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Raising the Bar in Physics Graduate Education

Meg Urry, Yale University (Department of Physics and Department of Astronomy)

The following is adapted from a keynote address given at the APS Conference on Graduate Education in January, 2013.



I am pleased to be addressing (and attending) this conference and I also know this audience is deeply committed to graduate education, so you probably don't need to hear what I am going to say. Nonetheless, I thought a keynote address should be provocative, so I've done my best to push some buttons...

The invitation to speak tonight came shortly after the election last November. Front and center in the news was the Republican party's concern about the shifting demographics in the United States: talking heads and columnists described the vanishing white male, the increasing diversity of the American population, and the sense that modern political parties have to adjust accordingly.

For example, here are some typical excerpts from an article by Michael D. Shear, *NY Times*, Nov 7, 2012:

"Before, we thought it was an important issue, improving demographically," said Al Cardenas, the chairman of the American Conservative Union. "Now, we know it's an essential issue. You have to ignore reality not to deal with this issue."

The Republican Party "needs messages and policies that appeal to a broader audience," said Mark McKinnon, a former strategist for George W. Bush. "This election proved that trying to expand a shrinking base ain't going to cut it. It's time to put some compassion back in conservatism. The party needs more tolerance, more diversity and a deeper appreciation for the concerns of the middle class."

Tom Davis, who used to represent Dale City as a Republican member of Congress, said that the problem for his former colleagues goes beyond just Hispanic outreach. ... "It is time to sit down practically and say where are we going to add pieces to our coalition," he said. "There just are not enough middle-aged white guys that we can scrape together to win. *There's just not enough of them.*" [my emphasis]

The point, in case you missed it, is that physicists can't get away with educating only white men. This has been clear for quite a while. Since 2001 (despite homeland security issues) there have been more foreign citizens in our PhD programs than US citizens. We've admitted them to keep quality high, to keep our physics programs strong. Of course, these foreign students are often European or Asian men, so in some sense, our embrace of diversity has not changed the face of physics very much. For graduate physics education in the 21st century, just like the

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Republican party, we will have to expand our “big tent” to include more diverse participants if we hope to keep quality at the highest possible level.

The analogy to political strategizing is imperfect. Physicists are concerned with attracting the best and brightest to the profession not in order to get votes or stay on top in some power structure but to solve the difficult and complicated problems facing us today, and to ensure that the U.S. scientific enterprise remains healthy (and pre-eminent, or is it too late for that?).

As the population becomes more diverse, it becomes increasingly difficult to justify the selection effects that result in an overwhelmingly white, male student population in our graduate classrooms. Women remain below 10% of active physicists, and no more than 20% in the youngest, most diverse ranks. The latest AIP data (www.aip.org/statistics/trends/reports/physgrad2008.pdf) show women receiving 18% of the physics PhDs granted in US institutions. People of color represent a much smaller fraction; for example, fewer than 3% of US citizens receiving PhDs are African-American and Hispanic. For comparison, together African-Americans (12.6%) and Hispanic Americans (16.4%) represent more than a quarter of the US population. By 2043, according to the US Census bureau, our country will be majority minority.

I am suggesting that graduate education must diversify not because of fairness or equal opportunity, although that certainly ought to concern us, but because it's vital for physics.

Why Diversity is Vital for Physics

The first statement of the problem is simple: if we for any reason exclude from our laboratories and classrooms more than 60% of the population (roughly, half being women, a quarter being racial minorities), we are limiting the bright minds who could bring their talents to bear on some really tough problems. Absent compelling evidence that those excluded are less capable, this is not smart.

But there is an even better argument for increasing diversity and inclusion, based on research on the roots of innovation: there is a competitive advantage in discovery fields to greater diversity among practitioners. As Sheila Tobias pointed out to me 20 years ago (when we wrote the Baltimore Charter after the first conference on Women in Astronomy in 1992), great civilizations have often arisen at the intersection of trade routes, where people of different societies encountered new ways of thinking. That is, the conflict of ideas stimulates new and better ideas.

More concretely, research shows that diverse groups are more creative and develop solutions to problems that are judged – by people unaware of the origin of the ideas – to be better. From the University of Wisconsin's Women in Science and Engineering Leadership Institute's booklet on Benefits and Challenges of Diversity in an Academic Setting, written by Eve Fine (historian of science and WISELI researcher on women and science) and Jo Handelsman (award-winning biologist then at the University of Wisconsin, now at Yale University):

A vast and growing body of research provides evidence that a diverse student body, faculty, and staff benefits our joint missions of teaching

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Note from the Editor, Katy Garmany

I want to acknowledge the excellent work of the other Editors of *STATUS*, who have contributed the majority of the articles to this issue. And I also thank Crystal Tinch of the AAS office, who turns a raw document into the polished final product that you are reading.

We are delighted to include in this issue an article by Annika Peter, now at Ohio State University, who has some very concrete suggestions for dealing with the well-known two-body problem.

I found Urry's article from her keynote address at the APS Conference to be very illuminating: the issue of diversity is rarely addressed with hard statistics, and Meg does just that. And you won't want to miss her story about salt pills!

Morrison's article summarizes a talk at the AAAS earlier this year on the history of women in science, not through their scientific research but through political and legal activity. This article was stunning: I came of age in the 1960's and was almost completely unaware of many of the lawsuits and other activity discussed here.

Hinz's book review of Dorothy L. Sayers' novel *Gaudy Night* reminds us that there is frequently a rich subtext to the stories behind an author. The fictional character Lord Peter Wimsey is familiar to many people, but I certainly knew nothing about the author who created him and the issues she confronted.

As always, if you would like to contribute to *STATUS*, or have ideas for articles, please contact any of the Editors!

and research by increasing creativity, innovation, and problem-solving. Yet diversity of faculty, staff, and students also brings challenges. Increasing diversity can lead to less cohesiveness, less effective communication, increased anxiety, and greater discomfort for many members of a community¹.

