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High School and College

Adolescence: Crisis and Opportunity

A child's basic personality emerges early, in the context of the family in which he or she grows up. But during adolescence both boys and girls begin to form their identity as persons, trying on various roles in a social context in an effort to define themselves in a way that will guide them toward adulthood while at the same time distinguishing them from others. At its best, adolescence is an exciting time of experimentation, growth, and development.

For adolescent boys, the pursuit of individual goals and dreams is normally not incompatible with what the culture expects of them. But for teenage girls, adolescence is a time of crisis, as the inner drive to follow their own interests and inclinations comes into direct conflict with the cultural expectations of marriage and motherhood, which call on them to attend primarily to the needs of others. Perhaps the key developmental task of adolescence, for both girls and boys, is to create an authentic identity within the context of mutually rewarding relationships with others.

The women who became mathematicians in the 1940s and 1950s began to focus their academic interests on mathematics during high school and college. What factors enabled them to develop an interest in mathematics—a field traditionally dominated by men—during these pivotal years of adolescence and young adulthood? First and foremost, they had to have a natural, intrinsic *curiosity* about mathematics. Next, they needed to have the *opportunity* to explore mathematics in some depth

and breadth—by taking advanced courses in mathematics or science, for example, or by having the financial means to attend college. Moreover, they needed the support and encouragement of key mentors and role models, both male and female.

In addition to all of these positive factors, quite a few of these young women seemed to thrive on a moderate amount of adversity: direct challenges to their mathematical interests and aspirations, if not overwhelming or preemptive, emboldened them to persevere. Many girls and young women respond to the message that they cannot or should not do mathematics with defiance, as if responding to a dare. For many of the interviewees, such provocation was an important factor motivating them to continue their study of mathematics. Indeed, the sense of specialness associated with being a woman in mathematics was something that a few of them actively enjoyed and that inspired them to go on in the field. At the same time, some of these young women were treated unfairly in high school and college, their mathematical talent ignored or downplayed because of their sex. Although all of them were able to persevere in mathematics despite these disadvantages, how their lives might have unfolded differently in the absence of such bias remains an open question.

In the pages that follow, I examine the complex interplay of internal motivation, social conditioning, encouragement, provocation, discrimination, and opportunity in the high school and college years of the thirty-six interviewees. Their experiences illustrate how young women of their generation navigated the rocky terrain of adolescence and young adulthood to take their first decisive steps toward a career in mathematics.

High School as an End to Isolation

The American high school experience in the twenties, thirties, and forties was quite different from what it has become in the latter decades of the twentieth century. Then as now, high school was a center of sports and social life for young people, but the academic significance of high school was much more widely understood and respected. High school was typically viewed within the family as a serious academic undertaking, a

mark of distinction, a privilege, and an important rite of passage into adulthood.

What were the purposes served by high school for the interviewees as young women? For many of them, high school spelled an end to isolation, as they finally met other people—teachers and peers, male and (especially) female—who shared their intellectual interests and outlook. As we have seen, many of the interviewees grew up in intellectually stimulating home environments, where books and ideas were valued and discussed. But for nearly all of them, high school provided the first place where their ideas could be shared, tested, and developed in a social context.

Prior to high school, Mary Dean Clement, Domina Spencer, and Margaret Marchand had undertaken a good deal of their formal education at home. Clement, for example, interacted only infrequently with children her own age during her elementary school years and recalls the tremendous discomfort she felt when she asked a young playmate about her reading preferences: “She looked at me cross-eyed” (Clement: 4). When Clement reached high school age, her parents sent her to Ward-Belmont, a private girls’ school in Nashville, which all of her older sisters and one of her nieces had attended before her. The experience of single-sex education proved invaluable to her at this stage in her life. At Ward-Belmont, the education of young women was taken seriously, and there, for the first time, she had girlfriends who shared her love of learning and were her intellectual peers. In fact, all of her closest friends from those days went on to professional careers.

From her earliest childhood, Clement had felt a natural affinity for geometry. A talented geometry teacher at Ward-Belmont helped her to develop her geometric intuitions by wedding them to logic and proof:

The geometry teacher was superlative. I think, probably, in my whole mathematical career, she was *the* best math teacher. She really taught you what geometry was about, what a proof was about, how to follow a logical argument, and how to gain an understanding of what a proof is. And now, if I’m confronted with a simple problem, my instinct is to try to solve it by plane geometry rather than by algebra or calculus or whatever. (Clement: 5)

In general, the high school years were a time of social growth and intellectual maturation for her.

Domina Spencer's transition from home schooling to more formal education was entirely accidental. In the fall of 1933, Domina, her sister Vivian, and her mother headed off to Philadelphia, where Vivian was to begin work toward the Ph.D. at Penn. Domina and her mother had planned to stay in the city for just a week or two, helping Vivian to settle in her new apartment before returning to their home in Oberlin.

While wandering around downtown Philadelphia one afternoon, Domina and her mother happened upon the grounds of the Friends' Select School. The Spencers had recently developed an interest in the Society of Friends and were naturally curious about what a Quaker school might be like. During their impromptu visit, they ran into the headmaster:

And he got to talking to Mother, and he discovered I'd never been to school except . . . one summer session. And he begged her to let me go to Friends' Select School while we were visiting. He said, "Come for six weeks." Well, I went four years! It was entirely unplanned. (Spencer: 8)

At Friends' Select, Domina Spencer gained a broad and deep exposure to art, history, science, and languages. Moreover, she says, "I learned to feel it was very important to be active in politics" (Spencer: 10). She engaged her peers in political debates; she acted in plays; and in general, she gained crucial experience in the give and take of intellectual life in a social setting. Her education at Friends' Select did *not*, however, include mathematics; she continued the private study of mathematics at home with her sister. Mathematics thus retained its special status, as an art to be studied with a private tutor, much as one might undertake the independent study of music or painting.

For Clement and Spencer, home schooling prior to high school was essentially a choice made by their families. The early educational isolation of Margaret Marchand, by contrast, was a product of circumstances. The remote, rural Manitoba community in which she grew up had "a one-room schoolhouse with one teacher and eight grades"; she took grades nine and ten "by correspondence from the department of education in Winnipeg" (Marchand: 3). She attended the one-room school every day, completing her first two years of high school work—including courses in mathematics, physics, and Latin—by independent study. "The lessons went to the teacher and the tests went to the teacher," she recalls. "All she did was give me the test and monitor it and then send it back" to

Winnipeg for grading (Marchand: 3). Although she found herself in the company of other children every day, her work was done in complete isolation, without assistance, direction, or feedback from either the teacher or her fellow students.

Her final two years of high school were completed at a boarding school sixty miles away from home. The move to "the little town of Teulon" liberated her from her solitude; there, for the first time, she found companionship and camaraderie among her peers. Understandably anxious about whether she would be able to perform as well at this new school after years of independent study, her fears were quickly laid to rest: "I ended up being suddenly right up with the rest of them. . . . I was able to do quite well compared to everybody else" (Marchand: 3). This realization did wonders for her confidence: she had, in fact, been able to educate *herself*.

In particular, the principal of the Teulon school, Mr. Robson, who was also the mathematics teacher, recognized that she had a "special aptitude" for mathematics and was the first person to suggest to her that she should go on to the university. "I was a shy little girl from the farm," she says, but her high school teachers recognized her talent and encouraged her to expand her horizons still further (Marchand: 1).

Margaret Marchand's high school experience led her, literally and figuratively, out of her isolation and into contact with a wider world of people and ideas. Two other women also attended boarding high schools, although not out of necessity. Grace Bates attended the Methodist-run, coeducational Cazenovia Seminary in New York State; and while she chafed under the rules and regulations that required boys and girls to be chaperoned at all times, she relished the freedom of being away from home. Patricia Eberlein's parents, concerned about the quality of the public schools of South Bend, Indiana, sent her away for high school to Shipley, a girls' college preparatory school in Bryn Mawr, Pennsylvania.

While none of the other women made the same sort of physical journey that these three did, many of them clearly viewed high school as an important new stage, a step forward into a world of expanded social and intellectual horizons. It is not an exaggeration to say that a significant number of these women saw high school as a place of intellectual adventure.

High School as a Place of Intellectual Adventure

Edith Luchins, the scholar of her Brooklyn, New York, family, resolved to make the transition to high school an adventure in travel as well, within her family's limited means:

I wanted to go out of town to high school, and that's what I did! Instead of going to one of the Brooklyn schools, I went across the river. I took the trolley every morning, with my girlfriends; a bunch of us had decided to go out of town. We went to Seward Park High School on the Lower East Side. We wanted to go out of town! Here was this inexpensive out of town experience. You could go to any high school you wanted to, but no one ever thought of going anywhere but those that were handy and nearby. And that was a very positive experience for me. (Luchins: 7-8)

At Seward Park High School, Luchins excelled in mathematics; there, for the first time, she began to savor her uniqueness as a woman in a "man's field." She tutored her classmates in mathematics, helping at least one struggling student to prepare for the Regents' Exam. At the same time, she explored her other interests and talents; she was elected president of the Seward Park High School's General Organization—"a little bit of the politician in me" (Luchins: 8).

