Athena Unbound

The Advancement of Women in Science and Technology

Why are there so few women scientists? Persisting differences between women's and men's experiences in science make this question as relevant today as it ever was. This book sets out to answer this question, and to propose solutions for the future.

Based on extensive research, it emphasizes that science is an intensely social activity. Despite the scientific ethos of universalism and inclusion, scientists and their institutions are not immune to the prejudices of society as a whole. By presenting women's experiences at all key career stages – from childhood to retirement – the authors reveal the hidden barriers, subtle exclusions and unwritten rules of the scientific workplace, and the effects, both professional and personal, that these have on the female scientist.

This important book should be read by all scientists – both male and female – and sociologists, as well as women thinking of embarking on a scientific career.

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Graduate education is not a smooth continuum, with a steady rate of 'leakage' from the pipeline, but rather a discontinuous, turbulent flow, with attrition rates rising at certain key junctures (NSF, 1994). We have identified several specific points in the career trajectory when people are propelled forward, pushed out, or dropped down to a lower level. We call these points 'critical transitions.' At the Ph.D. level these transitions are likely to include: (1) the qualifying examination, (2) finding a research advisor, (3) negotiating a dissertation topic, and (4) deciding what is sufficient work for the granting of the degree. Academic transition points sometimes coincide with events in the course of a life time that affect how decisions are made. Thus, for example, a student who is pregnant might have difficulty in finding an advisor, if decision makers view child-rearing and research as inherently incompatible.

The most crucial transition in the experimental sciences is the one from being a student in courses to becoming part of a research environment. A female graduate student described it as an apprenticeship: 'You learn the part of being a physicist through interaction with other physicists.' However, a belief permeates many departments, and is transmitted to incoming female students, that their admission is based on affirmative action rather than merit. Female students' self-confidence is eroded by the attitude of faculty and male peers that women are less competent than men. Rather than promoting interaction as fellow scientists, the attitude towards women can create feelings of incompetence and lack of success. As a

female faculty member observed, 'This support [of the faculty] is key. If you don't have it, if you have people with the attitude that it's their job to fail certain people, then yes, people are going to drop out. Then they wonder, why don't we have more women here.' The ability to negotiate a transition point successfully often depends on access to informal sources of information which are often more readily available to males than females.

Transition processes are not uniform but are strongly affected by degree program organization and structure. The experiences of Ph.D. students vary widely, depending upon the practices of a discipline, university, department or advisor. For example, finding a research advisor in biology takes place through the custom of rotation among laboratories during the first year, which typically introduces the entering student to three professors and their research practices. Some critical transitions are highly structured, with clear benchmarks; others are more informal with loose or shifting criteria. A few Ph.D. programs have recently been reorganized to make transition points more flexible. For example, in some instances a series of written qualifying examinations have been replaced by a research paper and sets of course grades, opening up alternative paths to certify acquisition of sufficient knowledge to undertake a dissertation.

THE U.S. GRADUATE EDUCATION MODEL

In the mid-nineteenth century, when American scholars returned from Germany after earning their Ph.D. they attempted to replicate the advanced education system they had experienced abroad. Not surprisingly, a building project for a domestic institution was often an interpretation of a particular idiosyncratic professor's laboratory abroad. Although U.S. scientists founded research institutes according to the models they had learned in Europe, their efforts usually failed through lack of resources at home.

By the late nineteenth century, when the German-style hierarchical professorship failed to take hold as the model for organizing research and teaching in U.S. universities, the department was invented as a

consortium of, more or less, equals (Oleson and Voss, 1979). The U.S. academic model was based upon a professorial status, with the ability to initiate research, granted early in the academic career.