Much of this research has been done in a business context rather than an academic or intellectual one, so it may be that the results do not apply in the physics world. However, (a) business organizations hire many physicists, and (b) business organizations are probably more aware than slowly changing academic physics departments of the influence of workplace culture on performance. So I believe this research is highly relevant to what we do.

A typical experiment is to create small groups that are, or are not, diverse in gender, race, class, or other variable(s).

Each group works independently on a set problem. For example, in one management training class I took, we were told our airplane had crashed while off its intended route, probably hundreds of miles from the nearest city; that we had a limited list of supplies at hand (compass, bottle of vodka, salt pills, blanket, mirror, ...), of which we could choose only five; and that each group of 5-6

people should decide collectively what to do. Our group's answer was probably pretty conventional, albeit almost totally wrong: we decided to take off in the best-guess direction (judged from the sun angle, some of us being astronomers), and we decided to consume the salt pills and carry the compass, bottle of vodka and mirror. I remember this quite vividly because I disagreed completely with the rest of the group. I thought we should stay put (someone would report us missing, they'd start a search, they'd get farther with search planes than we could walking) and that taking salt pills was a big mistake (dehydrating), but I was completely outvoted. (You can tell this still stings!) Despite the fact that I had good explanations, the rest of the group all agreed with one another. They had vaguely heard that salt pills were good for desert environments. I explained that this was correct if you took a salt pill and then drank a ton of water and then went to the desert. I also pointed out that it hastened death to drink saltwater if shipwrecked. But what mattered was that their similar opinions reinforced one another. They easily ignored the one outlier (me).

In their article on "Ethnic Diversity and Creativity in Small Groups," McLeod, Lobel and Cox² posed a simple problem related to tourism and asked experimental subjects to brainstorm answers. Experts from the travel

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industry then graded the responses, not knowing which groups produced each idea; they judged ideas from ethnically diverse groups to be “of higher quality – more effective and feasible – than the ideas produced by the homogeneous groups.”

Experimenters also report more strife in diverse groups. It’s much easier to talk to and work with someone who is just like you. But talking to yourself about a difficult problem doesn’t add as much value as talking to someone with a different perspective.

The value of diversity of thought has been demonstrated specifically for undergraduates. When confronted with a variety of different viewpoints, they are more likely to develop “cognitive complexity” (Antonio et al. 2004)³.

Many experiments, with different boundary conditions, collectively find that:

1. Diverse groups experience more conflict.
2. If diversity is welcomed (well managed), diverse ideas lead to better solutions (described in various papers at more innovative, more practical, more original and/or more creative; e.g., Hoffman & Maier 1961; Triandis, Hall & Ewan 1965).
3. If diversity is unwelcome, diverse groups fail.

What is behind these results? As McLeod et al. (1996) explained, “Hofstede (1980) has shown that people of different ethnic backgrounds hold distinctly different ‘world views,’ as measured by the dimensions of individualism-collectivism, masculinity-femininity, power distance, and uncertainty-avoidance.” That is, heterogeneous groups hold a variety of perspectives. This means different ideas come into play, and perhaps the conflict between ideas challenges the group to improve its reasoning. It may also stimulate creativity (e.g., Nemeth 1992). So diverse backgrounds lead to different views and in the best case, to a beneficial refinement and resolution of those conflicting ideas.

The claim that differences among people cause them to think differently is quite controversial – for example, there are reams of articles debating whether women inherently think differently than men. Without entering that debate, I think it is clear that the experiences of men and women in physics are different, as are the experiences of ethnic minorities and majorities. That is, how we approach problems, how we think about solving them, how we engage and mentor

students, how we work with colleagues – in short, how we do our jobs as physicists – is informed by our individual histories. These tend to have been different for men and women, for different economic classes, for racial groups, and so on. So we have a lot to teach one another.

Perhaps we do best when we work with people who annoy us! I try to remember this when someone is really irritating me. “Hmmm,” I think (I hope), “I could probably learn a lot from this person.”

Not all conflict or diversity is beneficial. If minorities are seen as outsiders, their voices are not heard and their ideas do not hold (no one believed me about those salt pills!). This is worse than had the group been homogeneous because there is the burden of conflict without the attendant benefit.

In a nutshell: more conflict plus more ideas leads to chaos (if conflict rules) or superior performance (if conflict is managed). Which situation do we want for physics?

Let me return to the specific issue of graduate education in physics. Our goal is to train bright, young people to be outstanding physicists. It is always easiest to mentor someone who is exactly like you because if you can get inside their head, you know what advice they need to hear. For example, is it good to encourage students (positive reinforcement) or to challenge them (criticism)? My father was a professor of chemistry with a reputation for toughness. His three daughters are scientists yet none of the four women graduate students who worked with him finished a PhD (although at least one went on to a very successful career at Bell Labs, with strong backing from my dad).

Why Diversity Improves a Graduate Student’s Experience and Performance

Think of this issue as “impedance matching” with your students. My father treated his students as he wanted to be treated. That means that when they were going through a tough or indecisive patch, he pressed harder. This had worked well for him. At some low point in graduate school, when his PhD advisor implied that perhaps my dad should give up on his thesis, he came back with a resounding, “No, I can do it!” What he didn’t realize is how others – like me or my sisters – might have reacted in a similar situation. I remember vividly the Thanksgiving dinner years ago, when my older sister (now a biology professor and textbook author) and I told him that kind of approach would have meant the end of our graduate careers. We both knew we would have quit if challenged that way by our advisors. “No, no,” he insisted, “you are both too good to quit.” But we pushed back, and I like

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to think he learned something that day, unfortunately too late for his women students.

So, my dad (who was a great guy with a big heart) was a wonderful advisor for students with his confidence, his sense of belonging, his style of learning. He would have been a disaster as my advisor. What would happen if all professors in a department were like my dad? Or all of them were like me? It's not good for the students.

