Attrition of Women in the Biological Sciences: Workload, Motherhood, and Other Explanations Revisited

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Women and men enter graduate programs in biology in about equal numbers, but women are less likely to become academic scientists. Various hypotheses have been suggested to explain this higher rate of attrition, most of which cite family issues as the reason. However, medicine successfully recruits and retains women physicians, despite being less family friendly than biology in terms of workload, stress, and inflexible work hours. Both professions are competitive but at different times in a person's career. Competition for entry into medical school is intense, but this period of competition occurs prior to family formation for most women. For women biologists, the most intense period of competition occurs during the search for faculty positions. Many women have partners or children at this time. The increasing competition for academic positions threatens to reverse the gains that women have made into the professoriate in biology, as well as in other sciences.

Keywords: gender, science, medicine, student, career choice

Women are attracted to science, especially biology. In Canada, more women than men receive their bachelor of science degree in the biological sciences, and this has been the case for several years (CAUT 2012). In the last 10 years, women have received at least 45% of all doctoral degrees in biology (CAUT 2012). By the 2008–2009 academic year, women were awarded about half (49.5%) of biology doctorates (CAUT 2012). However, there are fewer women biologists in academia than would be expected, given the number of trainees. For example, across Canadian universities in 2009, 35% of assistant professors in biology were women (CAUT 2012). Those who hold the position of assistant professor have typically been hired within the previous 5 years (e.g., tenure and promotion to the associate professor rank typically occurs in the fifth year; DFA 2012). Therefore, the number of women in this group should reflect the number of doctoral students trained over the last decade, but it remains consistently lower. In addition, there is a decline of about 10% in the proportion of women in master's to those in doctoral programs in biology (NSERC 2010, CAUT 2012). There are more women than men in biology up to the master's level (CAUT 2012). This trend is not unique to Canada. A similar loss of women occurs during training in the sciences in the United States (Goulden et al. 2011). The loss is greatest among married women with children (Goulden et al. 2011).

Recent papers support several explanations for the decline in women's participation in academic science (e.g., Wolfinger et al. 2010 and the references therein, Goulden et al. 2011). Motherhood has been listed as the most important factor that results in women leaving a scientific career (e.g., Ceci and Williams 2011, Goulden et al. 2011). In the United States, women with children are more likely to leave science than are single women or men (having children appears to have no negative impact on male retention in science; Goulden et al. 2011). In this article, I examine the issue of the retention of women in science, focusing on the field of biology, by comparing the attrition of women during training across professions (science and medicine) and across countries (the United States and Canada).

Causes for the loss of women in science

Recent studies have suggested the following as possible causes for the loss of women in science.

Stress and workload. One hypothesis posits that women leave science because it is a high-stress, high-workload profession, which makes it difficult to balance a family and a career (e.g., Goulden et al. 2011). However, if this were true, one would expect that women would also avoid careers such as medicine. Medicine epitomizes a high-stress, high-workload career, in both Canada and the United States (e.g., Myers 2003, Sibbald

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2003, Wansbrough 2003, Schernhammer et al. 2005). However, in both countries, women make up a large proportion of practicing physicians (see NPS [2010] for Canada and AAMC [2011] for the United States).

In Canada, physicians work an average of 83 hours a week, including their time on call (NPS 2010). Women physicians work about 5 hours a week less than men, but they still work more than female scientists do. Most faculty in the sciences work about 50 hours a week in the United States (Goulden et al. 2011), and Canadian academics probably do the same. Even family medicine, which attracts a disproportionate number of women because it is considered more "family friendly" than other subspecialties (Gartke and Dollin 2010), requires a longer work week (NPS 2007) than that of the average biologist. In the United States, female physicians also work more hours a week than female professors (Wolfinger et al. 2010). Nevertheless, despite the stress and long hours, women are flocking to medicine. Women have outnumbered men in medical school classes for several years in Canada (NPS 2010).

More important for this discussion, women not only choose medicine; they stick with it. There is little attrition of women doctors. For example, Ryten and colleagues (1998) followed a cohort of 1722 Canadian medical students for 7 years, 761 (44%) of whom were women. Seven years after medical school, 99% of this cohort was still in medicine. Therefore, women do not appear to be deterred from entering and staying in a field simply because it is a high-stress, high-workload occupation. In science, however, retention is much lower for both sexes. Fewer than 40% of PhD graduates stay in science, and retention is significantly lower for women than for men (NSERC 2010).