The department became an association of relative equals, with each professor representing a different aspect of the discipline. The emerging U.S. academic system was much less centralized than the German model, typically built around a single professor. Research was developed relatively inexpensively by hiring students as research assistants instead of using Ph.D.s as in the European Institute model. In time the Ph.D. training process in the sciences was also transformed from an individualized research endeavor, which still persists in the humanities, to a group effort. In an apprenticeship format, an entering student typically takes off from the work of an advanced student and is, in part, supervised by the student whose work they are building upon (Etzkowitz, 1992). Under these collaborative conditions the dissertation is also transformed. Although still presented under an individual signature, the thesis increasingly looks less like a monograph on a single subject and more like a series of co-authored articles on discrete topics.

Some female graduate students assume that the old model of the lone investigator still holds. Often less integrated into their research group than men, they sometimes expect to have to produce a magnum opus for a dissertation. Some male faculty members, who are resistant to women, use this cultural lag against their female students by assigning ambitious projects in expectation of inducing failure. After the supportive social environment that many experienced in their undergraduate training, female students are often surprised at the resistance to their presence in graduate departments. Lacking access to informal sources of information that would allow them to make a smooth transition, women usually find the norms and rules of graduate school opaque and difficult to decipher, placing them at a severe disadvantage.

Contrary to gender stereotypes, female graduate students are often left to be the 'rugged individualists', having to fend for themselves,

while male professors draw many of their male graduate students into a supportive, caring environment. Such coteries surrounding a faculty member, typically including students from many nations and cultures, constitute the basic social unit of U.S. doctoral education. The countries that Ph.D. candidates come from may be at odds in the outside world, but in the research group students, irrespective of their background, are expected to form bonds that will last a career, if not a life time. In the experimental sciences there is typically a common physical site in a laboratory. In theoretical fields the informal social ties that form the basis of the group often originate in a seminar.

THE ILLUSION OF MALE AUTONOMY

Male students appear to be singularly work-directed and able to function autonomously. They are in fact formally and, more importantly, informally very connected to each other, whether in the laboratory, in study groups, at conferences, on the basketball court, or in a bar. The male students receive informal 'mentoring' from male advisors who reflect themselves and see themselves reflected in these students. Even when men do not receive ideal support from their advisor interactions among peers and senior associates provide sufficient connection, feedback and information to shore up their self-confidence, thereby encouraging the capacity for assertiveness and risk-taking.

The existence of these mechanisms for support and connection belies the notion that somehow males are mysteriously constructed to be individualists, devoid of any relational needs. While acceptance of gender differences provides greater richness to complex questions, 'difference' does not indicate two rigidly distinct camps with no common ground between them. This notion gives license to a false perception of a fundamental disparity in personality structure, in which it is presumed that men are automatically programmed to function autonomously and women to be dependent. Such differential socialization is often falsely believed to decide, in advance, who can achieve in academic science and who cannot. But in fact, the way some

male students function may not only reflect learned behaviors and coping mechanisms specific to gender, but also demonstrate the importance of identification with like others, based on subtle acts of inclusion and validation.

THE UNOFFICIAL PH.D. PROGRAM

An unofficial doctoral education process, based upon the establishment of informal ties, runs parallel to the official degree program of formal instruction, examinations and research production. Informal support structures and social gatherings provide information, encouragement and, most importantly, opportunities to learn from peers and role models in unpressured settings. Pick-up basketball games, pub visits with faculty, and study groups with fellow students to prepare for examinations are less open to women Ph.D. students than men in those disciplines where women have traditionally been scarce.

The induction of male graduate students into academic culture usually takes place with great ease. Knowledge is passed on about the informal rules of the game such as finding a compatible advisor and how to gain approval of a feasible thesis topic. This relatively invisible informal side of doctoral training in engineering and the sciences is more readily recognized in other disciplines. For example, it is well known that the motivation for attending a renowned business school to pursue the MBA degree stems not only from the cognitive content of the degree but also from the contacts to advance a future career that can be made during the course. Even when women are admitted to the official Ph.D. program, they are often still excluded from the unofficial, informal doctoral training process.