Similarly, Augusta Schurrer was transported from her relatively poor, German-speaking neighborhood in New York City into the company of other bright students and talented teachers at Hunter College High School. A succession of nurturing elementary school teachers, who truly cared for the welfare of their students, encouraged and directed her toward Hunter, where admission was by competitive exam and tuition was free.

At Hunter, Schurrer was introduced to a range of subjects she had not previously imagined. "I loved languages," she recalls. "I loved anything that came from books," including English, history, and physics, although she confesses, "I was a klutz in the lab!" (Schurrer: 4). It was at Hunter that she first set her sights on college. Faculty members from Hunter College came to the high school to talk with the students about their options for the future, and Schurrer credits one of these visiting professors with inspiring her to consider a career in the mathematical sciences:

I came from a poor family. We had to make a living. And at one point, J. Hobart Bushey—who was professor of statistics at Hunter College—came and gave a

talk at the high school and said that this was a field in which you could earn a lot of money, it was mathematical, and if you enjoyed mathematics, this would be something to go into. (Schurrer: 1)

It was then, for the first time, that she made the connection between studying mathematics and making a living. This experience caused her to think seriously about setting a course for the future in which mathematics would play a central role.

In her home city of Vienna, Herta Freitag attended not high school but its nearest European equivalent, gymnasium, which lasted for eight years (from age ten to age eighteen) and was entirely single-sex. In gymnasium in the 1920s, Herta Freitag found the presentation of subjects to be thoroughly integrated, "completely noncompartmentalized." In mathematics, for example, algebra, geometry, trigonometry, and analytic geometry were completely interwoven. She likens her gymnasium education to a spiral, which each year progressively "widens and deepens, until you get to the top"—which, in mathematics, was calculus (Freitag-1: 1).

The teachers in gymnasium were often remote and sometimes inscrutable, and they were treated with reverence and respect. In fact, what was most striking and important to Herta Freitag about the culture of the gymnasium was that knowledge itself was revered and respected. She recalls that in Vienna in the twenties, class distinctions were based more on education than on money, so that education was held in the highest esteem.¹ Freitag recalls that, of the twenty-seven students in her gymnasium class,

twenty-six went on to study in university. And we were, at the time, in the culture—very, very interesting, I remember everything clearly—terrifically idealistic and terrifically very animated by the desire to study. For instance, about that person that didn't go on to university, the talk was, "Leave it to that dumbbell! She'll probably get married right away!" (Freitag-1: 6)

Herta Freitag enjoyed a peer culture in gymnasium in which education was valued and those who dropped out of school, even at an advanced level, were looked down on. Moreover, the values of the school were reinforced in the larger culture—a consistency in values that she sees as sadly lacking in the United States.

Even in U.S. high schools, however, these young women were able to find or to create social worlds in which intellectual and cultural

values were shared. As in the Viennese gymnasium, this was frequently easier to accomplish in a single-sex environment. But having even one friend who supported her intellectual interests in high school could be enough to keep a young woman going. It was just such a friend that Barbara Beechler had, from seventh grade onward, in her boyfriend, Bob Blair. Beechler and Blair were “the two stars” of their public high school (Beechler: 4). Although they rarely took science or mathematics classes together, Blair was the *one* peer with whom Beechler could not merely share but cultivate a passionate interest in mathematics and science—physics, in particular. It was this companionship that helped her sustain a sense of intellectual adventure during her high school years, years that were made more difficult for her and for her family by World War II and her father’s extended hospitalization with tuberculosis.

High School as a Place of Limitations

While high school can be a place where intellectual, cultural, and social horizons expand, it can also be a place where painful limitations are placed on the curious. These limitations often reflect biases against exceptional students—female students, in particular. What is striking among the group of interviewees is that nearly all of them viewed such limitations as challenges to be overcome, as provocative experiences that served to reinforce their resolve to excel.

The limitations of Mary Ellen Rudin’s high school were of the equal-opportunity variety, since they affected male and female students alike. Because the school was so small, course offerings were extremely limited. “We had minimal quantities of mathematics and science,” Rudin recalls. “I did not have anything like trigonometry, for instance. . . . Everybody took the same thing” (Rudin: 3). These limitations did not, apparently, affect the seriousness with which a bookish student might approach his or her studies. In the remote Texas town where Rudin went to high school, this meant that students simply invested more time and energy in what was available to them.

At Cazenovia Seminary in New York in the 1920s, Grace Bates encountered an unexpected obstacle when she tried to take as much

mathematics as was offered at the school. "I was taking the usual elementary algebra and then geometry," she recalls, "and I wanted to go on in my senior year with intermediate algebra. And they said there that I'd have to take a history course [instead]" (Bates: 3). While the school argued that the history class was a requirement, there is no evidence that male students were similarly barred from the algebra course. The fact is that it was highly unusual for a female student to take all of the available mathematics courses at Cazenovia in those days; her exclusion from the algebra class may well have been a case of sex discrimination.

How did Bates respond to this affront? "I squawked—and I wrote my dad," she recalls (Bates: 3). Her father, who was secretary to the commissioner of agriculture in New York state, used his influence to bring pressure to bear on Cazenovia Seminary. Authorities within the state government argued on her behalf that while she could take a history course "any time," it was crucially important for her mathematics education to proceed without a break. Cazenovia was willing to modify its stance under pressure, and Bates was able to take another year of mathematics.

At other high schools, however, the limitations encountered were more overtly sexist. As we have seen in chapter 3, Alice Schafer's earliest emotional investment in mathematics was shaped by a teacher's doubts about her ability. At her small, rural high school in Scottsburg, Virginia, she excelled in mathematics; but her mathematics teacher stood firm in his opposition to the idea of her going on in the subject:

In high school, there were three teachers; of course, not many courses were offered. I liked mathematics and Latin and history best of all the courses. When I was applying to go to the University of Richmond for college, I needed a scholarship. And I said to the principal, who was the one who taught mathematics, "Would you write a recommendation for me?" He asked, "What do you want to major in?" and I told him these three fields. "Oh," he said, "if you want to major in mathematics, I won't write for you because girls can't do mathematics." (Schafer: 1)

Her fury at his statement simply added fuel to her determination to prove him wrong. "I don't remember any more whether he wrote for me or not," she says. "My Latin and history teachers probably wrote for me" (Schafer: 1). She got the scholarship and went on to major in mathematics at the University of Richmond.

Jean Walton recalls receiving subtler but no less powerful messages about the mismatch between girls and mathematics. After attending public elementary school in Bucks County, Pennsylvania, she attended George School, the private Quaker boarding school where her father was headmaster. She enjoyed mathematics and continued taking coursework in it all through high school. "I took an advanced class. In those days, advanced high school math was solid geometry and trigonometry," she recalls. She does not remember anyone objecting to her decision to continue on in math. But she was aware of her unique status as the only girl in the class, and she remembers feeling distinctly out of place there:

I remember very vividly a class session, during that senior year, when the teacher said, "Now, any of you who are going on to college and planning to go on in mathematics, I want to urge you to buy a slide rule and to get familiar with using it." And, as you probably know, in any case, in those days there were no calculators, and the slide rule played a very important role. But the thing that I remember so vividly was the clarity of my conviction that "He's not talking to me. Because girls don't take math! I, of course, won't be doing that when I get to college. I'm doing it now because it's kind of fun, but that won't be what I will do, and I don't need to get a slide rule and I don't need to learn how to use it!" (Walton: 1-3)

Whether the teacher was communicating this to her directly or not, she clearly held the conviction that while it was all right—permissible—for her to be taking mathematics, it was *not* all right for her to be taking it seriously. Mathematics was for fun—it was not something she *needed* to do—although the very next year, she went on to Swarthmore College and majored in the subject:

I never got a slide rule, and I never learned how to use it. And before very long I became embarrassed over not knowing, and I tried to hide the fact that I didn't know. And I was able to do this; I got along perfectly well. I used tables, and I guessed, and I never used a slide rule. (Walton: 3)

During her teens, Walton says, "I was . . . very aware of the fact that men were the people who knew things, and men were the authorities. And I was not a person who had a mind of her own at all at that stage of my life" (Walton: 3). These attitudes, though not *explicitly* communicated, were almost certainly part of the culture at George School, and they were also reinforced at home, by the example of her headmaster-

father. Their impact on her was long-lasting, undermining her sense of accomplishment in mathematics for many years to come.