Motherhood. Women are not choosing medicine because it manages to be family friendly despite the hours. The medical system in Canada was male dominated for many years (Gartke and Dollin 2010). Some medical practitioners still retain sexist attitudes (e.g., Ferris et al. 1996, BMA 2004). This legacy has left the field with little institutional support for women with families (e.g., Mobilos et al. 2008). These older attitudes help explain why women physicians have fewer children than do male physicians (NPS 2010). Women physicians find it difficult to balance a family and with their career (Mobilos et al. 2008, Parsons et al. 2009, Gartke and Dollin 2010). In Canada, there are no legally mandated policies on maternity leave for female physicians after residency. Women physicians frequently feel that they cannot take time off to be with their children. Although some women physicians have the possibility of part-time work, not all medical practices give physicians that choice. Some groups are understaffed, and women are pressured into taking minimal maternity leave (NPS 2004, Mobilos et al. 2008). In rural areas, there can be enormous pressure on doctors to work long hours (Parsons et al. 2009). During a study of physicians in Newfoundland and Labrador, women physicians commonly used phrases such as "I feel like I am missing out on my child's life," "I feel like my kids are being raised by a babysitter," and "Trying to parent and be a physician is incompatible" (Parsons et al. 2009). This issue is a serious and ongoing problem in the medical community, and it influences the specialties that women choose (Gartke and Dollin 2010).

The plight of mothers in medicine can be contrasted with the comments of 2009 Nobel Prize winner Carol Greider on her ability to combine science and motherhood:

> My lab knows that I am a mom first, and the flexibility that academic science provides makes having a career and a family possible. I can go home when needed, or to a school play in the middle of the day, then come back and finish my work day, or work from home on the computer. The main thing is to find the time to get things done; it is not the hours at work but the overall productivity that counts. Having flexibility takes a huge amount of pressure off.
>
> Grandin 2010

Arguably, medicine is less child friendly than science is.

Women do not leave medicine, despite the difficulty of combining motherhood with this career. In fact, women physicians have more children than do women biologists (Wolfinger et al. 2010). Therefore, it appears to take more than family-unfriendly conditions to drive women out of a profession. Other forces must be interacting with motherhood to push women out of science.

Money changes everything… maybe

If having children hinders the retention of women in science, why has this not happened with female physicians? One hypothesis is that women physicians earn far more than biology professors and can afford high-quality care for children and support for domestic duties. In essence, women physicians can "buy a wife" (Wolfinger et al. 2010).

However, this argument is not as straightforward as it seems. First, women are disproportionately found in family medicine, the lowest-paying specialty of medicine in Canada. The median income for a family doctor working full time is $124,688 (Canadian dollars) per year (Statistics Canada 2010), which is similar to the salary of the average full professor in the biological sciences (CAUT 2008). Assuming a typical career trajectory for both the physician and the scientist, and assuming that both work until they are 65, the family physician will earn about $600,000 more over her career than will the biology professor. However, if the family physician is self-employed, as most physicians are (NPS 2010), she will have no pension and no benefits. Economists estimate that a person needs to save $704,000 to have a pension of $50,000 per year that would last 25 years, assuming a 5% rate of return (Anspach 2011). Therefore, it is not clear that the average family physician has much additional income compared with the average biology faculty member.

Specialists earn more than family physicians do (Statistics Canada 2010). However, specialists typically have heavy workloads and inflexible schedules, especially in the surgical

specialties (NPS 2010). For example, general surgeons work about 100 hours per week (NPS 2010). This is not "family friendly" regardless of pay. Papers detailing the many difficulties for women physicians with children (e.g., Parsons et al. 2009) support the notion that income—even when it is substantial—does not remove the career–family conundrum.

What causes the difference in retention between medicine and science?

A major difference between academic and medical professions is the relationship between the number of job openings and the number of students trained. In biology, the number of trainees is not related to the number of projected vacancies. This lack of strategy has resulted in a global oversupply of academic biologists (see, e.g., Kennedy et al. 2004). Most biology doctorates do not find a job in their subject area (either inside or outside the university), and even fewer (less than 15%) find positions as academic biologists (NSERC 2010). This issue is not a new one (e.g., Kennedy et al. 2004). Medicine avoids this problem by admitting fewer students than are needed to fill the number of predicted openings. For example, Canadian medical schools admit fewer students than there are Canadian residency slots, the next step in a physician's training. Canada has 2576 medical students competing for 2778 residency positions (CMA 2012). Most doctors find employment in their specialty after they finish their residency (Comeau 2010). Therefore, the medical education system provides a relatively secure promise of employment. Most medical students admit that this job security was an important reason for choosing medicine as a career (Harth et al. 1990). The competition for entry into medical school, however, is steep. For example, in 2011, Dalhousie Medical School received 656 applications for 112 positions (a 17% success rate; *http://admissions.medicine.dal.ca/class.htm*). In contrast, admission into graduate school in most biology-related departments is less competitive than entry into medical school (e.g., the minimum criteria for admission to the Medical School at Dalhousie University is higher than that for entry into the Faculty of Graduate Studies; see *http://dalgrad.dal.ca/regulations/iii*). However, competition among biologists for postdoctoral fellowship awards and faculty positions is fierce (CAPS 2009). The anxiety about job prospects is at an all-time high for young scientists (Fang and Casadevall 2012).