Women's precarious status has predictable social and psychological consequences that, if not countered, eventually affects scientific work. Particularly during the first two to three years of the Ph.D. program, women experience severe 'anomie' (loss of identity or meaning, a state of being without order), both psychological and social. In this context, a set of rigorous courses has the potential to challenge self-esteem built

on earlier success. Feelings of 'anxiety–isolation–purposelessness' are the psychological counterpart to sociological anomie (Merton, 1938). In this instance, sociological anomie arises from the encounter with male-centered Ph.D. programs which disadvantage female students. A female graduate student described her predicament, 'I felt like I didn't have any back-up support. I didn't know how to pick a topic. The guys talk about that at the bars. I don't go there.'

The themes expressed by entering students revolved around the need to feel connected to others, to feel psychologically safe, to be given a professional identity, to be cared about, to be provided the strategies required to succeed and knowledge of the 'rules of the game'. However, the overwhelming experience of women is that of isolation and disconnection in their departments, and, in the most severely negative academic environments, among themselves. Thus, not only are they an alienated group within the department, they are isolated from each other as well.

Even when a woman was fairly well accepted, she was often excluded from crucial aspects of the graduate student experience. For example, a female doctoral student reported:

> We would all go to parties together and go and have beer on Friday, but if somebody came in to ask what drying agent to use to clean up THF, they would never ask me. It just wasn't something that would cross their minds. Nobody ever came in my office to ask what an answer was. People came in my office to ask the person who was in my room with me. I wouldn't have known if there were study groups . . .

The degree of invisibility of the informal education process is reinforced by a faculty informant who reported that through much of her graduate student career she was unaware that she was being left out of study groups; she simply didn't know that they existed.

EXCLUSION FROM STUDY GROUPS

The unoffical Ph.D. program begins with the formation of study groups

of peers, considered by students and teachers alike as the best way to prepare for doctoral qualifying examinations. This informal counterpart to the course structure consists of regular meetings of small groups of students in a department. Such groups provide a non-evaluative arena for thinking about complicated theories and articulating the jargon of the field. Technical knowledge is reinforced through discussion and informal presentations in these shadow structures to coursework and the qualifying examination. Departmental lore as well as other tacit knowledge is shared about faculty interests and idiosyncrasies that are likely to be transmuted either into exam questions or gaps in the examination regime. We identified some degree of exclusion from study groups in virtually all departments studied.

Participation in study groups and other social networks of peers in the department and the broader scientific community is an essential element of expected future success in science. An isolated individual has fewer intellectual possibilities. As one informant put it:

> If you're not in that scientific conversation then you're stifled. You can't get any help and you can't progress as far. Sitting and talking about scientific issues makes your brain work. Your creative juices flow and that didn't happen for me as a woman because discussions didn't occur. What was hard was that I was in class with all these people, and often getting better grades, and they knew I wasn't stupid, but it didn't matter. Oh, it was very isolating.

This exclusion from participation in study groups is not only personally painful but also removes access to a crucial component of graduate education.

QUALIFYING EXAMINATIONS

All students are concerned about qualifying examinations. However, women and men cope differently with this anxiety. Women tend to internalize difficulties and resort to self-blame, in contrast to men,

who externalize and blame outside forces. Moreover, women are more likely to buy in to the likelihood that they will not pass. In the instance below, this student did not accept the self-fulfilling prophecy of a professor:

> [He] said, 'I think you should take them very soon so that you can fail them and then we can figure out what you need to do to pass.' I was struck that he expected me to fail, [that] someone can be that overt to me about their prejudices. I was able to go back to this person and say, 'You know, I was thinking about your strategy and what I prefer to do is figure out what I need to do to pass and then take them.' He actually became one of my biggest allies and was throwing questions at me once a week and I passed.

Another woman described her success in the candidacy examination as giving her a very strong push to complete the Ph.D. She felt that the experience raised her scientific maturity and provided '. . . reassurance that I can complete a task.' Too often many women absorb the message that they cannot pass these examinations and elect to leave, particularly when they have failed once. A female graduate student said, 'I had very little expectation to pass and everyone had told me all along, you may get in, you can do the work, but you'll never get through those exams.' We suspect that the largest number of drop-outs may come either prior to the qualifying examinations, or even more likely, after one failure.

