired her. Apparently Carmichael believed that having too many women on the faculty in a given department would be "detrimental to its reputation" (Rossiter 1995: 36).

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9. Harshbarger 1976 and Eisenhart 1989 provide an overview of the statistical offerings at American colleges and universities before the end of World War II. Because of the interdisciplinary nature of applied statistics, it is not uncommon even today—when most major universities have degree-granting departments of statistics—for statistical research and graduate training to be dispersed among many different departments, such as biostatistics, public health, medicine, or agriculture.

10. Churchill Eisenhart (Ph.D., University College London, 1937; 1913–1994), a Ph.D. student of Jerzy Neyman, worked at NBS from 1947 until 1983, where he served as founding director of the Statistical Engineering Laboratory. His father, Luther Pfahler Eisenhart (Ph.D., Johns Hopkins, 1900; 1876–1965) was also a mathematician—a differential geometer with a secondary interest in statistics (Eisenhart 1989; Cameron and Rosenblatt 1995; Stigler 1995).

11. Lee Lorch (Ph.D., Cincinnati, 1941; born 1915) chaired the mathematics department at Fisk from 1950 to 1955 and was regarded warmly by both faculty and students there (Mayes 1976). During the McCarthy era, Lorch lost a succession of academic positions because of his civil rights activities (Schrecker 1986).

12. For more on the civil rights movement during the Roosevelt administration and increased employment opportunities for blacks in World War II and after, see Perrett 1973, especially chapters 11 and 27.

13. From 1949 to 1950, Cronin Scanlon was briefly married to her dissertation director, Erich Röthe. She states simply, “The marriage did not work at all” (Cronin Scanlon: 18).

14. Paul Erdős (1913–1996), perhaps the most prolific mathematician of the twentieth century, earned a Ph.D. from Cardinal Pazmany University in Budapest, Hungary, in 1934. He was especially well known for posing interesting, difficult, and challenging problems to other mathematicians (Hoffman 1998).

15. For more on the events leading to the passage of Title IX, see Rossi and Calderwood 1973; Sandler 1973; Rossiter 1995. Rossiter writes that “despite the antinepotism rules that had forced some off the faculty in the late 1940s,” the University of Wisconsin Medical School employed a husband-and-wife team of cancer researchers, Elizabeth Miller and James Miller, in tenured positions as early as 1959 (1995: 140). In her interview, Mary Ellen Rudin refers to antinepotism at Wisconsin as a generally accepted “practice” rather than a “rule” and says that her promotion came about when the University realized that these practices were being applied inconsistently across departments (Rudin: 18–19).

16. Indeed, during the years 1950 to 1956, Cronin Scanlon published a total of eight papers.

17. Brooklyn Polytechnic has been mentioned several times in this chapter. It was the school that interviewed but did not hire Evelyn Granville after her NYU postdoc and that hired Herbert Morawetz as a professor of chemistry.

18. Kenneth Wolfson (Ph.D., Illinois, 1952; born 1924) spent his entire mathematical career on the faculty of Rutgers University, chairing the mathematics de-

partment there from 1961 to 1975 and serving as dean of the graduate school from 1975 to 1985. In his history of the Rutgers mathematics department, Charles Weibel writes that by 1965, "Rutgers had practically cornered the market on women mathematicians. . . . Seven of the thirty-two senior faculty (22%) were women. The national average was under 1% women then, and is still only 8% today" (Weibel 1995: 12).

19. Indeed, Walter Rudin and Mary Ellen Rudin have written just one joint paper (Rudin and Rudin 1995).

20. Among the mathematicians hired during Tilla Weinstein's tenure as chair at Douglass were Amy Cohen (Ph.D., California/Berkeley, 1970), Jean Taylor (Ph.D., Princeton, 1973), and James Lepowsky (Ph.D., MIT, 1971).

21. Weinstein served a second term as mathematics chair at Douglass from 1978 until the merger of the Douglass and Rutgers departments in 1981.

22. The Mansfield Amendment was enacted in 1969 and remained in effect for just one year. Despite its limited scope, however, the law has been broadly interpreted as sharply curtailing the authority of the Defense Department, and many other federal agencies as well, "to fund basic scientific work that cannot be clearly related to their missions" (David 1985: 45).

23. Eugene Guth (Ph.D., Vienna, 1928; 1905–1990) was a physicist on the faculty of the University of Vienna until 1937, when he became the first Research Professor of Physics at Notre Dame University (Schweinler et al. 1991). Arnold Ross (Ph.D., Chicago, 1931; born 1906), a doctoral student of L.E. Dickson, devoted the early years of his career to research in number theory. It is perhaps ironic, in light of Willerding's observations, that Ross is best known not for his research but for his work with high school teachers and mathematically talented high school students (Lax and Woods 1986; Shapiro 1996).

24. For more on the attitude toward women at Tufts, see note 8.

Chapter 7: Research, Teaching, and the Question of Identity

1. Granville retired from Cal State L.A. in 1984, Texas College in 1987, and the University of Texas at Tyler in 1997.

2. Larney hints at these views in a provocative *Monthly* article (1973), which appeared just as the women's movement was beginning to have an impact on the mathematical community. For a careful analysis of gender differences in research productivity that substantially refutes Larney's claims, see Valian 1998 (especially chapter 12 and the references given there).

3. Harriet Lord, personal communication, October 1996.

4. Wurster asserts repeatedly during her interview that it was her failure to do research, rather than gender discrimination, that caused the difference in pay. But a reward system that values research more highly than textbook publishing and externally funded teaching and service activities is likely to be inherently biased against the sort of activities at which many women excel.

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5. Bates's work with Neyman is briefly described in Reid 1982: 227.

6. Edward Kasner (Ph.D., Columbia, 1899; 1878–1955), who spent his profes-
sional career at Columbia, was a prolific researcher in differential geometry and
mathematical physics. A man of diverse intellectual interests, he gave popular
lectures on mathematics in a wide variety of venues, ranging from elementary
school classrooms to the New School for Social Research (Douglas 1958).

7. Vera Kistiakowsky (Ph.D., California, 1952: chemistry) and Elizabeth Urey
Baranger (Ph.D., Cornell, 1954: physics)—each a daughter of a prominent nu-
clear scientist—were research associates in physics at MIT in the late 1960s; Vera
Pless had become acquainted with them through her husband. In 1972, Kistia-
kowsky received a sudden promotion to a tenured professorship in physics at
MIT, where she remains to this day. Baranger, a Swarthmore College classmate
of Rebekka Struik, is currently professor of physics and associate provost at the
University of Pittsburgh.

8. Blum 1991 gives a brief history of the first twenty years of AWM.

9. The Committee's first report to the AMS Council is Morawetz 1973.

10. In her interview, Barrett reveals that Anna Pell Wheeler—who remained ac-
tive in the Philadelphia-area mathematics community on her retirement from Bryn
Mawr—played a key role in bringing Barrett to the attention of Wellesley and
Bryn Mawr Colleges. See also Grinstein and Campbell 1982.

11. Violet Larney, of course, had held the position of acting chair at SUNY Al-
bany during the academic year 1966–67.

12. See chapter 2, note 2.

Chapter 8: Dimensions of Personal and Professional Success

1. The quote is from Stewart and Vandewater 1993: 253. In the psychologist
Erik Erikson's model of adult development, generativity is one of the key tasks
at midlife, once concerns with identity and intimacy have been worked out. For
a discussion of generativity in older adulthood, see Erikson, Erikson, and Kivnick
1986.

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ers, 1991 (Photograph courtesy

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