At first glance, Lakeview High School on Chicago's North Side, with an enrollment of some five thousand students, could not have been more different from the high schools that Alice Schafer and Jean Walton attended. Yet Violet Larney, who graduated from Lakeview in 1938, experienced much of the same sort of discrimination there that Schafer and Walton had experienced in far smaller, more intimate, more bucolic high school settings. Larney studied mathematics throughout all four years of high school, earned straight As in all of her courses, and came out at the top of her class of well over a thousand students. Yet her mathematics teacher tried to discourage her from continuing in mathematics, much as Alice Schafer's teacher had done:

When I told my mathematics teacher that I was going to go to college and major in mathematics, even though I was a straight-A student in his mathematics classes, he said, "Well, there isn't much call for mathematics these days. It's the social sciences that are getting all the interest." It was 1937 when he said this to me! And he said, "You might not get a job if you go into mathematics, especially being a woman." (Larney: 3)

Despite her obvious academic talent, Larney's high school teachers never really encouraged her to make plans for her future education. She was an only child whose father died when she was a high school senior, and it was her mother—not a high school teacher or counselor—who insisted that she continue on to college. When it came to choosing a college, Larney decided to go to Illinois State Normal University on the off-hand suggestion of a family friend. Larney chalks her experience up to the fact that "they gave very poor advice in high school in those days" (Larney: 3). But at the same time, she is also acutely aware of what became of the male salutatorian of her class, who went on to work on the Manhattan Project at the University of Chicago: "He went farther than I did, even if he did get one B!" (Larney: 1). One has to wonder what sort of advice was being given to *him*.

Violet Larney, who should have been the pride and joy of her teachers, was simply not taken seriously because she was a girl. She responded to the situation in the only way she could: by making do and pressing onward with the resources available to her. But still, sixty years later, she

wonders what it would have been like if she had been able to explore her options more fully at the time.

High School as a Place of Encounter with Mathematics

High school is the place where, under the influence of a particularly inspiring teacher, a good many of the women interviewed had their first serious encounter with mathematics. For Margaret Marchand, as we have seen, going on to university and going on in mathematics were two sides of the same coin: neither would happen without the other, and perhaps neither would have happened without the intervention of her teacher, Mr. Robson, at a crucial juncture in her high school education.

Lida Barrett traces the origins of her active interest in mathematics to her participation in the junior high school mathematics team. "Texas had an interscholastic league," she recalls, "and schools had math teams. When the football team went to play football, the math team went and 'played math' against the math people at the other school" (Barrett: 1). In particular, Barrett attributes much of her early facility in math to the training techniques of the coach, Miss Emma Finch, who opened her eyes to a sense of how mathematics *worked*. Possessed of this understanding, she came to regard mathematics as "easy"—as something that she was fully capable of doing, and doing well.

From her adolescence until well into her twenties, Patricia Eberlein had eclectic interests; she would not make the decision to dedicate herself to mathematics until long after graduating from college. But in high school, she found algebra and geometry especially interesting. Before moving off to high school at Shipley in Bryn Mawr, she took a high school algebra class in South Bend, Indiana, where she had an unusual encounter with the mathematician Karl Menger.² "Menger, who was at Notre Dame at the time, used to proctor my exams. He even gave me papers he'd written, which of course I couldn't read!" (Eberlein: 2). While it may have been preposterous for Menger to have given Eberlein his research papers to read, his attention and encouragement had a lasting impact on her. Later on, at Shipley, she was one of only two girls at the school who enrolled in a full four years of mathematics. Her encounter with algebra and with

Menger in South Bend laid the groundwork for her much later emergence as a mathematician.

Anneli Lax's educational experiences prior to college were repeatedly disrupted by her family's flight from the Nazis. Despite the seemingly interminable interruptions, Lax had key experiences with mathematics during her high school years that influenced her long thereafter. Her interest in mathematics was awakened by Euclidean geometry, which she first studied in lyceum in Berlin around 1935. The constructions and the logic of geometry afforded her "the perfect sort of escape: I didn't have to look up anything; I didn't have to consult libraries or books. I could just sit there and figure things out" (Lax: 1).

As she was leaving Germany, her teacher from the Berlin lyceum urged her, "Whatever you do, whatever happens to you, make sure you go to university" (Lax: 4). On her arrival in the United States, she took geometry yet again from "a lovely old lady, Miss Eaton," at a high school in Queens (Lax: 3). These two significant encounters with geometry convinced her that logic was what made mathematics satisfying and pleasing. Because she could not see its underlying logical structure, the algebra class that followed on Miss Eaton's geometry course was a disappointment: "It looked like a lot of tricks. It was only much later that I saw that there was a foundation to the stuff. . . . I never liked rules that didn't have a basis that I could understand." Despite her dissatisfaction with algebra, Anneli Lax came out of high school "fascinated with mathematics" (Lax: 4-5).

Jean Rubin and Edith Luchins attended New York City public high schools—Rubin in the forties and Luchins in the thirties.³ An all-around good student, Jean Rubin enrolled in the college preparatory program at Andrew Jackson High School in Queens. During her junior and senior years there, she developed her particular interest in mathematics. She says, "I had a very interesting instructor. He had a Ph.D. in math, and I think he turned me on. I really became interested in mathematics after that" (Rubin: 1).

By contrast, Edith Luchins had been interested in mathematics from her earliest days in elementary school. But it was in high school that her mathematical experience broadened and deepened, and her confidence grew. She took all the mathematics courses offered by the school; she

participated in the math club; she tutored her fellow students; her mathematics teachers occasionally asked her to assist them with grading or to take charge of the class for a time. She grew not only in her love of mathematics but in her desire to teach it as well. For Luchins, as for nearly all the women interviewed, high school set the stage for a much fuller and deeper engagement with mathematics at the college and university level.

The Transition to College

In recent years, college attendance for both women and men has become the norm rather than the exception, but (particularly for women) this is a relatively recent development. In 1930, just over 10 percent of all women eighteen to twenty-four years old attended college; during the years of Depression and war, this proportion continued to increase but had not yet reached 20 percent by 1950 (Solomon 1985: 64). As Herta Freitag has observed, in Austria as in other European countries, class distinctions have long been based on education. In American society, where the class structure is somewhat more complex, there has nevertheless been a strong correlation between educational level and socioeconomic advancement.

For the women who became Ph.D. mathematicians in the forties and fifties, the transition from high school to college was their first decisive step toward a professional career. Unlike the prospective college student of today, most of them applied to just one or two schools for admission; their choice of institution was frequently constrained by the availability of scholarships and the limited financial means of their families. Twenty-two of the women interviewed lived at home for all or most of their college years and made their choice of college based on the assumption that they would do so. For example, growing up in Pittsburgh and coming from a poor family that did not particularly encourage her to go on, Dorothy Maharam Stone realized that she would have to go to a local school. She chose Carnegie Tech (over the University of Pittsburgh) because they offered her a scholarship and because they were willing to let her major in mathematics rather than "home economics or secretarial work or library work" (Maharam Stone: 1).

Anne Lewis Anderson grew up in Lynchburg, Virginia, home of Randolph-Macon Woman's College, which she attended on a scholarship

as the top-ranking female student in her high school class. "As far as I know," Anderson recalls, "I had never considered any other college. From the time I was a child, Randolph-Macon was there and I was headed toward it" (Anderson-2: 2). Similarly, Margaret Willerding, Lida Barrett, Jane Cronin Scanlon, and Augusta Schurrer attended hometown colleges because they were affordable and, in some cases, free.

Many of the women were quite young when they started college. Augusta Schurrer, who had been promoted through the "rapid advance system" of the New York City schools, was fifteen when she made the transition from Hunter College High School to Hunter College in 1941. Vera Pless was also fifteen when she enrolled in the "Hutchins College" of the University of Chicago in 1946; she was admitted after two years of high school on the basis of her performance on an entrance examination.⁴

Although they had their share of fun, the women who attended college close to home did not lead the sort of all-encompassing campus life that students at residential colleges and universities typically experience. But Marie Wurster, who grew up in Philadelphia and attended nearby Bryn Mawr College, had the best of both worlds. For her first two years, she lived at home and commuted to Bryn Mawr. After that, she says, "I got a second small scholarship which enabled me to live there the last two years," and she was able to enjoy the experience of living on campus (Wurster: 3).