On the other hand, women who pass their qualifying examinations at the first attempt report a tremendous boost in self confidence. The successful experience with the examination is taken as proof that they will make it through the program. Often graded blindly, the qualifying examination comes closest to being a gender-neutral element in the Ph.D. program. Even when responsibility for its sections is handed over to a group of specialists in the field, the qualifying examination is a collective review. This, perhaps, explains why minor changes are always being made by professors in the department, 'especially in the qualifying exam'.

FINDING AN ADVISOR

Finding an advisor to work with is essential to attaining the Ph.D. degree. Students are expected to develop a close working relationship with their faculty advisor, a relationship that lasts several years and is crucial to the progress of the student through the program and out into the professional world. Yet entry into a relationship with an advisor is charged with ambivalence and ambiguity. Ph.D. students undergo a transition from a classroom to a research environment where they must learn to follow instructions and, virtually simultaneously, learn to make their own decisions. Thus, the content of the advisor–advisee relationship is likely to be even more significant, and more difficult, than the process of establishing the initial connection. Although it is presumed that the advisor has the most knowledge of the area of study, in reality the student soon accumulates a greater knowledge base in the particular area of their dissertation research. An imbalance between power and authority often emerges, in which near-absolute control rests with the advisor, even as the student's knowledge increases.

Despite the official existence of a committee for each student, most of the Ph.D. process is under the control of the individual advisor who has great leeway in defining the Ph.D. program for their students. The advisor decides what constitutes acceptable research for the dissertation and determines satisfactory progress.

A former student who had attained the Ph.D. discussed the necessity of developing strong ties with an advisor to reach that goal, especially given their discretionary authority. She said, 'One of the good and bad things about research universities is that the professors aren't really given guidelines . . . to turn students into scientists.' A female graduate student referred to the power of the advisor explaining, 'Most of the rewards come through the professor.' Despite the existence of a larger committee and even department-wide reviews of all students, there is great reliance on the opinion of the advisor. The advisor retains the authority to make the final judgment; the other professors on the committee are essentially there to support the advisor's decision.

The quality of the ongoing advisor–advisee relationship is crucial to

the student's success. Difficulties in establishing a good relationship or deterioration of an existing one are signs of potential trouble in attaining the Ph.D. Without encouragement from a good advisor, a student can be lost and waste valuable time and effort. There is a great strain in having an advisor who is unable to provide guidance or shows a lack of concern with a student's progress.

For example, a physics student attributed her lack of direction to an inattentive advisor who was difficult to arrange to see, owing to a busy schedule. Their relationship deteriorated and the lack of contact contributed to the slow pace of her work. Even though she had found an advisor, the relationship did not provide the assistance needed.

Advisors have virtually complete freedom to make their own decisions, with the expectation that they will be supported by their colleagues. This situation can sustain both successful advisor–advisee collaborations, or contribute to a breakdown of relations without likelihood of repair. A student who developed a good relationship with her advisor used the advisor's help to plot a course which made the transition into research seem less abstract.

She explained ' . . . You have to know what you will be doing', and she described a 'settling in' process, a 'transition within the transition' in which, ' . . . as soon as I figured out what I wanted to do, I was happy with the work.' Having been appropriately guided, she did not 'float', the term some women applied to their state of lack of advisorial direction and support. A transition with a positive resolution left this student engrossed in research and finding satisfaction in her work.

Negative interactional patterns between male advisors and their female graduate students have been identified that, ' . . . [lessen] their opportunity for advancement' (Fox, 1988: 226). We also found a series of gender-related blockages to successful advising. Sometimes, there was an attempt at equal treatment based upon the faulty assumption that women had been socialized and educated the same as men. At worst, women graduate students were stereotyped as less capable and uncompetitive and were viewed as non-scientists. Such advisors simply could not take women seriously as graduate students. On the

other hand, some male advisors were markedly more successful with their female advisees than some women faculty members.

