social context for her to return to graduate work. It was the mathematics community at New York University that drew her back in.

> Part of me wanted to stay home and just be with the kid. But I also wanted to keep doing what I was doing. I certainly couldn't imagine always staying home, and I was afraid that if I stopped I would cut off those options. I liked the feedback of being accepted as a peer on a work level either in graduate school or afterward. It was very important for my own sense of self. . . . I was getting a lot of good feedback from being involved in mathematics and the work community and the social community that went with it. I was not ready to give that up.

Much of her identity and positive sense of self were tied to the mathematical community. Had that community been discouraging rather than encouraging to her, it would have been harder to maintain the determination, focus, and energy that it takes to balance children with mathematics.

Not all women (nor all men) are so fortunate to find such a supportive community in graduate school. As a result, some leave mathematics altogether, while others continue but are stifled in their development. Some respond by finding alternative communities. Judy Roitman, for example, was a graduate student at the University of California at Berkeley. Because it was a difficult place to be a woman in mathematics, she developed a secondary community at the University of Wisconsin, where she found a stimulating group of mathematicians in her field and a female mentor. She also became actively involved in the newly formed Association for Women in Mathematics.

Vivienne Malone-Mayes was one of the few women interviewed who had a distinctly negative experience at the beginning of graduate school. Being both black and female made her doubly isolated. As she recalled, "Although there were two other girls in the class, they avoided me like I was some sort of plague, because if you're not a white woman, you can't associate with anybody except maybe handicapped men." As time went on, she became more accepted in the community, but Malone-Mayes was never able to develop the same kind of professional support network for research that other women interviewed for this book did. It is likely that this had an impact on the number of research publications she later produced. There were certainly other factors that influenced the amount of research she was able to do; she had other priorities, other commitments, and other pressures. However, when she did receive support, for example in the form of a graduate scholarship from the American Association for University Women, it had a tremendous influence on her belief in herself, and her determination to pursue graduate work despite the obstacles she encountered. At a professional level, she might well have

benefited from the kind of network that Fern Hunt found in New York among black mathematicians. Instead, Malone-Mayes faced almost complete isolation as both a woman and an African American in mathematics at Baylor University. That isolation took its toll.

Finding a Job

Neither initial access to mathematics nor early training accords with the image of a mathematician as a loner, particularly among women mathematicians. But what about once one is a certified mathematician?

Even here, we see that mathematics is in fact a very social activity. Almost all of the women interviewed said that forming connections with a critical person or group of people in their field was key to their success in mathematics. This could be an advisor, a mentor, a patron, or even a small group of powerful people. Such a person becomes one's advocate and plays a major role in establishing and promoting one in the mathematical community. The first time this comes into play is in finding a job.

It is often assumed that getting a job after graduate school is based purely on merit, but the reality is quite different. As Karen Uhlenbeck points out, connections are extremely important:

> That's how you get a job. It's really bad the last few years. There were no jobs for a while, so that wasn't good. It hasn't gotten any better in the abstract because every place like this gets 750 job applications. We can't process that. So you hire people that you hear about—which means that your pals call you up. So it's gone back to the "good old boy" system without any question because we can't handle the paperwork. Nobody really desires that. We would like to look at the applications and decide who is more suitable to the department. For instructors you want people you think are good combined with people who are suited to the research environment here. You don't pick necessarily the best people. You pick the people that you think will fit in and will benefit. [But because of the paperwork], you hire people that you know. For instructors it's pretty much who your friends are out there, because they haven't even had the opportunity to publish their work.

Advisors play a critical role at this stage; they act as mediators between the recent graduate and the mathematical community by promoting their students and helping them gain public recognition.[15] Therefore, *who* one's advisor is, and how well connected he or she is to the mathematical community, are quite important.[16] Many interviewees stated that when young mathematicians were looking for a job, their advisor would get on the phone and call friends and colleagues. The assumption was that the

favor would be exchanged in the future. It was considered shocking and embarrassing to have to actually go out and apply for jobs. That's not what strong candidates did.