Another way in which diversity is a benefit stems from the increasing role of teams in modern science. Today it is rare for a "rugged individual" with sharp elbows to make the big contributions. The Large Hadron Collider collaboration has upward of 5000 members, and the Hubble Space Telescope is used by thousands of astronomers world-wide, as will be its successor, the James Webb Space Telescope. Even smaller-scale "desktop" physics is typically done by collaborative groups.

Business, too, depends heavily on groups working smoothly together. Yet, much like physicists, they still hold tight to the idea of the top performer, the miracle man, the great leader – even when research shows women are better team players and leaders than men.

Many physicists still cling to the image of Einstein, toiling alone in the customs office, having brilliant insights all by himself. But that is not how science happens today – and it wasn't really ever that way, even in Einstein's time. Working together well is critical.

Many institutions have made a lot of progress in diversifying. When I started in physics it was very rare to see women faculty; more than half of physics departments had no women. Now, it is rare to find a department of any size without at least one woman faculty member, and many departments have done much better. There are also prominent physics leaders of color, though far fewer. (The numerical reality is that women are within a factor of a few of parity, but under-represented minorities are low by an order of magnitude.) But these success stories – women or other minorities in physics – must be seen as exceptions rather than the rule. Typically they faced higher obstacles and thus probably had to perform at a higher level to succeed.

My colleague Peter Parker – some of you know him (no, not Spiderman, but a long-time nuclear astrophysicist) – told me about arriving at Yale in the 1960s to find all-white-male faculty and AWM students – and, he said, "I didn't even notice there was anything wrong!" He

went on to say, "It's much better now." Indeed, our top students are frequently women (30-40% of our physics majors) and/or minorities.

My contention (no real data) is that top men and women succeed. The difference is one step down, where men can pass through the evaluation filters and women and minorities generally cannot. We will have achieved equity when women of slightly-less-than-world-changing ability succeed as easily as men of similar ability.

Graduate Admissions and the GRE

Let me touch on one more topic about graduate admissions: the physics Graduate Record Exam. Data show that women and minorities score lower on these tests than white men do (see presentations by Ted Hodapp and Casey Miller, this conference). I know that my own score was low, perhaps because I went through a less rigorous physics program than students at, say, Johns Hopkins (where I went to graduate school) or MIT (where I was a postdoc). For example, I discovered that the textbook we used for quantum mechanics my senior year in college was a sophomore-year textbook at MIT. As a first-year grad student at JHU, I took courses alongside their seniors and occasional juniors. On the other hand, low GRE score or not, I was one of only 3 of 12 first-year students to pass prelims that winter. So the physics GRE didn't predict my performance level very well relative to my male colleagues. Perhaps, as is known to be the case for the SAT, a given score predicts higher performance for women than for men.

Other women physicists I know – including incredibly successful, outstanding scientists and leaders – also had low physics GRE scores. There are undoubtedly a variety of reasons for this. One interesting explanation is "stereotype threat," the under-performance of a group because of a negative stereotype rather than lack of ability, a field developed by Claude Steele and colleagues. The classic experiment is as follows: a class is told they are to take a very difficult math test. The men score an average 25 of 100 points on the test; the women score 10. Some journalists would stop right there and write yet another article about how women are not as good at math as men. As Larry Summers famously put it, at the high end of the distribution of abilities, men vastly outnumber women. (He neglected to mention that Japanese women out-perform American men, or that the gender difference within the U.S. has changed markedly over a 30-year period, ruling out any kind of Y-chromosome-based explanation.)

What Steele and company did instead was to repeat

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the experiment with one small change: they typed, “This test was designed to be gender neutral” at the top of each test. Now the women score 20 of 100 points, double their previous score. Interestingly, the men’s average score is the same, 20/100, the idea of gender neutrality somehow having suppressed their performance. In any case, the gender gap is gone.

These experiments are repeatable, and subsequent testing turned up other interesting results. The gender gap is exacerbated when the stereotype is activated or emphasized. If you were to say to your students that women generally don’t perform very well in physics – well, you would probably cause the performance of women in your class to drop. A similar effect is seen for under-represented minorities in science and math. Note that these gaps occur regardless of the educational background of the students; even those who have performed well in rigorous programs can be induced to under-perform under the pressure of negative stereotypes. Now think of the atmosphere of a graduate physics cohort that includes very few women or minorities: the subliminal (and sometimes explicit) message is that those minority groups are not top performers in physics. Lo and behold, perhaps this leads to low GRE scores and issues with qualifying exams.

The dominant skill the physics GRE tests for is the speed at which the test taker does physics problems – which measures familiarity as much as understanding. Indeed, it favors rote learning over conceptual thinking. There are way too many questions for the time allotted. We use the GRE because it is quantitative and standardized. It provides a uniform way of measuring something about students, independent of the vagaries of their institution’s grading or letter-writing practices. But does it actually measure what we want to know?

There are many qualities needed by a successful physicist, which each of us has in different measure: intelligence, curiosity, creativity, determination, persistence, openness to new ideas, speaking ability, writing skill, ability to multitask, integrity, teaching ability, sense of the big picture, willingness to ask questions, ability to work with others, etc. Qualities that are sometimes used as proxies for excellence but in my opinion have little to do with the ultimate impact of one’s work: aggressiveness and assertiveness, as well as how little sleep a person can get away with.

What qualities does the physics GRE score correlate with? As reported at this conference by Frances Hellman (UC Berkeley) and Casey Miller (U Central Florida), performance in graduate school is uncorrelated with physics

GRE score, for scores above roughly the 30th percentile. Some students with low GRE scores turn out wonderfully well, while some with high GRE scores wash out. Nor is performance correlated with Verbal or Quantitative GRE score, or with GPA in college, or with any other easily reported variable. Perhaps this should not surprise us, given the range of qualities that affect a scientist’s work.