We identified female experiences with male advisors ranging from the denigrating to the supportive. On the negative side are interactions that leave women with doubt about their self-worth. Even though this advisor probably thought that he was allaying concerns, the effect was the reverse. 'He said to me, "You don't have anything to worry about, they want women; so you'll pass [the qualifying exams]." You have the feeling, "Am I here because I'm a woman or because I am qualified?" It's like they take away all your achievements.' Women also discussed specific incidents in which their gender led to presumptions of lack of scientific ability.

For example, a female student was talking to a professor about her research problems and he said she was an 'emotional female'. She recalled, 'I couldn't believe he was thinking that. Maybe he was thinking I shouldn't be in physics. I always thought he was a nice guy. That's when I feel it: I'm out there on my own.' Male faculty members can exacerbate or mitigate the effects of traditional female socialization, depending upon their awareness, sensitivity and political stance on sex roles.

Most women are not socialized to understand the political strategies necessary to advance within the academic system. Without an advisor who is willing to encourage and direct, women are often unable to puzzle out the strategies necessary to get through graduate school. Women report that the best advisors are encouraging, give concrete directions and show them the ropes.

A women faculty member called attention to women's relative lack of knowledge of how to negotiate the academic system, explaining that many women lacked a strategy to deal with the admissions process:

> What you're supposed to do is get a hold of the brochure and if you want to get in at least say that's what you want. The women don't seem to have grasped that . . . the men go down the list and say, I want to work with this professor for this reason, that professor for

> that reason . . . the females give me no indication that they have even looked at the brochure.

This female faculty member suffered a particular sense of conflict since, in her own graduate career, she had taken a pragmatic approach, putting aside her own intellectual interests until later and pursuing her professor's research to get the degree in good time.

Attempts to find an analogy to the traditional female role for women in the laboratory are part of the notion of science as a 'male milieu' in which women's presence is viewed as disruptive and threatening. A chemistry professor used analogies from cooking in his discussion with a female student. (In a Japanese laboratory, the female graduate student took over tea and coffee duties in the secretary's absence.) These 'degradation ceremonies' may be followed up by subtle and not so subtle attempts to eliminate the unwanted presence.

For example, one woman commented: 'When I was trying to get something to work, [my advisor] would come up to me and say, "Did you see it yet?" Everyday he would say, "Did you see it?" I should have stopped it, but sometimes it takes a long time to see what's going on. It was very humiliating.' It is not only male advisors' treatment of female students that affects their situation but also how male advisors instruct their male students to act toward women. A female graduate student said, 'I hear rumors about myself . . . being involved with somebody. [I heard that] a faculty member was advising his students that it might be interesting to have an affair with me.'

Of course, men have also served as successful advisors to women. An offset to viewing women as 'sex objects' can be found in the following instance of advice about how to negotiate the shoals of negative behavior toward women. A sensitive male advisor helped this student make future decisions based on the reality of being a woman within the field:

> His attitude toward women is very understanding, very supportive, without being condescending. He doesn't say 'I understand what's going on,' which is offensive because it's hard

> for a man to understand what's going on. He doesn't bring these issues up, I bring them up. He is very politically aware. He'll say, 'Don't talk to—.' Sometimes [his advice] was because of sexism and sometimes because this person was an arrogant son of a bitch and sometimes because this is a good person, but is just not comfortable with women.

Thus, women and men faculty do not, simply by virtue of their gender, automatically make good or poor mentors for female students.

Faculty who make the best mentors are aware of the different experience of men and women in the Ph.D. education process. They buttress their female students against the 'slings and arrows' of outrageous treatment. Sometimes they are willing to advocate change, going against prevailing conservative academic ethos with respect to academic practices. Traditional academic training programs are usually strongly believed to be meritocratic, even when and sometimes because they discriminate! In the next chapter we discuss the different experience of women and men in a 'male-centric' academic system.