Therefore, the period of the most intense competition in these two professions occurs at different times in a student's life. In medicine, it occurs prior to the time most women have children. The average student entering medical school at Dalhousie University is 25 years old (*http://admissions.medicine.dal.ca/class.htm*). In Canada, the average woman has her first child at the age of 28 (Statistics Canada 2008). In science, the most intense period of competition occurs later, when women are in their late 20s and early 30s. As Goulden and colleagues (2011) and Clayton (2011) pointed out, this timing tends to be disadvantageous for women, because by this age, many women have partners or children. Women with partners are less geographically mobile, which constrains their ability to apply for and accept rare faculty positions (Goulden et al. 2011). Women with children may be less able to withstand the financial and geographical insecurity of a series of short-term postdoctoral positions while waiting for a faculty position. Women with children may also find it more difficult to put in the number of hours required to outcompete a large percentage of their colleagues in order to gain a faculty position (Wolfinger et al. 2008, Goulden et al. 2011). Although men are parents too, studies have repeatedly shown that women invest more time in childcare and household duties than do men (e.g., women ecologists; McGuire et al. 2012) and that marriage and children do not have a negative impact on a man's scientific career (Goulden et al. 2011). Some women opt to become instructors at this point—staying in science but leaving the professoriate track. Sixty percent of the instructors in biology in Canada are women (CAUT 2012). However, permanent instructor positions are few; only 6% of full-time biology faculty members are instructors (CAUT 2012), and this number has been declining in both relative and absolute terms over the last 10 years (CAUT 2012). Therefore, competition for these positions is likely to become increasingly stiff, too.

There is evidence that the competition for faculty positions is increasing (CAPS 2009). Data from the Canadian Association of University Teachers (CAUT) show that the number of new full-time positions in the biological sciences (including botany and zoology) has declined by about 20% over the last 8 years (CAUT 2012). Over that same time period, the number of PhDs produced in the biological sciences has increased by 23% (CAUT 2012). This decline in the number of academic positions with the simultaneous increase in the number of graduate students (CAPS 2009) is leading to high levels of job insecurity and extreme levels of competition. Such competitiveness creates a variety of negative impacts on science (Fang and Casadevall 2011, Martinson 2011).

This severe career bottleneck affects women more negatively than men for the reasons discussed above (also see Clayton 2011). In fact, it is likely to be a key factor driving down the number of women in science. The increasing competition for faculty positions makes motherhood during the trainee years difficult, which leads to a loss of women in science. Such a decline may already be occurring. In Canada, the increase in women assistant professors that occurred during the 1980s and 1990s has ended, and there has been a slight decline in the percentage of women faculty (in all disciplines) at the assistant-professor level between 1995 (41.4%) and 2005 (40%) (CAUT 2008).

Evidence from a cross-country comparison: Retention of women in science in Canada and in the United States

Gaining tenure at Canadian universities is not a competition. Faculty must demonstrate a threshold of ability and effectiveness (e.g., DFA 2012). In Canada, the evidence suggests

that once women scientists land their first faculty position, they gain tenure as often as men do (NSERC 2010). However, most studies have shown that women scientists in the United States are less likely to achieve tenure than men are, or more precisely, married women and women with children are less likely to gain tenure (e.g., NSF 2004, Goulden et al. 2011; but see Kaminski and Geisler 2012). Goulden and colleagues (2011) found that women with young children were 27% less likely to be awarded tenure than were married men with children. The differences in the maternity policies between Canada and the United States may play a role in explaining these different outcomes.

In the United States, the standard maternity leave in most universities is 6 weeks with pay (Goulden et al. 2011). Even when they are entitled to more leave, women often do not take it (Villablanca et al. 2011). Women scientists fear that if they take time off for maternity leave, they will fall behind on their federally funded projects, which would decrease their ability to secure future grants (Villablanca et al. 2011). Such attitudes are not lost on female postdocs. Goulden and colleagues (2011) found that 46% of the female postdocs in the University of California system began their program wanting an academic research position, but at the end of their postdoctoral training, only 11% did. For men, the change was also negative but much less so—from 59% to 45%. When they were asked why they had shifted their career goals, most of the women—especially those with children—felt that academic research careers were too demanding and that there was not enough support for those with families (Goulden et al. 2011).

