Gender Segregation in Elite Academic Science

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GENDER SEGREGATION IN ELITE ACADEMIC SCIENCE

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Efforts to understand gender segregation within and among science disciplines have focused on both supply- and demand-side explanations. Yet we know little about how academic scientists themselves view the sources of such segregation. Utilizing data from a survey of scientists at thirty top U.S. graduate programs in physics and biology (n = 2,503) and semistructured interviews with 150 of them, this article examines the reasons academic scientists provide for differences in the distribution of women in biology and physics. In quantitative analyses, gender is more salient than discipline in determining the reasons scientists provide for gender disparities between disciplines, suggesting that gender may act as a "master status," shaping the experiences of scientists regardless of the gender composition of the discipline. Qualitative interviews confirm this interpretation and reveal that scientists also perceive mentoring, natural differences, discrimination, and the history of the disciplines to be important factors. Results contribute to research on the relationship between emotional labor and occupational gender segregation conducted in professions such as law and nursing.

Keywords: *class/stratification; knowledge/science; work/occupations*

The differential distribution of women and men across occupations has long drawn both popular and scholarly attention. From a scholarly perspective, one of the primary attractions of studying occupational gender segregation[1] includes understanding the worker-job matching process. In particular, scholars have explored sex-typing—the notion that some jobs are more appropriate for men or women only—and whether and how that

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perception changes over time. Researchers have interrogated proposed causes of occupational gender segregation, ranging from personal preferences developed in early life to the sex-typing and statistical discrimination that occur as a result of employers' perceptions that sex links to certain job requirements (Blau, Brinton, and Grusky 2006; Gatta and Roos 2005). These changes have been largely asymmetrical and uneven, with women making inroads into occupations at different rates and moving into previously male-dominated occupations but rarely the reverse (England 2010).

In particular, the underrepresentation of women in science has drawn considerable attention from both scholars and national science bodies (National Academy of Sciences, National Institutes of Health, and National Science Foundation).[2] Scholars increasingly argue that a gender-diverse body of academic scientists is important to maintaining both the United States's leadership role in the sciences and a competitive national science workforce (National Academy of Sciences 2006; Page 2008; Smith-Doerr 2004). They also contend that workforce diversity along race, gender, and ethnic lines increases creativity and problem solving (Jehn, Northcraft, and Neale 1999), meaning that if women experience barriers to entry or success in certain science disciplines, science and even society as a whole suffer by losing important human capital that might contribute to advancing scientific knowledge (Blickenstaff 2005). For example, as a result of the different social worlds they inhabit, women have developed inventions related to the home and their gender-segregated jobs (Glick, Wilk, and Perreault 1995), such as the automatic dishwasher and Liquid Paper. And women's perspectives have been important to revising the perceived passivity of the egg in the process of human reproduction (Martin 1991).

Sociological explanations for the low proportion of women in most science disciplines have explored the effects of gender socialization and discrimination on choice to enter, remain in, or leave science (Betz 1990; Ecklund and Lincoln 2011; Farmer, Wardrop, and Rotella 1999; Fox 2001; Sonnert and Holton 1995), often emphasizing women's continuing greater role in childrearing (Preston 2004). As the expected involvement of professional women at home has changed over time (Blair-Loy 2001), these same explanations are insufficient for understanding the differential distribution of men and women among disciplines within science. For example, the majority of physical scientists are men, while women are concentrated in the social and life sciences (England and Li 2006; Schuster and Finkelstein 2006). These differentials suggest that gender may act as a "master status" (e.g., West 1984) that shapes not only career choices but tracks within careers, which is surprising given that scholars who study science argue that being a scientist itself may be a kind of master status identity that overrides other identities in shaping narratives and practices (Downey 1988; Knorr-Cetina 1999). Our findings indicate that gender remains extremely salient in scientists' explanations of the gender disparities among disciplines, indicating that even those women who persist in science remain different from their colleagues who are men in terms of how they explain their career choices, in particular their choice of a career in one discipline instead of another. And the perceptions senior academic scientists have about why women are more likely to go into biology than physics are particularly important because of the impact these scholars have on the next generation of academic scientists.