The students who went away to college or university did so for a variety of reasons. Throughout her childhood in Iowa, Winifred Asprey felt that she was on a trajectory toward Vassar College—much as Anne Anderson felt that she was destined to go to Randolph-Macon. At Vassar, she would be following in her mother's footsteps and continuing a family tradition. Mary Dean Clement decided to attend Wellesley College in fulfillment of a family tradition of a different sort. "My parents had a very strong belief that a person should explore the rest of the world," Clement says. "And we did not have the money or the facilities for just traveling for the sake of traveling. So it was encouraged that all of us go off to school" in a different part of the country. She was attracted to Wellesley because it was a women's college, close to the cultural amenities of Boston, and yet located "in a village that had an identity of its own" (Clement: 6).

Evelyn Granville attended Dunbar High School, the academically oriented high school for black students in Washington, D.C. "Dunbar had a great tradition of sending students to the Ivy League schools," Granville recalls. "Men, boys went to Amherst, Dartmouth, Yale, Harvard, and the women went to the women's colleges." With the encouragement of her high school homeroom teacher, Granville set her sights on Smith College, "even though my mother was certainly not financially able to send me" (Granville: 4). When she was admitted to Smith, her entire family bore the expense:

I did not receive a scholarship the first year [at Smith], and I was told later that they didn't see how in the world as poor a child as I could afford to go there. In my [high school] class, two went to Mount Holyoke, one went to Wellesley, one went to Vassar, one went to Bates. There were several [who went to] Ivy League schools. Their families were professionals, and they probably were able to afford it. In the group that went away to school, I was probably the only one who was financially inadequate. But the first year, my aunt helped my mother. Of course, after the first year, I got scholarships. I lived in a co-op house, worked during the summers, and I was able to [pay for it]. It was not a financial burden after the first year. (Granville: 4-5)

For many young women in the 1940s, going away to college could be an act of rebellion—a conscious effort to *break* with family tradition. This is most evident in Barbara Beechler's decision to attend the University of Iowa in the fall of 1945. The war years had been difficult for the Beechler family. During her father's illness, her mother went to work at the draft board; her older sister lived at home, worked part-time, and attended Augustana College, a Lutheran school in their home town of Rock Island, Illinois. As a senior in high school during 1944-1945, Barbara decided that she needed to get away from home. Without seeking the advice of anyone—neither her parents, nor her teachers, nor her boyfriend, Bob Blair, who was about to go into the military service—she chose the University of Iowa, about fifty miles from home. Why did she choose Iowa, when the University of Illinois, in her own home state, was actually a greater distance away? Perhaps it was the adventure of *leaving the state* where she had spent her entire life to that point—while at the same time having the option of easily coming back home should she feel the need.

News of her admission to the University of Iowa in the spring of 1945 came as a surprise to her parents, who had no idea that she had even applied

there. They anticipated that she would go to Augustana College, just as her sister had done. Beechler, who came from a Catholic family, sought the assistance of a higher authority to win them over to her point of view:

I went to the local priest, and enlisted his aid, and got him to tell my parents—ah, shame on me!—that I shouldn't go to Augustana because I would be required to go to chapel. And it was not a Catholic chapel. [Augustana College is] Lutheran, Swedish Lutheran. And of course, this was total nonsense, but at any rate, it worked. (Beechler: 5)

Barbara Beechler's decision to attend Iowa granted her a degree of freedom from her family, while at the same time maintaining family ties. It was rebellious, original, independent—but still relatively safe. For Margaret Marchand, on the other hand, each new phase of her education *necessitated* her traveling farther away from home. Her transition from the family farm, to the high school in Teulon, and on to the University of Manitoba in Winnipeg was a continuous expansion of her intellectual, social, and geographical horizons. Tilla Weinstein's journey from New York City to the University of Michigan in the early 1950s was a blending of both kinds of experiences. She went away to school to get away from the discord between her parents at home; she chose Michigan because there would be relatives living close at hand: "The branch of the family that I was most taken by—the branch of the family that had done well and seemed to enjoy life—lived in Detroit and encouraged my parents to send me to Michigan" (Weinstein: 4).

At the same time, Michigan was for Tilla Weinstein what Manitoba had been for Margaret Marchand—a genuine expansion of her intellectual and cultural experience:

I was going to major in English—there was an English honors program that I loved, and there was a philosophy honors program that I loved. And I had a cousin who had just gotten a Ph.D. at Michigan, was just finishing, and kept twisting my arm and making me stick with calculus. . . . I loved everything about being there. I didn't miss New York because I knew I could go back. It was the most ideal intellectual environment. . . . I had never been in a situation where I could work all the time and get eight hours of sleep at night. I did notice that I didn't see any poor people, I didn't see any sick people. And that was a change from New York. It was a young population. (Weinstein: 4–5)

Whether close to home or far away, college life brought these women significantly closer to the integration of their intellectual and cultural

interests with their future lives as adults. And for nearly all of them, college or university was the place where they first made a long-term *commitment* to mathematics.

Choosing Mathematics from a Range of Options

Several of the women interviewed—Clement, Bates, Larney, Marchand, Freitag, Gassner, Hahn, Luchins—knew that they wanted to go on in mathematics even before they graduated from high school. But for most of the others, the conscious choice to go on in mathematics was made during the college years, under a variety of circumstances.

Some of them came to mathematics through an initial interest in physics, shifting their interest to mathematics in a quest for greater clarity, logic, and certainty. Jane Cronin Scanlon made the switch from physics to mathematics after taking a course in quantum mechanics as a junior at Wayne State University. She felt uncomfortable with the material even though she did well in the course: “I felt that I didn’t understand anything, [and] I couldn’t explain what I didn’t understand!” Mathematics seemed like a refreshing change:

One of the things I liked about mathematics was that there were clear statements: “Now, this is what we’re going to *assume*. And this is what you have to *prove*.” This was clear-cut. Now, a physical science can’t be clear-cut in the same way because one doesn’t *know* what’s going on; one has to take guesses. And when it’s a good guess, then it’s a great theory; but I, of course, understood nothing of this [at the time]. (Cronin Scanlon: 5)

In short, mathematics offered a clarity that no empirical science could match.

Barbara Beechler actually completed a bachelor’s degree in physics at the University of Iowa, but as she moved on into upper-division physics courses, her desire to understand the underlying mathematics made it difficult for her to keep up with the physics. Like Cronin Scanlon, Beechler continued to do fairly well in physics courses but understood less and less of what she was studying. At the same time, she had had some marvelous teachers in mathematics and logic who recognized her talent and took a personal interest in her. Her positive experiences with mathematics ultimately led her to go on in mathematics rather than physics in graduate school.

For quite a few of these women, far more divergent fields competed with mathematics for their attention. Biology was the chief competing interest for both Anne Lewis Anderson and Lida Barrett. Anderson decided in favor of mathematics when she began to tutor her fellow students in mathematics and discovered how much she enjoyed teaching the subject. For Lida Barrett, the path toward mathematics and away from biology was more convoluted. "I had started out in biology but had trouble with my eyes. Microscopes were not binocular, and I wasn't using my eyes well together," Barrett recalls. "The eye doctor wouldn't let me continue with biology, so I switched to math for a year" (Barrett: 2). During her year-long hiatus from biology, she took sophomore calculus with a graduate assistant whose inexperience translated into extremely poor teaching. She was "disgusted" by the experience and had all but decided to switch back to biology when Hubert Bray, head of the mathematics department at Rice, intervened. Bray did what he could to persuade her to stay on in mathematics, and Barrett realized that, despite the poor teaching, it was mathematics that had captured her imagination.

Several of the women—Asprey, Wurster, Granville, Rudin, Lax—had dual interests in both languages and mathematics. Marie Wurster, who entered Bryn Mawr in 1936 at the height of the Depression, quickly decided that "mathematics was a more practical field to major in" (Wurster: 2). Similarly, Evelyn Granville says, "When I got to college, I realized that there's more to French than the language. There's French literature and all that, and I decided I'd better stick with mathematics" (Granville: 4). Mary Ellen Rudin, on the other hand, managed to complete a dual major in mathematics and Spanish, although going on in Spanish was an option she seems never to have seriously contemplated.

Anneli Lax entered Adelphi College, then a small women's college on Long Island, in the late 1930s. "I was torn between languages and mathematics," she says. "I liked languages and I was good at them. On the other hand, I was fascinated with mathematics." Although mathematics was much more of a struggle for her, she continued to derive pleasure from the fact that she could do mathematics just by "thinking about it by myself but not studying the books" (Lax: 5). In the end she chose to major in mathematics, despite—or perhaps because of—the fact that mathematics was more challenging.

Winifred Asprey entered Vassar intending to major in French and stuck it out for quite a while. She rapidly discovered that “everybody in class, it seemed to me, had had a French governess or lived in France,” while her own background in French was relatively “spotty” by comparison. To succeed in French classes, she memorized entire sections of the textbook, saving them for the appropriate moment in class. “I waited until the discussion swung anywhere near what I had prepared, and I flung my arm into the air,” Asprey recalls, “and when [the teacher, Mademoiselle Monnier] called on me, I rattled forth exactly what I had memorized. So it sounded as if I were speaking at rat-a-tat speed” (Asprey: 7–8).