At the same time, the dependence of GRE scores on gender and/or ethnicity suggests that the physics GRE is not an unbiased indicator of performance. Using the same cutoffs or ranges as for white male students will unnecessarily exclude diverse students who will perform comparably.

Diversity After Graduate School

I’ve talked a lot about the diversity of students entering graduate study. Let me finish with just a few words about the diversity of outcome: not every student will become an academic. There are obvious reasons why the academic route is better for the advisor: her work will be multiplied, her papers will be referenced, her students will send her their protégées – in short, her career will be helped. Having worked in both a laboratory environment, at the Space Telescope Science Institute, with minimal access to students, and in a university bursting with excellent students, I can tell you it’s much easier to be productive with students.

But not all students are well suited for the academic track, which they will realize along the way. Encouraging their aspirations is our job. We should train them well to do whatever physics-y thing they decide is their direction. I almost said “their passion” but that goes back to the medieval priestly version of academia. Indeed, at the same 1992 Conference, Sheila Tobias described the origin of the modern academy in medieval monasteries, and the persistence of that culture into the culture of physics today:

- “Calling” – priests/physicists are born to the profession, or not; it’s not something you can learn to want to do, or learn to do better.
- “Dedication” – physics takes precedence over everything else; you must devote every waking hour to it.
- “Celibacy” – god forbid you should have a personal life, like a partner or a family.

Does this sound like the physics profession? I contend it’s not a good template (though it may explain why the template attracts white male dominant populations). The truth is: people can come late to physics and find amazing things, they can learn (as opposed to always knowing how to do everything), and many, many physicists have combined work with family life. So the monastery is the wrong model.

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The analogy works in this way, though: if an older monk mentors an apprentice monk, he feels a failure if the apprentice leaves the monastery. The term itself – “non-academic” careers – clearly reveals our bias toward keeping our protégées in the priesthood. We will have other talks about this so let me make two quick points:

We should help our students succeed regardless of where they go. (Professors, colleges: your future endowments are more likely to come from outside academia.)

This means we need to train students broadly, beyond the standard Mechanics-E&M-StatMech-Quantum skill set. Actually, management skills will probably help students in standard academic positions as well.

Final Words

We are fortunate to work in an important, exciting field that we love and to be well paid (even graduate student salaries exceed the poverty level for a family of four). Let’s also remember that we are ideally suited to better the world. I’ll end with one final anecdote:

Two weeks into the fall term, shortly after I became department chair, one of the incoming graduate students asked to meet with me. She was thinking of leaving graduate school, she said, because she wanted to “help others.” She had spent the summer working for a non-governmental agency in South America, and felt that was much more valuable work for the rest of humanity than solving the fluid equation.

For a quick moment, I saw her point – saw how it looked to her – and I realized in that same instant that we are teaching students that what we do is an intellectual exercise, gratifying to ourselves and other weird creatures like us but not ultimately useful to others.

This is wrong. As the provost at a large Midwestern university once said to me (he was an economist and son of a physicist), “Physicists are a lot like economists. They think they are the smartest people on the planet; they think that if they have not addressed a problem, it has not been solved; and they think there is no problem they could not solve.” Sounds about right. ;) So let’s put our money where our mouths are: let’s teach our students that they can solve the problems of the world, that physics tools are essential. Look at climate change, global warming; biological systems; even finance: physicists are there in the thick of it (for better and worse). There is nothing we can’t do. Even if you won’t go quite that far, we can do

as much or more than anyone to address the challenges facing this nation and the world. So let’s find students who reflect the constituency and interests and concerns of the world, and equip them to make the world a better place.

¹ This conclusion was based on papers by Manzoni, Strebel, and Barsoux 2010; Herring 2009; Page 2007; Putnam 2007; van Knippenberg and Schippers 2007; Mannix and Neale 2005; Cox 1993. Other key references: Nemeth 1995, 1986, 1985; Schulz-Hardt et al. 2006; Sommers 2006; Antonio et al. 2004, and McLeod, Poppy; Lobel, Sharon; Cox, Taylor (1996). Full citations can be found here: http://wiseli.engr.wisc.edu/docs/benefits_references.pdf, which is the reference list for the WISELI publication, *Benefits and Challenges of Diversity in Academic Settings*.

² McLeod, Poppy; Lobel, Sharon; Cox, Taylor (1996). “Ethnic Diversity and Creativity in Small Groups.” *Small Group Research* 2(27): 248-264. <http://hdl.handle.net/2027.42/68515>

³ Antonio, A. L., Chang, M. J., Hakuta, K., Kenny, D. A., Levin, S., Milem, J. F. (2004). *Psych. Science*, Vol. 15, No. 8, p. 507-510



Women Who Changed Modern American Science

Nancy Morrison, The University of Toledo (Department of Physics and Astronomy, retired)

The Boston meeting of the American Association for the Advancement of Science (AAAS) in February, 2013, included a session on the history of women in science¹. This

article summarizes the presentation by Margaret Rossiter, which was entitled “Thirty Women Who Changed American Science, 1970–2010” and was based on the third in her series of books, *Women Scientists in America*. It described the changes these women wrought, not by means of scientific research, but rather by means of political and legal activity. Every woman who began a career in science in the 1970’s and later owes them a great debt.

Rossiter opened by remarking, “It goes without saying that we live in historic times.” In all fields of science, both the percentages and the absolute numbers of women students and degree recipients are rising. Employment is also going up, partly as a result of epoch-making legislation passed in March and June 1972. Before that time, nonprofit organizations, universities, and governments were exempt from equal-opportunity cases; their employees had no standing to sue. The Equal Employment Opportunity Act of 1972² changed this situation. At the time, it received virtually no publicity, and even avid newspaper readers were barely aware of it.