Few researchers have asked academic scientists themselves how they perceive gender stratification among disciplines (Evetts 1996; Sonnert and Holton 1995; see also Irvine and Vermilya 2010 for a recent exception). Understanding how scientists explain gender segregation among disciplines of science will shed light on ideas about the gendering of academic science that may frame women's thoughts as they are entering a given science discipline. For example, if scientists themselves perceive that one discipline is more difficult than another for women to succeed in, then mentors (often—although not always—more senior scientists who actively direct a junior scholar's career) and role models (influential figures who are sometimes not directly related to a scientist's career but who affect their choices through emulation) at the undergraduate and graduate level may subtly discourage a woman from persisting in a given discipline.[3] Indeed, this is one possible implication of Irvine and Vermilya's (2010) study of 22 veterinarians who are women. In that study, the authors asked women practitioners in the rapidly feminizing field of veterinary medicine what they think draws women to the profession and what attracted them personally. The scholars found a stark dichotomy between what women veterinarians think about the decision-making process of other women when compared to what they believe about their own decisions. Such research provides an important reminder to examine how women scientists perceive their own and other women's motivations for entering different disciplines. Research on this dichotomy illuminates possible differences between the way decisions are conceptualized and how they are truly maneuvered on the ground. In this article, we examine the reasons men and women academic scientists in two science disciplines (biology and physics) provide for gender segregation in academic science.

GENDER SEGREGATION IN ACADEMIC SCIENCE

As increasing numbers of women pursue postbaccalaureate degrees in science, and enter academic science in particular, shifting the focus of relevant research to a more refined understanding of differences in gender integration among the disciplines is crucial. For example, as early as 1966, women comprised one-quarter of the bachelor's degree recipients in the biological sciences, one-third of those in mathematics, and nearly one-fifth in chemistry. Yet in 2006, 81 percent of women scientists in academia were concentrated in just three disciplines—psychology, social sciences, and life sciences such as biology—while not even 12 percent of women academic scientists worked in the physical sciences or engineering (National Science Board 2010). Women are particularly underrepresented in physics. Although almost 50 percent of high school physics students are female (McDonnell 2005), women earned only 19 percent of bachelor's degrees in physics and about 19 percent of general physics doctorates in the 2008–2009 academic year (National Science Board 2010). In contrast, the proportion of women in biology is rapidly increasing (England and Li 2006).

Such differences have consequences. For example, Taylor (2010) found that women working in male-dominated fields perceive much less support than women working in more integrated fields. Thus, a more refined understanding of these disciplinary differences will ultimately help explain why attrition is gendered among science disciplines. In particular, the perceptions that scientists at the most elite schools have for such disparities will show us what scientists themselves may be doing to contribute to or rectify such interdisciplinary differences.

Supply-side Explanations

Some supply-side explanations of differential gender distribution across the occupational structure posit that the underrepresentation of women in some occupations is caused by inherent sex differences (Blau, Brinton, and Grusky 2006) ranging from natural aptitude to personal preferences. In another view put forward in this journal, England (2010) argues that gender essentialism gives women more incentive to move into occupations that do not challenge traditional gender norms.

While research shows that men and women have few differences in natural aptitude (England et al. 2007; McDonnell 2005), researchers do find that evaluation and self-perception may play a large role in career choices (Correll 2001; Steinpreis, Anders, and Ritzke 1999). For example, women evaluate their personal performance on tasks that require high math aptitude more poorly than do men, even when women have similar aptitudes as men (Correll 2001, 2004; Fiorentine and Cole 1992). For example, Cech et al. (2011) find that women's perception of their "professional role confidence" is a significant factor in their choice to pursue engineering careers after studying engineering as undergraduates. Such perceptions may turn women away from careers they think involve significant mathematical skill (Correll 2001).

Although scientific work may affect both men's and women's family choices after they become established scientists (Ecklund and Lincoln 2011), expectations for the challenges of trying to balance family responsibilities with career demands may have a greater influence on women's career entrance choices (Mason and Ekman 2007; Reskin 1993). If scientists perceive one discipline as requiring a larger time commitment than another, women interested in having families may be discouraged from pursuing the more time-intensive discipline. And women scientists may leave academic science once they have children to work in sectors they perceive as more family friendly. Thus, as the presence of women increases at different rates among disciplines, it is worth asking whether scientists themselves perceive one discipline as more compatible with family than another.

Demand-side Explanations

Demand-side explanations point to the structure or environment of academic science (Settles et al. 2006), qualities of science itself that may keep women out (or keep women out of certain disciplines) even if women have the desire and ability to enter the discipline. Researchers maintain that both formal structures and implicit biases in science create a negative social environment for women and discourage them from entering. Fox (2001) points out that men and women in science have very different opportunities for research collaboration or participation in collegial networks. Furthermore, married women scientists often have little time to informally interact with colleagues, leading to a sense of isolation (Zuckerman, Cole, and Bruer 1991).