This deception proved successful in all of the classes she took with Mademoiselle Monnier. But deep down Asprey realized that she really wasn’t learning the French. As a scholarship student, she was ineligible to spend her junior year in France, which would have been her first real opportunity to develop her language skills in a French-speaking environment. Reluctantly, she set out in search of a new major.

Mathematics provided an attractive alternative. She had been taking mathematics electives all along, and doing well in these courses required much less of an effort than was required for success in French:

By this time, mathematics was *really* getting interesting. We were up into calculus. [Math] was my easiest subject. It was the one place that I did not have to worry. . . . It was the subject that I found that if I did all the rest of my homework, I’d say to myself, “Now, you can spend the rest of your time on math!” And so, it suddenly dawned on me that it might be something to major in. Well, I began majoring in it, really, my junior year. (Asprey: 9)

In contrast to Anneli Lax, who was intrigued by the challenge and the unfamiliarity of mathematics, Asprey chose mathematics over French because it was easier, more familiar, and more natural to her.

Tilla Weinstein’s path to the mathematics major is perhaps the most unusual of any in the group. She entered the University of Michigan in 1951 as a major in English and philosophy, and she remembers her coursework as a source of intense pleasure and delight. “I *read* for the first time in my life, extensively. I’d never been a reader,” she says. “I *wrote* seriously for the first time in my life and enjoyed that enormously.” She was enrolled in the honors program in both fields and uses words like “wonderful” and “splendid” to describe the programs and courses in both subjects (Weinstein: 6).

Like Winifred Asprey, she had continued taking mathematics as an elective during her first two years of college. As a freshman, she took an honors calculus course with the geometer Hans Samelson. "I worked very hard," Weinstein recalls. "I got an A. But I felt I didn't understand anything, and in retrospect, I *didn't* understand very much! I suppose the only thing that shows I was *potentially* a math student is that I *understood* that I didn't understand" (Weinstein: 7).

After an uninspiring third semester in calculus, her cousin, a doctoral student at Michigan, suggested that she try a course in foundations of mathematics taught by R.L. Wilder:

It was *perfect* for me: you needed no knowledge. He threw out an axiom, gave you a few models for the axiom, gave you a few definitions involving undefined terms, suggested one or two things that could be proved, and let us loose. The whole content of the course, when you looked back, was on a stack of index cards: axiom, definition, theorem. I enjoyed it enormously. It was self-contained and beautiful. . . . You didn't learn many facts. You didn't learn many skills. But you came away with a sense of how things actually came together and how very *much* you get out of very *little*. That was the first time I had enjoyed math since I was in high school. And I was willing to take the plunge into advanced calculus. (Weinstein: 7-8)

Wilder's course set the stage for the unexpected turn of events that followed. At the end of her freshman year, she received a proposal of marriage from a young man from back home in New York. "In those days, if someone you loved, loved you, you got married," says Weinstein; and that's exactly what she did, "June after my sophomore year" at Michigan. Marriage meant that she would leave Michigan and transfer to a college in New York, where her new husband was employed. Her intention was to go to City College because it was free, but she discovered that the requirements at City College would have forced her to retake courses she had already had at Michigan. "It seemed a waste of my college time," Weinstein said, "so I went to NYU" (Weinstein: 4, 6).

At NYU, she discovered to her disappointment that the English and philosophy departments were decidedly less appealing than they had been at Michigan. This might have been reason enough for her to change majors, but there was yet another reason for doing so:

I was marrying someone who intended to go on and get a Ph.D. in English. And it was not comfortable for me to be in the situation of being in the same field as

my husband. There was the discomfort of possibly competing; wives didn't compete with their husbands in those days. (Weinstein: 6)

Desperately seeking a major at NYU, it was the memory of Wilder's course at Michigan that brought her into mathematics:

And I remember asking, "What's good here?" And the adviser said, "Oh, there's mathematics." And he never got farther on the list because I had just had the wonderful course with Wilder at Michigan, which I truly enjoyed. (Weinstein: 7)

And she stayed in mathematics at NYU, right on to the Ph.D.

What these stories clearly illustrate is that, for a great many of the women mathematicians of this generation, the decision to pursue mathematics seriously at the undergraduate level was by no means a foregone conclusion. Contrary to the myth of the mathematical life course, these women came to the subject comparatively late, choosing it from among a range of other subjects in which they had demonstrated interest and ability.

Gender Barriers

From elementary school on through high school, college, and beyond, girls and women have often been told that they cannot or should not do mathematics and science. Among the women interviewed for this study, it was at the college or university level that these messages became most explicit, to the point that they became barriers to their educational advancement.

In the thirties and forties, college advisers were frequently unable to take a woman's ambitions in mathematics or science seriously. When Barbara Beechler arrived at the University of Iowa in 1945, not only was she the only undergraduate woman majoring in physics, but she was (so far as she knew) the only undergraduate woman who had *ever* majored in physics! During her first (and last) encounter with an academic adviser in the physics department, she was told that physics was "a very good field for a woman" because "physics studies color, and women really need to know a lot about color, so that they have proper decoration of homes." Beechler says, "I never went near the man for another piece of advice" (Beechler: 7).

Similarly, at Illinois State Normal University, Violet Larney found the advising no better than what she'd had in her Chicago high school. "If

you were to major in mathematics and minor in a science like physics," Larney was told, "you'd never get a job. They only want men for that, so you'd better get into secretarial science and business as your minors" (Larney: 3). Larney was aiming for a career in high school teaching. In those days, *men* were routinely hired for jobs in "science and coaching, or mathematics and science," but the message was clear: "a *woman* wasn't supposed to be teaching mathematics and science" (Larney: 3-4). In the end, Larney chose minors in accounting, law, and secretarial sciences; she still regrets the fact that she never studied science seriously at the college level.

As we have seen, from early childhood onward Alice Schafer was acutely aware of the many disadvantages of being a woman. Already in high school, the principal's opposition to the idea that she might go on to study mathematics in college posed a difficult—though ultimately not insurmountable—barrier to her continuing on to study mathematics at the University of Richmond. This was not the last such barrier she was to encounter.

When Schafer arrived at Westhampton College, the women's coordinate college of the University of Richmond, in 1932, she was undecided about her major. The decision was a toss-up between history, Latin, and mathematics; it would be difficult to imagine three more widely disparate fields. At Westhampton, Schafer recalls, "I had a wonderful teacher in history—a University of Chicago Ph.D., as a matter of fact, in ancient history. And it was clear to me that I did not write well enough to be an historian. So that knocked out history." Latin was ruled out when Westhampton's Latin teacher left the school to teach in China; "so that left mathematics" (Schafer: 4).

Westhampton College, like many other women's coordinate colleges, had very limited offerings in mathematics. In particular, "there was one woman who taught mathematics, Isabel Harris. At that time," Schafer recalls, "the women were on one side of the lake and the men on the other; and there were no classes together until you got to the advanced mathematics courses, and the same with the sciences" (Schafer: 4). As it happened, Schafer was the only woman mathematics major in her class. After the sophomore year, she began to take classes on the men's side of the lake and was often the only woman in a class of men.

The head of the mathematics department at the University of Richmond was so firmly convinced that women could not and should not succeed in mathematics that, apparently, he did everything in his power to ensure the outcome:

In my junior year of college, the dean of women called me into her office and said that the head of the mathematics department was flunking all the women mathematics students, for he wanted no women majors in mathematics. The dean told me, "You are to stand your ground." I was too naive for it to have occurred to me *not* to stand my ground!

The course the department head was teaching must have been an advanced calculus course. A woman in my class who was a chemistry major had not been flunked—as she told me later—but had been given a D. I believe that earlier she *had* been thinking about being a mathematics major. Our examinations were not returned to us, and we were never allowed to see them. But a member of the history department told me that the mathematics department head had said in a faculty meeting that I had made 100 on my final examination, and she was shocked when I said I knew nothing about this. (Schafer: 4–5)

Although Schafer does not report what her final grade in the course was, it was clear that her academic performance was so good that the department head was compelled to acknowledge it, at first to his fellow faculty members, and then—grudgingly—to Alice. During her junior year, she won the Crump Prize, awarded for the best performance by a junior mathematics major on a competitive examination:

The head of the mathematics department never congratulated me when he was told that I had won. What he said was, "I never thought *you* would win the prize." I was so angry for so many years that it took me some time to realize that he and the others who graded the papers must have graded them fairly!

By the end of her senior year, the department head "came around slightly," offering to help her get a fellowship to graduate school in mathematics (Schafer: 5).