In contrast, maternity leave for women faculty is legally mandated in Canada. Women at Dalhousie University are entitled to 17 weeks of maternity leave, as well as 14 weeks of parental leave at 95% pay (DFA 2012). A further 21 weeks of parental leave is available with partial pay, for a total of 1 year. The parental leave can be taken by either the mother or the father (*www.servicecanada.gc.ca/eng/ei/types/maternity_parental.shtml#much*). Canadian universities typically allow tenure deferral for women with child-care duties (e.g., DFA 2012), and most have on-site daycare (e.g., Dalhousie University's University Children's Centre; *http://ucc.dal.ca*). The main granting agency that funds basic biological research, the Natural Sciences and Engineering Research Council of Canada (NSERC), allows up to 2 years of additional operating grant funding for women on maternity leave, and NSERC granting committees are explicitly instructed to take maternity leaves into account when assessing productivity (NSERC 2011). The main funder of basic biological research in the United States, the National Science Foundation, does not yet have such policies. Therefore, many of the concerns discouraging US women scientists from taking maternity leave (Goulden et al. 2011, Villablanca et al. 2011) have been addressed in the Canadian system. The NSERC system is also one that emphasizes quality and innovation, without excessive competition, and the success rates for established researchers in the biological sciences are above 70% for the basic 5-year operating grant (NSERC 2012). Women are as likely as men to have their national NSERC grants renewed (NSERC 2010). These family-friendly policies may help explain why there is no evidence for a loss of women scientists in Canada once they become faculty (NSERC 2010). These observations suggest that women can and do successfully combine high-quality science and motherhood, as long as supportive practices are in place.

In Canada, the greatest attrition of women, both in total number and relative to men, occurs during the training period from the beginning of graduate school to the first faculty position (NSERC 2010). This is the stage of scientific training in Canada that suffers the severest competition. It is also the stage that receives the least family support. Funded maternity leaves are less generous for Canadian graduate students and postdocs than they are for women faculty. NSERC provides 4 months of funded leave for women graduate students and postdocs (NSERC 2011). There is no federal mandate requiring hiring committees to take maternity leaves into account when assessing a job candidate's productivity.

Increasing family support for women postdocs and graduate students can only help to retain women in science. However, it will not address the more fundamental issue of the dearth of permanent positions. It is this lack that is driving competition for faculty jobs to unhealthy heights. This competition may produce a reversal of the gains that women have achieved (NSERC 2010) in entering academic science.

Conclusions

Why women leave science is a complex issue. This article is not meant to be an exhaustive survey of all of its causes. However, it does demonstrate that long hours, a heavy workload, high stress levels, and motherhood do not appear to be barriers to the recruitment and retention of women in medicine. Therefore, they are unlikely to be the main drivers of female attrition in science. In fact, tenure-track positions in biology have become more family friendly, at least in Canada, which has led to good retention rates for women from assistant to associate professor. More needs to be done in creating a family-friendly work environment for graduate students and postdoctoral fellows.

But even more effective would be greater job security for trainees. In Canada, the job prospects for medical students are excellent, which gives them more control over where they live and how often they move. This job security is probably the most important contributing factor to the greater retention of women in medicine than in science. Although the need for alternative career paths and other methods of enhancing employment opportunities for graduate students and postdocs in biology has been pointed out repeatedly (e.g., Kaplan 2012), it is unrealistic to assume that there are enough nonacademic jobs available in biology for all the graduate students that we are training (CAPS 2009). Moreover, academic positions remain the favored career for most postdocs (CAPS 2009), which drives intense competition.

To reduce this competition, we need to train fewer students. By placing the heaviest competition for a scientific career earlier in a student's life (i.e., entry into graduate school), women would suffer less of a disadvantage. Such a change would require a coordinated response involving granting agencies, universities, and individual professors. For example, universities and federal agencies could offer fewer but better-funded graduate scholarships.

Departments attempting to reduce graduate student numbers would need to develop policies to equitably divide up graduate student positions among faculty members. Unfortunately, many countries are facing a decline in science funding (e.g., the United States; Fang and Casadevall 2012). This decline is likely to increase the pressure on individual departments to accept more graduate students, because they are less expensive than full-time technicians. Perversely, this could lead to an increase in the number of trainees even though the number of academic positions is declining.

The benefits of training fewer students have been promoted before (e.g., Kennedy et al. 2004), but one benefit not typically mentioned is that decreased competition for academic positions is likely to increase the proportion of women choosing science as a career. If we are serious about attracting women into science, this issue will need to be addressed. The increasing competition for faculty positions will select for only the most driven of biologists, both male and female. If no effort is made to change the unfavorable ratio between the number of aspiring scientists and the number of scientific positions, married women and women with children will be increasingly less likely to enter science, which will further decrease the number of women in science. Our success in retaining women faculty shows that it is not motherhood that drives women from science; it is the interaction of motherhood with the corrosive competitiveness that follows from too few positions for too many biologists.

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