Structural issues, such as the constraints of the tenure clock, the inconsistent hours in maintaining a lab, or the travel inherent in doing research in a particular discipline (Hogan et al. 2010), also pose significant obstacles to the advancement of women already in science if they have family or caregiving responsibilities (Mason and Ekman 2007). In addition, men may be evaluated more favorably than women, an implicit bias that disadvantages women scientists (Foschi 2000; Steinpreis, Anders, and Ritzke 1999).

The presence or absence of same-sex role models also may play an important part in encouraging women to pursue careers in certain scientific disciplines, although the specific effect is not clear. Researchers find that if classes in a major are taught by women, then women are more likely to pursue that major regardless of discipline (Bettinger and Long 2005; Rask and Bailey 2002). Yet Lincoln (2010) finds no effect of faculty sex composition in a program on applications to veterinary medical school. And Bettinger and Long (2005) show that women students who take an introductory science class taught by a professor who is a woman are less likely to take a subsequent science class when compared to students taught by a professor who is a man.

Perhaps these relationships are mitigated at the graduate level. For example, when a woman student pursuing a doctoral degree has a woman mentor, she is more likely to succeed (Neumark and Gardecki 1998). Thus, the relative lack of women role models—and consequently mentors—in some disciplines may be a significant obstacle (both a supply- and a demand-side factor, discouraging women from entering or pushing them out once they do enter) to succeeding in academic science.

FILLING GAPS

Little existing research explores gender segregation differences among academic scientists at elite universities,[4] let alone the perceptions of both men and women at elite research universities of the reasons for interdisciplinary gender segregation. As scientists are integrally involved in the process of socially constructing science, analyzing their perceptions is important to understanding gender inequality in the sciences. Furthermore, scientists work together to produce science within a framework of existing social norms and mores (Knorr-Cetina 1999), meaning that their perceptions allow us to examine the barriers faced by women in different science disciplines.

In this article, we study biology and physics because the distribution of men and women between the two is vastly different yet both are core disciplines within the natural sciences. We survey and interview scientists in top graduate programs (from graduate students to full professors) regarding their perceptions about why there are fewer women in physics compared to biology. While not every scientist employed in these programs is necessarily a leader in the discipline, these programs as a whole have an extraordinary impact, as graduates are more likely to go on to become leaders in their disciplines and professors in such programs train the next generation of scientists (Fox 2010; Lindsay 2007). Furthermore, scientists not only transfer scientific knowledge to their students but also may have an incredible impact on how their students frame gender as well as which disciplines undergraduate and graduate students ultimately choose to pursue and which types of employment they seek. For example, Gross and Simmons (cited in Jaschik 2006) found that almost 75 percent of professors believe that men and women have different interests that cause fewer women to choose careers in academic science. These sorts of perceptions, whether accurate or not, contribute to the culture of science and the structures that shape the science profession.

DATA AND METHOD

Data come from the Perceptions of Women in Academic Science study, which consists of a survey and in-depth interviews with scientists in 100 departments at 30 universities. We selected a random sample of 3,455 scientists from the more than 14,000 graduate students, postdoctoral fellows, and tenure-track/tenured faculty members in the top-20 PhD programs in all subfields of astronomy, astrophysics, physics, and biology, including cell and molecular biology, ecology and evolution, genetics, and developmental biology. We used program rankings from the National Research Council (1995) and correlated them with *U.S. News & World Report* (2008) rankings. The sample was stratified by rank in the career track, and where possible, we selected a disproportionately high number of women within each rank.

The survey ran from November 2008 through February 2009, using World Wide Web and telephone surveys, and interviews occurred between June 2009 and April 2011. The survey yielded a response rate of 72.4 percent (n = 2,503 respondents; see Table 1). Roughly 25 persons responded from each department. Regression analyses are weighted by career stage, sex, and discipline to reflect chance of selection into the sample. For this article, we focus on the following survey question:

> Researchers have found that there are vast differences in the proportion of women and men in different science fields. For example, there are far fewer women in physics than biology. If you were asked to give your best explanation for this difference, which one of the following comes closest to what you would hypothesize? [Select ONE response.]