Among the factors that influenced Alice Schafer to continue on to graduate study in mathematics was her observation of how badly Isabel Harris was treated at the University of Richmond:

Isabel Harris—Miss Harris, as we called her—had never gotten a Ph.D. In fact, I asked her later why she had not; and she, in essence, said, "Why bother? They would never have let me teach anything higher than analytic geometry." "They," of course, referred to the men in the mathematics department. . . . No woman was allowed to [teach the men]. (Schafer: 5–6)

Harris had done graduate work in mathematics at Columbia and Chicago, but she was apparently convinced that completing a doctorate would not improve her situation at Richmond. As a tribute to Harris and as a matter of honor, Schafer resolved that *she* would complete a Ph.D. in mathematics herself. From elementary school on through college, Alice Schafer's determination to study mathematics was fueled again and again by the dual forces of interest and outrage. Her natural affinity for the subject, combined with her sense of injustice at all the barriers to women's success in mathematics she had seen and experienced, served only to intensify her own determination to continue in mathematics to the highest level of which she was capable.

At about the same time that Alice Schafer was struggling against the powers that be at the University of Richmond, Grace Bates was experiencing the limitations of study at the coordinate college associated to Middlebury College in Vermont, where she enrolled as a freshman in 1931. At Middlebury, as at Westhampton, there was just one mathematics teacher on the women's side, Ellen Wiley. Unlike Isabel Harris, however, Wiley had a somewhat freer rein to teach a wider range of courses. On the other hand, at Middlebury, women were not expected to *want* to take the upper-level mathematics classes that were available only on the men's side; women certainly did not take them as a matter of course. As a result, Bates reports, "I had to petition the trustees at Middlebury to get into a course in differential equations my senior year because it was only taught in the men's side" (Bates: 6). Once enrolled in the men's courses, however, she does not report having sensed any hostility to her presence there. At Middlebury, the chief barriers to a woman's seeking advanced education in mathematics seemed to be primarily administrative, while at Westhampton the barriers were more of a personal nature. Both Bates and Schafer were successful in overcoming both kinds of barriers, but they did so in a mathematical climate that was intimidating and inhospitable to them.

A decade later, Rebekka Struik chose mathematics over chemistry as her major at Swarthmore College because there the *chemistry* department was actively inhospitable to women. When Struik entered Swarthmore in the fall of 1945, she was enamored of chemistry, having had an

excellent high school course. She did well in first-year college chemistry, but as might be expected in any major, she began to struggle in her sophomore year. Organic chemistry was especially difficult—"like memorizing the telephone book!"—and she turned to the teacher for help. He was anything but supportive:

The chemistry professor was openly antiwoman. This was probably 1947, so there was nothing illegal about it, but by now the chemistry department has cleaned up its act at Swarthmore. But [then,] his attitude was that it was a waste of resources to train a woman in chemistry because "you're just going to get married and have children. And you *should* get married, and you *should* have children." Well, I was doing poorly in the organic, and I went to talk to him, and he thought it would be a good idea if I changed majors. (Struik: 1)

She is convinced that the chemistry professor tried to drive her out of the department, not because of her performance but because she was female. Struik knows of at least one male classmate who did as badly as she in organic chemistry but went on to a distinguished career as a chemist and wonders what the organic chemistry teacher had to say to *him*. It seems unlikely that the male student was given a lecture about the waste of resources that his perseverance in chemistry would entail. "It's one thing to discourage a student because he or she is doing poorly," says Struik. "It's another thing to discourage them because they're of the wrong gender, or the wrong race, or the wrong religion, or whatever" (Struik: 1).

Mathematics was a natural second choice for her after chemistry. Organic chemistry relied heavily on memorization; but in mathematics, "you could just figure it all out. And that's what was important. And that, definitely, appealed to me" (Struik: 6). Moreover, the warm welcome she received in the mathematics department helped to seal the decision. After her unhappy meeting with the organic chemistry professor, "I went in tears to the chair of the math department, Dr. Arnold Dresden, who was a friend of my father's," Struik recalls.⁵ "He welcomed me into mathematics, and I've been there ever since!" (Struik: 1).

Rebekka Struik was just one among many women of this generation who were told that an education in science would be wasted on a woman. Domina Spencer was told the same thing a decade earlier when, at the age of fifteen, she sought admission to MIT. Following her junior year at Friends' Select School in Philadelphia, she attended summer school at

MIT at the suggestion of her sister. During that summer in Cambridge, she enrolled in freshman physics and took up sailing, which was to become a lifelong avocation. It was her love of sailing that inspired her, at summer's end, to ask the dean about the possibility of admission to MIT the following year. MIT was suffering from depressed enrollments at the time, and Dean Petré was quick to capitalize on her academic qualifications, guaranteeing her admission on the spot. "They had a nice regional scholarship for the Philadelphia area," Spencer recalls; Petré encouraged her to compete for it, and she won. But when the time came for MIT to invest money in Domina Spencer's education, they were far less forthcoming:

The MIT tuition at that time was five hundred dollars a year. And you know what they gave me for a scholarship? Fifty! Ten percent of tuition! Ten percent of the tuition is what they gave me, fifty dollars for the year. And I asked them why I got so little. I was third in my class at Friends' Select; there were a boy and a girl [with] grades slightly better than mine, but I was third out of a class of thirty-five, thirty-seven, something like that. And I was sixteen, and they were probably a couple of years older than I was. But they gave me a token scholarship.

Their explanation was simple: MIT told her point-blank that "women are a very bad investment! They just come here to get husbands. They don't do anything with their careers, so why should we waste scholarship money on them?" (Spencer: 12)

Spencer was outraged. In fact, she was *keenly* aware of the value of her education and of what an important investment in her future it really was. She started work toward a bachelor's degree in physics at MIT in the fall of 1937. "I didn't want to do the same thing as my sister," she recalls, "I wanted to *use* mathematics in science rather than studying pure mathematics" (Spencer: 15). Because her MIT scholarship was so paltry, she remained heavily dependent on the financial resources of her family and particularly of her sister, who by this time had completed her Ph.D. at Penn and was working for the federal government in Washington.

Intensely motivated to complete her undergraduate work as quickly and cheaply as possible, Domina Spencer struck a bargain with H.B. Phillips, then head of the mathematics department at MIT. Phillips agreed that if she could pass his course in advanced calculus, he would exempt her from the mathematics classes required for the physics major, a

challenge that she easily met. "That's how I got through MIT in two years rather than in four!" Spencer says. "I also went to summer school and took some advanced standing examinations. . . . You just studied the course for a week, took an examination, and it didn't cost a cent" (Spencer: 14–15).

When all was said and done, Domina Spencer was a student at MIT for a total of five years, earning a bachelor's degree in physics and a master's and Ph.D. in mathematics. During her years at MIT, she says, "I kept an eye on the boy that had gotten 'my' scholarship, and he was still fooling around as an undergraduate when I was getting my doctor's degree!" (Spencer: 12). Nevertheless, MIT never admitted their mistake in not offering her a proper scholarship.

Perhaps the most egregious case of gender discrimination at the undergraduate level was that experienced by Tilla Weinstein during her senior year (1954–1955) at NYU. "I became pregnant at the beginning of the summer, quite accidentally," she recalls. When she returned in the fall to plan her schedule for senior year, she was in for a rude surprise:

I wanted to arrange my schedule, sixteen credits in the fall and fourteen credits in the spring, so that I'd have a lighter load the semester I was having the baby, hoping that I could still keep my small scholarship which required fifteen credits per semester. [When I discussed this with a dean,] he informed me that there was no way they would allow me to register as a student in the second semester. As a matter of fact, first he leaned back and laughed, heartily, for about five minutes. What was funny was that I thought I was going to go on with my education even though I was having a baby. He said, "My daughter just had a baby, and she's been in bed for five months," wiping away the tears from his eyes because he thought it was so funny. (Weinstein: 8–9)

The dean told her that to attend classes while pregnant would have been a violation of state law, "that I would be perpetrating a fraud by registering for the class, because I could not *come* to class." She says she has no idea whether what he said was true or not, but she was unwilling to challenge him because "he was also a senior professor in the English department" where her husband was working toward a Ph.D. "To challenge him would have been to incur the animosity of someone who had power over my husband." Ultimately, a compromise was struck:

There was a negotiation between the people at the Courant Institute—probably Lipman Bers—and the dean. I was not allowed to take a full program. I was not

allowed to register for a course. I was allowed to register for two reading courses. And, in fact, I continued taking the two graduate courses I had planned to take—linear algebra and complex variables—but on my transcript, they read as reading courses. And then—which was much harder for me than it would have been otherwise—I had to go to summer school to finish up my degree, after the baby was born. (Weinstein: 9)

Grace Bates, Violet Larney, Alice Schafer, Rebekka Struik, Domina Spencer, and Tilla Weinstein were all victims of sexism. But in the thirties, forties, and fifties, the discriminatory remarks and practices they encountered reflected the mores of the times and were easily explained away: “Women don’t do science”; “women will just get married”; “pregnant women should not appear in public”; “pregnancy makes women helpless and debilitated”; “pregnancy and education are incompatible.” There were no laws, no authorities to whom these young women could appeal for redress of unfair, outrageous treatment.