Then in June 1972 was passed the Education Amendments Act, also known as the Patsy Mink Equal Opportunity in Education Act. It includes Title IX, which made it possible for the federal government to investigate such things as admissions quotas, athletic scholarships, and stipend levels. Quotas of all kinds were common at that time. Universities were arrogant about these policies. In retrospect, their self-interest might have been better served through voluntary change, which might have kept the federal government out of their affairs. As it was, these laws had powerful effects on all women in science, especially mid-career women who were confronting glass ceilings.

Enforcement was crucial. Universities are powerful, have influential organizations in Washington, and might have been able to stymie enforcement. But, in the 1970’s, many activists, both paid and volunteer, were watching employment issues. Journalists were interested. Petitions

were signed.

Recognition issues also came to the forefront, even when not legally mandated. Among the most visible markers of change were women who became scientific society presidents, university chancellors, and Presidential appointees.

Young society members learned the system, got on nominating committees, and made sure women became candidates for society offices. Rossiter presented a long list of women presidents of scientific organizations. Noteworthy among them is Mina Rees, the first woman president of the AAAS, elected in 1971. Bodil Schmidt-Nielsen became the first woman president of the American Physiological Society in 1975. In an autobiographical essay, she later wrote that she was embarrassed because her candidacy was actively promoted by the younger women in the society rather than by the senior men. C. S. Wu was elected the first woman president of the APS and Margaret Burbidge of the AAS in 1975 and 1976, respectively. The last to be the first woman president of a scientific society was Doris M. Curtis, who was elected president of the Geological Society of America in 1991. In some societies, a long gap occurred between the first woman and the second, while other societies have frequently had women presidents.

Some of these women were elected in the year in which the Equal Rights Amendment was on the agenda of the organization, and they were charged with promoting it. Many were not interested in politics and were not comfortable in this role, but their duty was to represent their organizations.

In terms of highly visible appointed positions, the first big breakthroughs occurred in 1987, when Donna Shalala became the president of the University of Wisconsin and Maxine Singer became the president of the Carnegie Institution of Washington. The first Chancellors of universities in the University of California system were also appointed in 1987.

But the highest-profile positions of all were Presidential appointees. One was Marina von Neumann Whitman, who was appointed by Richard Nixon to the Council of Economic Advisers in 1973. Although a Presidential

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continued

appointment was a triumph for women, it could be uncomfortable, because these women went to offices that had never had women leaders before. Although Whitman was not a feminist activist, she did a lot to help other women in the federal government, and having her there was a significant step forward.

At the same time, Eloise E. Clark was at NSF. Gerald Ford appointed a few women, and Carter more, including the young Donna Shalala. Under Reagan, Bernardine Healy became the first woman head of the National Institutes of Health (NIH). George H. W. Bush appointed only four women in four years. Clinton appointed quite a few; he was “one of the biggest glass cutters of all time.” George W. Bush was responsible for only three names in eight years. Obama has made several female Presidential appointments, and he still has time to make more.

Now let's focus on the list of thirty during the period 1970 to 2000, which includes some names already mentioned. Some are no longer living. Future generations should know about these women because they still make a difference today. The highest accolade goes to six women who fought lawsuits, which dragged on for six months to ten years and were “lonely, expensive, and exhausting.” Among the few who won major victories were Julia Apter and the Association for Women in Science (AWIS), who sued the Department of Health, Education and Welfare in 1971-1972. Getting standing to sue the US government was a breakthrough. The immediate result was a dramatic increase in the number of women on NIH grant review panels.

June Chewing took on the Energy Research and Development Administration (ERDA) (now called the Department of Energy). By collecting data, she showed that the agency was really an old boys' network with a strong buddy system, so that women were always in junior positions regardless of qualifications. The Justice Department agreed fully, giving her a victory just on the basis of statistics.

Louise Lamphere led a class-action lawsuit against Brown University in 1977, alleging that the university had discriminated against women in the awarding of tenure. Needing to start a fundraising drive and not wanting a lengthy lawsuit, the university president settled quickly.

Shyamala Rajender v. University of Minnesota was a big case. She started alone, and then it became a class action lawsuit, won in 1980. The whole state university system

was placed in the charge of a special master for years until many women were hired, especially in science. Retroactive to 1972, the award shows the influence of the laws that were passed that year.

Typically, the outcomes of these lawsuits were generous to future hires: grievance procedures and improved hiring protocols were instituted, managers were retrained, and so forth. But those who sued received only minimal financial settlements. These women deserve biographies or honorary degrees but probably won't get the latter from their universities.³

Rossiter's next group of noteworthy women are fifteen who led caucuses and other organizations. In particular, she mentioned: Alice Rossi, one of the founders of the National Organization for Women (NOW); Janet Welsh Brown, the first head of the AAAS Office of Opportunities in Science; Bernice Sandler, who worked with NOW and with the Women's Equity Action League (WEAL) and made the first suggestion that led to Title IX; Abigail Stewart, a psychologist who runs the ADVANCE program at the University of Michigan in Ann Arbor; and Betty Vetter, Executive Director, Scientific Manpower Commission, which was organized by the AAAS and other major scientific societies.⁴

These women got grants, hired staff on soft money, put out newsletters, spoke to the media, testified before Congress, and ran meetings. They cemented the connections between organizations in Washington and grass-roots activists on campuses and other institutions all over the country. They provided outreach to young women and sparked innovations in many areas.

Rossiter's next group consists of eight women whom she calls gadflies or critics. This list overlaps the previous one, but other names include: Agnes Green, who produced the “list of zeroes” issued in 1970 by the American Chemical Society, showing that few chemistry departments had women faculty; and Sheila Tobias, who wrote well-known books on math anxiety.