Mary Ellen Rudin, for example, has never applied for a job in her life. R. L. Moore, her advisor for both undergraduate and graduate school, made all the arrangements for her first position at Duke without even consulting her. She knew nothing about it until she was informed that that is where she was expected to go. Another colleague later arranged for her to receive a fellowship for which she had never even applied. These behind-the-scenes informal arrangements were standard for students coming out of research institutions.

The informal nature of these avenues for finding jobs must be stressed. It is the "softness" of this process that can make it hard to pinpoint the ways that subtle bias can be built into the system. When recommendations are made by word of mouth, or unsolicited comments conveyed, there is often no paper trail to document inequity. How a senior person feels about a student can play a powerful role in the student's future, yet the student may have no knowledge about these behind-the-scenes discussions. One woman interviewed, for example, who is now a highly respected mathematician, was suggested as a candidate for a position at a prestigious Ivy League institution shortly after she finished graduate school. Recommendations were solicited from faculty members at her graduate institution. Most were extremely positive; however, one senior person wrote a letter saying that she would be at best a good high school teacher, and that they must be out of their minds to think of hiring her. The candidate learned what had happened only because one of her colleagues confidentially told her about it. Fortunately she was able to make sure that in the future the professor in question would not be asked to send a letter evaluating her work. Had she not found out what had happened, her career could have been sabotaged. To what extent did her being female play a role? It is always hard to know; however, it is unlikely that a male who had just completed a respected doctorate at a prestigious institution would be described as fit to be only a high school teacher. How one is perceived plays a critical role in one's future, yet women are often perceived differently than their male peers.[17]

Professional Development

The significance of connections to the mathematical community continues even after one has a job. An advocate—someone who can "vouch for" younger and less established mathematicians—can smooth the transition to the larger mathematical community. This is particularly important for women because they are more likely to be initially viewed with suspicion.[18] Such advocates help bring women's names to the fore not only in the context of job opportunities, but also as invited speakers at professional meetings, for important committees, as journal editors, and for awards.

In addition, the mathematical community guides one not only through the highs, but also through the inevitable lows of mathematical research. It helps by supplying both intellectual and emotional support. Karen Uhlenbeck:

> I tell my students that the most important thing, if you want to keep doing mathematics, is that you establish mathematical contacts. Even if you don't need to work with them, you're going to get depressed sooner or later and you're going to need some sort of input. . . . Whether people stay as research mathematicians or not, I think the big item is that they have some contact in the mathematics community of a personal nature. That sounds weird because mathematicians are crazy. They work by themselves, and you think of them as sitting in their room working by themselves, but every mathematician hits bad points. And how do you get over it? Somebody has got to come along and say, "Cut it out, kid." Or somebody has to come in with a new idea and hit you on the head with it. I see young people who always think they want to go to a place where there's a lot of action and a lot of ideas going on. I think the only benefit they really get from that is that they make strong relationships. Some mathematicians are social. Some mathematicians work together, but a lot don't. What happens to the people who go out and work in isolation? I think nothing, except that you're bound to hit a bad point and then how are you going to get over it? . . . There are people who sail through and nothing ever goes wrong. Normal people aren't like that.

In this sense, the mathematical community serves as a kind of protective net for those walking the tightrope of research. Great achievements require great risk; the net limits injury when one falls off, and gives one the opportunity to get up and try again. This is as true for men as it is for women.