Respondents could choose “Women seem to have more natural ability in biology than in physics,” “Women seem to prefer biology more than

TABLE 1: Descriptive Statistics for Perceptions of Women in Academic Science Survey

	N (Response rate %)				
	Biology		*Physics*		
	Men	*Women*	*Men*	*Women*	*Overall*
Graduate student	145 (84.3)	135 (78.9)	209 (66.2)	248 (78.4)	737 (75.6)
Postdoctoral fellow	129 (75.9)	121 (71.2)	143 (64.8)	90 (75.3)	483 (71.0)
Assistant professor	152 (79.6)	120 (76.3)	143 (76.9)	27 (66.2)	442 (76.9)
Associate professor	171 (73.4)	86 (74.4)	94 (64.2)	22 (66.9)	373 (70.6)
Full professor	120 (68.9)	121 (69.4)	180 (66.7)	47 (59.7)	468 (67.1)
	1,300		1,203		

physics," "There is a lot more funding support for women in biology than in physics," "Women are discriminated against more in physics than in biology," "There are fewer mentors for women in physics than in biology," or "There is some other reason"; in the latter case, respondents were given a place to specify.

Once the survey was completed, 216 survey respondents were selected to participate in in-depth interviews from a disproportionate stratified random sample that oversampled women. Overall, a total of 150 interviews (a 69 percent response) were completed with 84 biologists and 66 physicists (see Appendix A). The interviews took between 20 minutes and two hours. Each respondent was interviewed once, either face to face or by telephone. The interviews were independently transcribed and edited and systematically coded for themes related to the central research questions, achieving an intercoder reliability of .90. Semistructured interviews capture the narrative aspect of the research, which builds on the quantitative analyses. For this article, the following interview question was primarily analyzed: "Researchers find there is a different proportion of women in biology than in physics. Do you have a sense of why this might be the case?" If respondents independently mentioned the disparity in gender composition of biology and physics in other parts of the interview, these portions also were analyzed as related to the research question. The narratives scientists use are important because narratives are discursive practices individuals use to actively produce social and psychological realities in conversation with the interviewer (Davies and Harre 1990) and because both memory and perception, whether accurate or not, strongly influence current belief and action (Thomas and Thomas 1928). Personal identities are constructed through language (Bourdieu 1991); if men and women scientists use different languages to describe science disciplines, it suggests they view their scientific identities in different ways. The semistructured interview format allowed respondents to elaborate on reasons gender disparities among various science disciplines exist, revealing the nuances of how scientists think about these issues.

RESULTS

Survey

On the survey, respondents overwhelmingly chose one of four offered explanations for the proportional differences of women and men working in academic physics and biology: women's natural ability for biology, women's preference for biology, discrimination against women in physics, and fewer mentors for women in physics (see Figure 1).[5] A substantial minority (18.6 percent) argued that it was several of the named factors in combination. Nevertheless, most scientists did choose one explanation, and there were explicit patterns in their choices by gender and career stage. When comparing men and women at all career stages, there is far more consensus for the mentoring and natural ability explanations than for the discrimination and preference explanations. Furthermore, any similarities between career stages are important for two primary reasons. First, career stage is highly correlated with both age and year of PhD (.8469 and .8737, respectively) and therefore of concern in a single model; second, given that full professors mentor graduate students, if those in both groups share the same perceptions, we have some evidence that the narrative may be carried on from one cohort to the next. The consequence of the sustenance of this narrative is that gender stereotypes may be perpetuated (or broken), potentially leading to the continued exclusion of women from or the entry of women into some disciplines of science.

We used multivariate logistic regression to examine respondent agreement with each of these four explanations. On the whole, gender is a more salient component of these explanations than is discipline. Compared to senior male biology faculty (the omitted category), women at all career stages in physics are less likely to say that preferences explain the disparity between disciplines. Women faculty in both disciplines are more likely to cite discrimination, while senior male faculty as well as male postdoctoral fellows are generally less likely to agree (see Table 2).[6] Graduate