Rossiter calls her final group of two women “influential insiders.” The first is Jewel Plummer Cobb, notably a Nixon appointee to the National Science Board. She set up a committee on minorities at the NSF. The other is MIT physicist Mildred Dresselhaus, who, when in New York city, always stopped to see influential people such as Lawrence Rockefeller, pleading that more be done to help women in physics and engineering.

Women Who Changed Modern American Science

continued

That completes the list of thirty. They kept the movement alive through good and bad times. They knew each other, were in frequent contact, and formed a network (not necessarily in the sociological sense). They worked out a division of labor analogous to an “endless field hockey game,” passing the ball back and forth until reaching a goal and then moving on to the next playing field.

Some continuing goals and activities are identifiable. Activists worked for new legislation, and indeed a women in science bill was passed in 1980.⁵ Another issue was enforcement of existing legislation, which requires funding and, therefore, constant urging of constituents to keep in touch with legislators. A result of this activity was the introduction of new programs at NSF, including the Visiting Professorships for Women (VPW) and Professional Opportunities For Women in Research and Education (POWRE). Critiques of the media began in earnest during those times. In general, the movement’s goals were to create space for equal opportunity for women and to protect it.

Absent here as individuals, but numerically very important, are students from the 1970’s and 1980’s. They voted with their feet, got degrees in science, and embarked on fulfilling careers. We don’t know what inspired them. Was it just removal of barriers, or was it hearing about prominent women? Was it positive recruitment through career programs? Saturdays at a federal laboratory? Sleepover at a natural history museum? Television programs such as NOVA? For whatever reason, thousands of young women obtained degrees in science who would not previously have done so.

The thirty women celebrated here are probably only a small fraction of the women who made contributions during this period. They had impact far beyond their numbers. Some dedicated thirty years or more of their lives to the cause of women in science. Every campus, scientific society, and government agency housed at least a few of them.

The study of the history of women in science continues. Biographies or autobiographies of many of these heroines are in progress. The American Institute of Physics has an oral history project and always needs more names of people to interview. Penn State has an oral history project on Nixon’s women appointees.⁶

Significant awards have been named for prominent women. For example, the NIH offers the Ruth Kirschstein National Research Service Award program. At Cornell University, the physics department has a room named for Barbara Cooper. But more should be done. By memorializing these women, we can work to change the atmosphere at institutions. No longer do we have to walk down corridors lined exclusively with portraits of bearded old men. “It’s not just Madame Curie any more;” there are lots of distinguished names in every field. Science needs its heroines, so that we can view their portraits, too.

¹ The session was held in celebration of the 25th anniversary of “the first multi-author collection of essays on the history of women in science, *Uneasy Careers & Intimate Lives, Women in Science, 1789–1979*.” The speakers were Margaret Walsh Rossiter (Cornell University), Sue V. Rosser (San Francisco State University), Nancy G. Slack (The Sage Colleges), and Pnina G. Abir-Am (Brandeis University). Audio recordings of all the speakers and the slides from Rosser and Slack are available for sale here: <http://www.dcpvideronline.com/aaas/index.php>

² The original text of the law before amendments is available here: http://www.eeoc.gov/eeoc/history/35th/thelaw/ceo_1972.html

³ Some stories end happily, though. About ten years ago, Lamphere gave Brown University a \$1 million gift to support the Louise Lamphere Visiting Assistant Professorship in Gender Studies, and, in 2008, the university sponsored a scholarly conference in her honor. Diffily, A. 2008, “Five Questions for Louise Lamphere,” *Today at Brown*, <http://today.brown.edu/articles/2008/10/lamphere>, October 16, 2008, accessed May 3, 2013

⁴ For this and other supplementary information, I have drawn on each woman’s entry in *Wikipedia*.

⁵ “An act to authorize appropriations for activities for the National Science Foundation for the fiscal year 1981, and to promote the full use of human resources in science and technology through a comprehensive and continuing program to increase substantially the contribution and advancement of women and minorities in scientific, professional, and technical careers, and for other purposes.” <http://www.govtrack.us/congress/bills/96/s568>

⁶ *A Few Good Women Oral History Collection*, <http://afgw.libraries.psu.edu/>



One Person's Advice on the Two-Body Problem

Annika Peter, Ohio State University (Department of Physics and Department of Astronomy)

My husband and I recently found a long-term solution to our two-body problem after seven years of hopscotching through job seasons. When we entered into the job season last year with

the goal of permanence in mind, I asked many faculty people for advice on how to approach the job search as a couple. The advice was all over the place. From this experience, I gleaned that there is no established protocol for solving the two-body problem; each couple's set of circumstances makes each search and solution look a little different. And actually, this is one of the lessons I would like to impart to you — there is no one, straightforward, established path to a two-body solution.

Nevertheless, there were a few bits of advice that we found extremely useful and appeared to be pretty generally applicable, and there were some things we learned along the way. The focus of this advice is on academic solutions at the faculty/staff level. However, a lot of this advice is applicable at a postdoc level, or at the faculty level even if you are looking for only one job, not two!