It is important to remember that these are the stories of those women who succeeded; they had the patience, the stamina, the financial and moral support of families who helped them to overcome the obstacles. And, in many cases, they had the encouragement of teachers and mentors who believed in their abilities and were strong advocates for their personal and professional success.

The Influence of Teachers and the Power of Mentorship

Teachers rarely know the impact that they have on their students. At their worst, teachers can be disorganized, obscure, and discouraging; but at their best, they can convey an enthusiasm for their subject and an interest in people that can capture a student’s imagination and fire her ambition. The support, encouragement, and influence of a caring and concerned mentor can help to ameliorate, and even to overcome, the most adverse circumstances, as Lipman Bers’s willingness to help negotiate a solution to Tilla Weinstein’s pregnancy “problem” bears out. Nearly all of the women interviewed mention that they had at least one teacher at the college level who sparked their interest in mathematics and made an investment in their present and future success. In some cases, they attribute their determination to go on in mathematics to the influence of just one special teacher.

Particularly at the women's colleges, mentorship was often provided by women of the older generation of pre-1940 Ph.D.'s. At Randolph-Macon Woman's College, Anne Lewis Anderson benefitted from the guidance and interest of two Chicago alumnae, Gillie Larew (Ph.D., Chicago, 1916) and Evelyn Wiggin (Ph.D., Chicago, 1936), who took an active interest in her work and encouraged her to go on for the doctorate at Chicago, as they had done.⁶ At Vassar, Winifred Asprey had many of her mathematics classes with Mary Evelyn Wells (Ph.D., Chicago, 1915) and Grace Hopper (Ph.D., Yale, 1934)—“the most inspirational people you can possibly imagine!” (Asprey: 9). In particular, Miss Wells was “the greatest teacher I ever had”—the teacher whose style she copied when she returned to Vassar as a member of the faculty (Asprey: 21).

At Bryn Mawr in the late 1930s, Marie Wurster took nearly all of her undergraduate mathematics with Anna Pell Wheeler and Marguerite Lehr (Ph.D., Bryn Mawr, 1925), who were the two permanent members of the faculty during those years. Wurster was particularly fond of Lehr—a student of Charlotte Angas Scott—whom she characterizes as “an outstanding teacher, whom everyone liked and admired” (Wurster: 4). At Smith, Evelyn Granville studied with Anne O'Neill (Ph.D., Radcliffe, 1942), who had been Winifred Asprey's Vassar classmate; and Susan Rambo (Ph.D., Michigan, 1920) who, though “very stern, caused us to be very disciplined mathematicians” (Granville: 5).

Augusta Schurrer recalls that, of her many memorable teachers at Hunter College in the forties, it was a woman, Anna Marie Whelan (Ph.D., Johns Hopkins, 1923), who turned her on to complex analysis, the field in which she ultimately did her doctoral research. Schurrer remembers Whelan's one-semester course as the one “where the fires lit up. . . I'd never seen anything as interesting in my whole life. I really, really loved complex” (Schurrer: 6). The geometric flavor of complex analysis brought mathematics alive for her in a way that one-dimensional calculus had not.

The few women mathematics Ph.D.'s working outside of women's colleges served as powerful mentors and role models, too. At the University of Minnesota in the 1930s, Margaret Martin was particularly impressed by Gladys Gibbens (Ph.D., Chicago, 1920) and Sally Elizabeth Carlson (Ph.D., Minnesota, 1924), “whom I liked and whom I was interested in

because they were women” (Martin: 5).⁷ Cathleen Morawetz, whose father was the distinguished mathematician J.L. Synge, says that she “became a mathematician by default” under his influence (Morawetz: 1). But while working toward her bachelor’s degree at the University of Toronto in the 1940s, Morawetz recalls that Cecilia Krieger (Ph.D., Toronto, 1930) was the first, and perhaps the only, member of the faculty to take an active interest in her mathematical future.⁸

As an undergraduate at Toronto, Morawetz was committed to an intense course of study in mathematics, physics, and chemistry. But the narrow focus of her studies was a frequent source of discontent. Seeking a change of pace and of scenery, she took a year off between her junior and senior years of study to do war work in Quebec. On her return, still feeling somewhat dissatisfied with her studies, she ran into Cecilia Krieger on campus:

She asked me what I was going to do the following year. And I had been cooking up the idea that I was going to respond to an appeal for people to go and teach school in India. I thought that would be nice and exotic, and I had enjoyed very much going to a different place—Quebec—and I thought it would be fun. So I told her so, and she was horrified. She said, “You’re not going to go to graduate school?” (Morawetz: 5)

Morawetz, who was doing well in mathematics but feeling ambivalent about it, protested that she couldn’t afford graduate school. Krieger, who was chair of the committee for the Junior Fellowship of the Canadian University Women’s Club, pointed out that money needn’t be an obstacle and suggested that Morawetz apply for the award. Morawetz followed her advice and won the fellowship; Krieger’s determined encouragement had caused her to take herself and her mathematics more seriously.

It cannot be emphasized too strongly that the support and encouragement of male teachers at the college level was critically important for the vast majority of these women. At Swarthmore in the 1940s, Arnold Dresden was an outstanding teacher and a welcoming presence in the mathematics department for both Anne Whitney Calloway and Rebekka Struik. Edith Luchins recalls a whole host of magnificent teachers from Brooklyn College in the 1940s, most of them male: Samuel Borofsky, Walter Prenowitz, Moses Richardson, James Singer, Margaret Young Woodbridge, and—perhaps most important of all—the historian of

mathematics, Carl Boyer.⁹ Lida Barrett's brief undergraduate career at Rice (from June 1943 through February 1946) was filled with memorable teachers, who "were interested in teaching—and knew what the students were learning." In addition to Hubert Bray, who persuaded her to stay on in mathematics, she recalls Szolem Mandelbrojt, who "just insisted that we all memorize the definition of the limit. His idea was that once you got the definition straight, you could work on it" (Barrett: 10).¹⁰

Many other women mention key male teachers from their undergraduate days: Margaret Martin fondly recalls William Hart, head of the department, and Dunham Jackson from Minnesota in the 1930s; Joyce Williams remembers Warren Loud at Minnesota in the 1940s; Evelyn Granville remembers Neal McCoy at Smith.¹¹ However, none of the interviewees had more powerful experiences of male mentorship at the undergraduate level than did Mary Ellen Rudin, Barbara Beechler, and Tilla Weinstein.

Mary Ellen Rudin's mathematics education at the University of Texas was almost entirely under the control of one man: R.L. Moore.¹² As she was registering for classes on her first day at the university, she met Moore, who promptly recruited her into his mathematics class. "I was in a class with him every year," she recalls, "from the time I entered the University of Texas in 1941 until I got my Ph.D. in 1949." His influence "was the thing that pushed me toward mathematics" (Rudin: 1).

R.L. Moore's idiosyncratic style of teaching has come to be known as the Moore method. In every course, at every level, he compelled his students to build the subject "from the ground up":

His way of teaching was to present you with things that had not yet been proved, and with all kinds of things which might turn out to have a counterexample, and sometimes unsolved problems—that is, unsolved by *anyone*, not only unsolved by *you*. So you had some idea of what it meant to be a mathematician—more than the average undergraduate has today. (Rudin: 4)

Rudin has always been supremely self-confident, a quality that was nurtured by her family in childhood. "Moore played on that," she recalls. "He encouraged people to believe in themselves as mathematicians because he felt that this was one of the principal tools for doing mathematics—to have confidence" (Rudin: 21–22). In other words, Moore's style meshed perfectly with Mary Ellen Rudin's talent and temperament.¹³

Moreover, her success in Moore's classes further enhanced her confidence. "I was aware," says Rudin, "that I was *the* person in the class, in almost all cases, who could work the problems" (Rudin: 5). She is firm in her conviction that her association with Moore and her early commitment to mathematics are inextricably intertwined: "I probably would not be a mathematician if I had not worked with Moore" (Rudin: 22).