It would be tempting at this point to argue that while being a mathematician may be social, the actual doing of mathematics occurs in isolation. That is, connections can be helpful in all the external ways mentioned above, but when it comes to actually working on mathematical problems, one is essentially alone. But in reality this division is not nearly so clear-cut. Doing mathematics involves discussing new ideas, new problems, and one's current work with other people. Often there is not a simple dividing

line between what is done alone and what is done with others. For example, Fan Chung describes the role of the renowned mathematician Paul Erdos in her mathematical activity:

> Erdos has great intuition. When I'm trying to prove a theorem he will immediately say "No," that I'm not going in the right direction, and after a while he'll push you in the right direction. Intuition is very important; otherwise you will try so very hard to prove something which is not true. It saves you a lot of energy, and he's great at pushing and pushing. When you finally think you're done, he's asking you another bunch of problems.

Marcia Groszek echoes this theme when she describes how important ideas for her thesis (and later research) grew out of ongoing mathematical discussions with a few close colleagues and mentors:

> I got academic support from a combination of people when I was writing my thesis. Gerald [Sacks—a professor at MIT] got me going in the right general direction. Ted and Peter [fellow graduate students at Harvard] gave me the ideas and questions that became my major theorem. Ted and Aki [Kanimori, an assistant professor at Harvard] gave me literature to read. It was Ted that I talked to on a day-to-day basis. I would wander over into the next alcove and tell him what was not working and what was working.

In the end she says, "I think working inside the mathematical community is really key. It's the place where I get questions, appreciation, and can share what I've found. I've had a lot of help and support from different people."

On a practical level, collaboration can be extremely productive. For not only are the relationships rich in feeding mathematical excitement, they also serve as a kind of living library. As Fan Chung, who has co-authored more than 170 papers, says, "It's a wonderful relationship. It's a little more than just friends. . . . My co-authors are my best teachers. You really learn how to actually use them. You learn a lot of proven theorems, known results, as well as how to actually use those results. You really see the action when you collaborate with other people."

This kind of intellectual interaction with colleagues plays a significant role in the lives of many male mathematicians as well. Dr. Leonard Adleman, a distinguished mathematician at the University of Southern California who helped develop a completely novel way of sending secret "unbreakable" codes, said that his best-known work grew out of an intense collaboration with two colleagues. Indeed, the problem that made him famous was one that did not strike him as particularly interesting. However, as he says of these two mathematical friends, "They would talk

endlessly about it and because we were all together so much, we would discuss it."[19] That kind of social interaction was critical to his professional accomplishments.

Even Andrew Wiles, who is one of the most extreme cases of relative isolation, had one colleague (who was sworn to secrecy) with whom he spoke regularly about his ideas. And many of the important tools Wiles used in his proof were developed by other contemporary mathematicians. Had he not known about their work, he would not have made the profound breakthroughs that he made. Despite his desperate desire to solve Fermat's Last Theorem completely on his own, in the last stages of his work he relented and brought in a collaborator: "I was very tired. I'd been working very hard, and I needed someone to check every statement I made. I needed someone to talk to all the time." He had the option of tapping the mathematical community whenever he needed or wanted to. Thus, while the ideal of isolation has a powerful hold, it rarely is an accurate reflection of how mathematicians work. Nor is it clear that it is beneficial to productivity.

Given how important these connections to community are, it is not surprising that almost all of the women interviewed had formed a network of colleagues who contributed to their success.[20] The reality, then, is a far cry from the image of a loner cowboy.

These findings are corroborated by other studies in science more generally. Mary Frank Fox, for example, documents that collegial connections are one of the best clues to productivity. Her findings also indicate that men, in general, have more access to collaboration than women.[21]

The Impact of Imagery on Women

One problem, then, with the image of the loner mathematician is that it can hurt those who take it too literally. It masks how important one's ties to the mathematical community are, and can be detrimental therefore to those who believe it—those who do not develop and seek out such connection.

However, even when women do recognize the need for such connection, it is often more difficult for them to create it. The very fact that they are women casts them as "others," a hurdle they must constantly jump over with new people in the community. It is harder for women to develop an easygoing professional relationship that is also comfortable personally.[22] As Marcia Groszek said, "Participation in conferences is half professional and half social. It's not as easy to fit in and socialize if you're only