- Have a goal in mind, and go in with an idea of what solutions you both would find acceptable: Is living under one roof most important to the two of you? Do you both want tenure-track jobs? If so, at what kind of institution? Do you both want staff science jobs? Do you want to be at the same institution? Do you absolutely **not** want to be at the same institution? How far away are you willing to live from your office? In what parts of the world would you consider living? It's good to know what you want, and what you are willing to compromise on, before launching into job season. Keep in mind that the more flexible you are, the more likely you are to find a solution. On the other hand, you should know what you will not compromise on.
- Be a good candidate: Do excellent research, give a lot of talks at a bunch of institutions, and be a delightful colleague. Do the work it takes to get glowing letters of recommendation from well-respected senior people at a variety of institutions. There are a lot of things in the job-search process that you have no control over, but you do have control over how good a candidate you are. However, note that being a good candidate is a necessary but not sufficient condition for landing a permanent job.
- Be proactive: Finding a single permanent job is hard. Finding two co-located permanent jobs is much harder. While it is never a good idea to wait until the last year of your second postdoc to look for a permanent job, it is an especially bad idea to do it if you do have a two-body problem. My advice is, as soon as you feel like you and your partner might have a shot on the job market, start looking around aggressively for jobs. Scour job listings on the APS and AAS job sites and apply for a lot of jobs. Call up colleagues at institutions that are interesting to you and find out what their near-term hiring plans are.
- Network like crazy: Give talks, go to conferences, chat with lots of people at any institution you go to. Not only is this good to do for your own research — travel lets you meet many awesome new people and generate lots of exciting new ideas — but you will need the visibility to get a job. When hiring committees are looking through hundreds of applications to fill one position, it's much easier for candidates to rise above the noise if they and their work are known to committee members. And it is critical that someone on the hiring committee really wants to hire you and is willing to do battle with the other committee members to get you onto the short list.
- If you have a partner in an unrelated field looking for a permanent job, keep this information to yourself until you have an offer. As distasteful as needing to hide anything as obvious and important as a partner may be, revealing anything to a hiring committee that would make their job more complicated before you have an offer in hand is likely to decrease the chance of your getting that offer. You might still not achieve the desired solution even after one of you has an offer (often, but not always, because of institutional financial considerations), but avoid shooting yourself in the foot before that foot is through the door.¹
- On the other hand, if you are in similar enough fields that everyone knows you come as a pair, you may find that you need to advertise yourself as such: You might find your case in my situation, where you and your partner work in related fields and anyone seriously interested in hiring one of you knows about the other. In this case, you can try marketing yourselves together. This approach

One Person's Advice on the Two-Body Problem

continued

worked well for my husband and me, but we didn't really have a choice about it. (Anecdote: I applied for a faculty position at an institute before my husband had submitted his application. Within 12 hours of my hitting the “submit” button, my husband got a call from the head of the search committee that started with “So, I see your wife applied for a job here...”) It also worked well because my husband was considered a senior hire, and this opened doors because of ...

- The hidden secret in academia — the senior faculty black market: One thing I did not fully appreciate before the last job season is that the total number of faculty positions filled can be larger than the number of faculty positions advertised because universities are constantly looking to poach excellent faculty from each other. If either you or your partner already has a faculty job, you will likely be dipping your toes into this market. This is where your past networking can really help you, and where dropping a few rumors to gossipy people that you may be “looking around” can open up interesting opportunities.
- Give a close look at universities that are friendly to couples. Some universities realize that friendliness toward academic couples may allow them to hire faculty with stronger credentials than they otherwise would. If you and your partner would be in the same department, look for ones that are looking to expand (and hence, have a lot of “free energy” in their faculty searches) or that are anticipating a lot of retirements. Location far from a major metropolitan area may be another motivation. Some of these places look at the “two-body problem” as a “two-body opportunity” (phrase credit: Tim Tait). Anecdotally, the Midwest has a number of couple-friendly institutions. My former postdoc institution, UC Irvine, has some nice incentives for two-body hires in different departments.

I hope this advice will help increase the effectiveness of your job search(es) and minimize the energy you dissipate in the process.

¹ Editors' note: Advice on when to reveal the existence of a partner varies widely. A careful discussion of this issue can be found here (“Negotiating for two”): www.nature.com/naturejobs/2010/100826/pdf/nj7310-1145a.pdf



Book Review of Dorothy L. Sayers' *Gaudy Night*

Joannah Hinz, University of Arizona (MMT Observatory)

I love a good mystery novel: Nancy Drew, Sherlock Holmes, Hercules Poirot, and crossover gothic adventures like Wilkie Collins' *The Woman in White* and *The Moonstone*. Many detective characters are described in ways that

we generally associate with scientists — Nancy's dogged persistence, Sherlock's encyclopedic knowledge of mud and cigar ash and his bizarre chemistry experiments, Poirot's knack of remembering tiny details that other people overlook. Indeed, many mystery novel detectives might have made good scientists, eccentric as some of them were — gadabout Campion and opera-loving Morse — because they all have the same drive to unravel complex situations and reveal truths using only facts and critical thinking. They searched for clues and allowed that evidence to draw them away from obvious or assumed answers and towards the recreation of actual events, despite whatever difficulties they encountered along the way.

A respected author in this genre is Dorothy L. Sayers. The main character and detective in her novels is Lord Peter Wimsey — an incredibly rich man whose fictional family ancestry goes back to a 12th-century knight who accompanied King Richard the Lion Heart on the Third Crusade. He is good at everything and an expert on every topic, including fashion, food, wine, cars, classical music, sports, and love. One of Sayers' novels featuring Lord Wimsey recently caught my attention under a completely different guise.

Sayers was one of the first women to obtain a degree at Oxford University. While Oxford's first women's colleges were established in the late 19th century, it was not until 1920 that women were eligible for admission as full members of the University. A ruling in 1927 that limited the number of female students was not lifted until 1957, though the number of colleges that allowed women was small enough that it effectively limited the number of female students until well into the 1970s. Unbelievably, it wasn't until 2008 that all colleges became co-residential, and the number of undergraduates is now essentially equal, though very slightly in men's favor. Sayers finished her

undergraduate study with first-class honors in 1915 but was not allowed a degree. A few years later she graduated as a Master of Arts, just as the rules were changed.

She chronicles her experiences in the Oxford environment at this crucial time in a novel entitled *Gaudy Night*. Rather than featuring only Peter Wimsey, it follows Harriet Vane, a mystery novelist and pretty obviously a stand-in for Sayers, as she returns to Oxford for reunion events at the request of an ailing friend.