As an undergraduate at the University of Iowa, Barbara Beechler's mathematical experience was shaped by the teaching of E.W. Chittenden and the advice of Gustav Bergmann.¹⁴ Beechler's first meeting with Chittenden, like Rudin's with Moore, was accidental. As a freshman at Iowa, she was placed in an algebra and trigonometry class that essentially replicated her high school course. After the first exam, Chittenden—realizing that she was capable of doing much more challenging work—invited her to take his course on foundations of mathematics instead. "There were only three people in the class," Beechler recalls, one of them a graduate student in philosophy. "I *loved* this course. I mean, we did things like plot the sine curve geometrically, and I learned about the four-color problem, and I learned all these neat things" (Beechler: 9). At the same time, Chittenden was a disorganized teacher, and his lecturing skills left his students exasperated. But his enthusiasm for his subject was infectious, and his students learned more mathematics in the process of trying to fill the gaps in his presentation than they ever would have learned had he delivered polished lectures. Chittenden maintained an interest in Beechler's mathematical development from the time of their first meeting until quite late in his life.

After he completed a stint in the Navy, Bob Blair joined Barbara Beechler at the University of Iowa; he became a physics major, and once again they resumed taking classes together. At Blair's suggestion, she began taking classes with the philosopher Gustav Bergmann, who introduced them to mathematical logic. Beechler's knowledge of both mathematics and German made her the star of the class:

I remember reading Gilbert Ackerman's *Mathematical Logic*; it was in German, it hadn't been translated. Gus was wonderful; he was sweet to me. I can remember, there were two rather inept philosophy graduate students in that course, and they didn't know any mathematics and they didn't know any science, and they really weren't catching on to this. And the mathematical logic was very algebraic

and formulaic, and I loved it. And I can remember Gus leaning over the table—he was a very ugly man, with buck teeth and, you know, spittle coming out all the time—but he would lean over the table and he would say, “All right, Barbara darling, tell the little boys what it says.” [*Laughs*] ‘Cause those poor guys couldn’t read German, either! (Beechler: 14)

Barbara Beechler regards Gustav Bergmann as “a very important influence. . . . I was stimulated beyond anything I’d ever done before. I loved the logic, I loved the formality. I had never really heard anyone as bright as he. He spent time *with* us and *on* us” (Beechler: 15). But his influence was a mixed blessing. When, as a senior at Iowa, Beechler realized how disillusioned with physics she had become, Bergmann dissuaded her from any thought of pursuing graduate work in philosophy by telling her, “It is no field for a woman.” His suggestion was that she continue in mathematics and, specifically, that she work with Chittenden: “You and Chittenden will have a wonderful time together!” (Beechler: 1). Bergmann’s clearly sexist advice came as a great disappointment to her, yet it was not entirely off the mark. In the aftermath of this conversation, Beechler went on to perhaps the most enjoyable research experience of her life—working on a master’s degree with Chittenden.

Tilla Weinstein recalls that when she was an undergraduate at NYU in the fifties, she was the only woman majoring in mathematics at the time. Her advanced calculus teacher, Jean van Heijenoort, recognized her mathematical talent and invited her to join NYU’s Putnam examination team.¹⁵ It was van Heijenoort who suggested that she should begin taking graduate courses at Courant Institute during her senior year. Weinstein dismisses van Heijenoort’s attention to her, insisting that there were two other undergraduates at NYU at the time who were far more mathematically gifted than she.¹⁶ But although she doubted his assessment of her ability, she *did* take his advice. “The next September, I found myself in Lipman Bers’s office, asking if I could take his complex variables class” (Weinstein: 8). Bers was to become her most important advocate and mentor.¹⁷

At their very first meeting, Weinstein told Bers of her pregnancy. “He was tremendously happy and delighted,” she recalls. “It was as if I had told a relative” (Weinstein: 8). Not long afterward, it was Bers who intervened on Weinstein’s behalf, negotiating the compromise that made it possible for her to finish her undergraduate degree without undue delay.

Thus did Tilla Weinstein begin a lifelong association—with Lipman Bers and with advanced mathematics.

Extracurricular Activity: Dating, Marriage, and Life beyond School

For most of the women interviewed, education was the most important activity of their teenage years. In fact, just over one-third of the women interviewed completed college during the year of their twentieth birthday—or earlier. Education was an all-absorbing preoccupation, akin to a full-time job. But school did not entirely prevent them from pursuing other interests and activities. Plays and concerts; student theatrical productions, college newspaper writing and editing, and student government; and part-time jobs all provided a sense of connection to a wider world beyond studying and abstract thinking.

In many important respects, adolescent women of the thirties, forties, and fifties grew up more slowly than they do now. There were fewer pressures and fewer opportunities for dating and involvement with the opposite sex. On the whole, the lives of these young women were much more bound up with those of their parents and siblings than they were with the formation of romantic relationships.

Even so, dating and relations with young men were very much on the minds of these women, particularly during the college years. For women at coeducational colleges and universities, it was their first real opportunity to interact socially with young men. As is often the case for adolescent women nowadays, these first forays into dating could be awkward and disappointing. Looking back on her social life at Swarthmore in the late 1930s, Jean Walton recalls her involvement with college athletics—hockey, basketball, and tennis—and her many “wonderful female friends,” with whom she got along splendidly. “It was a very successful college career, except that it was not successful in terms of the wonderful happy times with boys that you’re meant to have in college,” she says with some regret. “I had several male friends who loved to get me to help them with calculus!” (Walton: 5).

As it was almost unheard of for young men and women to carry on extensive romantic or sexual relationships outside of marriage, it is not surprising to find a few early engagements and marriages in this group

of women. In addition to Tilla Weinstein, both Patricia Eberlein and Anneli Lax married while in college. Weinstein's first marriage lasted fourteen years, but for Eberlein and Lax these first marriages were rather short-lived. Cathleen Morawetz, Joyce Williams, Barbara Beechler, and Edith Luchins all entered on early engagements during their college years; for all but Beechler, the ensuing marriages were extremely long-lasting.

The success of these early engagements and marriages depended in no small part on the intellectual compatibility of the partners. Tilla Weinstein and her first husband were bound together by similarities of upbringing (they had grown up in the same New York neighborhood), by shared academic aspirations, and by the early birth of children. Anneli Lax did not enjoy the same sort of compatibility with her first husband. "He was quite a bit older than I, and I think he had the feeling that he should take care of me," Lax recalls. While she tried to share in her husband's interests, working occasionally in his automotive repair business, Lax feels that he did not make an effort to take part in things that mattered to her:

What I couldn't stand in the long run was that he didn't seem to enjoy my friends. I had friends and classmates come over to our house, and . . . he would have very little to do with them. And I felt a resentment there. That didn't work. And then I just felt that we were growing apart, and I just left. (Lax: 9-10)

Lax's increasing commitment to mathematics left little common ground on which to continue the marriage.

Perhaps the most unusual of all the early pairings was that between Edith Luchins (then Edith Hirsch) and the man she ultimately married. During the summer between her junior and senior years of high school, Edith enrolled in a WPA-sponsored course in psychology taught by Abraham Luchins, seven and a half years her senior, who was at that time working toward a Ph.D. in educational psychology under Max Wertheimer at the New School for Social Research and NYU.¹⁸ From the first, Abraham Luchins was pleased by her interest in mathematics, while Edith became intrigued by cognitive psychology, especially as it applied to mathematics education. Over a period of several years, they became inseparable companions. From very early on in their friendship, Edith and Abraham Luchins had begun to plan their lives together, and Edith's education in mathematics was always part of the plan. In particular, Luchins

recalls that her husband-to-be "insisted that we not be married until I graduated from college. He wanted to make sure . . . that I had a bachelor's degree" (Luchins: 13).

For many of the other interviewees, there simply were not many opportunities for dating during the college years. Joan Rosenblatt attended Barnard College—the women's coordinate college of Columbia University—while living at home during World War II. With some amusement, Rosenblatt recalls: "We had a little song composed by one of my classmates: 'There Is No Pursuit after Girls Who Commute'! The only men around, practically, were the people in the V-12 program . . . and a midshipmen's program at Columbia" (Rosenblatt: 11). Dating was a rare occurrence during wartime.

For many of the interviewees, however, the joy and excitement of learning at the college and university level in the company of like-minded friends was in itself immensely rewarding and satisfying. Herta Freitag, who spent nearly six years in pursuit of the *Magisterium rerum Naturalium* degree in mathematics and physics at the University of Vienna, recalls a vibrant and happy social life with many classmates, male and female. But marriage was decidedly *not* on their minds. Their view, as she recalls it in those days, was this: "It's all right to have happy little outings together, but no responsibility, no marriage. That's for old people" (Freitag-1: 17).

For most of these women, undergraduate study had offered them their first serious taste of advanced mathematics. For those few women who were engaged or married, their personal lives had taken on a new structure or were on the brink of doing so. But for all of them, the question became pressing: "Where shall I go from here with my life?" For all of these women, whether sooner or later, the answer seemed to be: "To graduate school in mathematics."