Harriet doesn't want to be there. She was, and remains, a bit of a loner, and the few she gets along with tend to be other academics. Vane is critical of the alumnae at her Shrewsbury College, showing immediately that the fact that they fought for the right to have a degree did not necessarily mean they all liked each other or shared much more in common other than the cause itself. Vane discovers at the reunion that many women gave up chances at careers to marry or raise children, and Vane's disdain, or perhaps pity, is apparent in her descriptions of their lives. Of all of the women at the reunion, only one is both an academic and a mother, and it is said that this was only achievable because she works directly with her husband (both passionate archaeologists) and that she leaves most of the rearing of her children to their grandparents.

Under judgment as well are the female undergraduates, who Vane thinks do not fully appreciate the hard-fought battles of the past that allowed them to be where they are today. They seem to flaunt their freedom by disregarding curfews, wearing too-skimpy bathing costumes, drinking too much, and going about without their formal robes. In Harriet's opinion, they try too hard to be like their male counterparts of "half a century ago" and should be mindful of the time when women were "chaperoned to lectures in a donkey-carriage".

One thing that does bond all the women, both those at the reunion and those still in attendance at the college, is the pain it causes them to be consistently underestimated. The warden of the college is a woman, but it is understood that she was chosen because she could "soothe with tact the wounded breasts of crusty and affronted male dons". They speak openly of their disgust for the pet names given to the female students ("undergraduettes") and make frequent reference to being made to feel as though they are second class citizens, e.g., "people would rather

Book Review of Dorothy L. Sayers' *Gaudy Night*

continued

know about him than her". Their male colleagues are "sympathetic" to their cause but don't advocate in the way many of the women hope for.

Scandal hits the week of the reunion when some women at the college receive 'poison pen' letters, criticizing their behaviors in typography cut from newspapers. Soon after, one of the female faculty members has her latest manuscript torn to shreds. There's further vandalism — paint splattering, demolished art in the newly finished library — and the events are timed to coincide with the arrivals of male donors or University officials. It becomes clear that this is a vicious attempt to discredit the women's college. The dean pleads with Harriet to remain at the college and find the culprit. All agree that any news of the prankster would only encourage those critics outside the college that they are right — that women shouldn't be at college or earning degrees, that women are too prone to internal bickering to be taken seriously, and that the events taking place are an example of why the college should be closed. Discretion is paramount. Vane considers what it would be like to lose ground for the women's rights she so strongly believes in and agrees to stay and investigate without calling in the police, even though her experience in solving crimes is limited to her novels.

The pranks at Shrewsbury College become more serious the longer our valiant Harriet remains. On one "gaudy night", Vane realizes that one of the undergraduates has been goaded by the poison pen letters into believing she will fail her exams and be sent home in disgrace, that she will never accomplish anything and should kill herself rather than face her failure. Vane intervenes in the nick of time, but the suicide attempt unnerves the women of the college, who realize they must now involve someone who has more experience in solving such cases before another incident occurs. Vane knows she must call in Peter Wimsey.

This is easier said than done. Wimsey has proposed marriage to Harriet multiple times, only to be rejected. Harriet cares for Wimsey but cannot face the fact that they met on unequal terms; he saved her from being wrongfully imprisoned in an unrelated case some years before. She is indebted to him, and this, she feels, is entirely the wrong base from which to form a marriage. Despite this and her deep reservations about calling on Wimsey to "save" her yet again, her concern for the college takes precedence, and Wimsey arrives to help her solve the case. While I won't give away the ending (hint: the butler didn't do it), the criminal gives a long, rambling speech about the

shortcomings of women and how they should really all be in the kitchen. The person is subsequently packed off to an asylum.

Apparent from the early chapters of this book is the terrible pressure Sayers must have felt to perform well while at Oxford. Not only did her academics have to be above standard, but her behavior as a representative of a college had to be exemplary. Any misstep, any sign that she could not handle either the academic material or her freedom as a young woman on a university campus, would have called into question her ability or her ambition to have a career. Nor did this pressure end with her time at the University. Consider, for instance, her relationship with her colleagues, even after obtaining her degree.

Sayers is sometimes claimed as part of the Inklings, a group of writers who met to discuss literature and read their new works at Oxford in the 1930s and '40s. Closer to the truth is that she was friends with C. S. Lewis and Charles Williams rather than a regular attendee. Nevertheless, the Inklings were familiar with her writing and her company, and did not necessarily support her efforts. Lewis couldn't stomach mysteries of any type and didn't read them (though he claimed he often read her cycle of plays, *The Man Born to Be King*, at Easter), and J. R. R. Tolkien read her earlier works but felt nothing but "loathing" for her later novels, particularly *Gaudy Night*. Thus, even within her own local academic circle, her works involving the feminine experience of that environment were roundly criticized. (Though perhaps we should be grateful that the Inklings didn't have a competition to see who could read her work for the longest amount of time without laughing, as they did with Amanda McKittrick Ros.) That she continued to be a successful novelist is a testament to both her literary ability and her courage.

Sayers has a knack for describing dry, academic conversations, tedious social situations, and the absurdities of everyday university life in a humorous manner. And though this is a thinly veiled summary of her own experiences, it's an entertaining one. Many of her characters' concerns will feel familiar to modern female academics, while some of them demonstrate how far things have progressed. The scope of topics is broad, touching on work-life balance (long before that phrase was used), academic rivalries, the role of economic and social standing in academic environments, and many more. On the less positive side, the list of characters is long and nearly impossible to remember. There are some passages that seem merely an effort to recall every interesting bystander, building, sound, and smell that Sayers encountered while at Oxford. Those pages don't move the plot along, and if you started to feel drowsy reading those, I don't think I would blame

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continued

you. I had to Google a few passages that were in Latin, though maybe some wouldn't consider that a negative thing. It was a small price to pay, anyway, because the novel is a rare gem — an honest, revealing look into Sayers' experience as one of the first recognized female scholars in modern languages and medieval literature and one of the most successful mystery writers of all time.