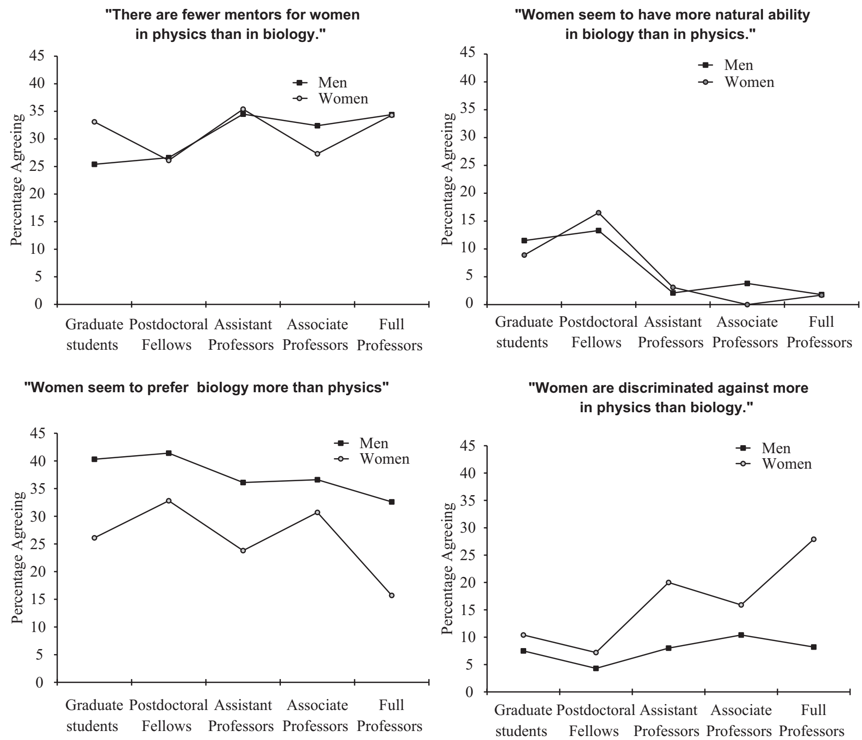

Figure 1: Explanations cited for the gender gap between physics and biology by career rank

students and postdoctoral fellows in physics who are men are particularly less likely to agree with the mentoring argument. Where career stage is most salient is the "women's natural ability for biology" explanation, which men and women graduate students and postdoctoral fellows in both disciplines are significantly more likely to support. Women assistant professors in physics all disagreed, and those cases dropped out of the model.

Conversely, the demand-side argument that women face more discrimination in physics is least supported by graduate students and postdoctoral fellows but gradually gains traction among faculty, particularly with women (see Figure 1). Given attrition from science careers, it is possible that those who remain are more likely to hold demand-side explanations than those who leave (selection), or that experiences change perceptions over time. Alternatively, it is possible that more senior women scientists' perceptions

TABLE 2: Multivariate Logistic Regression of Scientists' Explanations for Why There Are More Women in Biology than in Physics

	Women Have a Natural Ability for Biology	*Women Prefer Biology*	*Discrimination against Women in Physics*	*Fewer Mentors for Women in Physics*
Men				
Physics				
Graduate student	5.534*** (2.578)	1.079 (0.220)	0.643 (0.214)	0.542** (0.119)
Postdoctoral fellow	6.161*** (2.998)	1.282 (0.294)	0.367* (0.171)	0.431** (0.114)
Assistant professor	0.597 (0.493)	1.202 (0.279)	0.719 (0.272)	0.644 (0.161)
Associate/full professor	1.093 (0.653)	0.802 (0.162)	0.417* (0.144)	0.859 (0.173)
Biology				
Graduate student	2.699 (1.543)	1.229 (0.306)	0.554 (0.246)	0.792 (0.206)
Postdoctoral fellow	4.915*** (2.446)	1.168 (0.268)	0.286* (0.144)	0.856 (0.202)
Assistant professor	0.935 (0.935)	0.720 (0.178)	0.540 (0.228)	1.317 (0.311)
Women				
Physics				
Graduate student	2.366 (1.200)	0.458*** (0.102)	0.847 (0.263)	0.999 (0.204)
Postdoctoral fellow	1.376 (0.990)	0.539* (0.161)	0.739 (0.331)	0.697 (0.203)
Assistant professor	—	0.218** (0.119)	3.095** (1.330)	0.727 (0.293)
Associate/full professor	0.440 (0.481)	0.643 (0.230)	2.521* (0.916)	0.563 (0.190)
Biology				
Graduate student	3.613* (1.886)	0.843 (0.202)	0.851 (0.306)	0.835 (0.201)
Postdoctoral fellow	7.304*** (3.601)	1.071 (0.265)	0.445 (0.209)	0.616 (0.164)
Assistant professor	1.117 (0.808)	0.648 (0.174)	1.577 (0.534)	1.243 (0.313)
Associate/full professor	0.302 (0.249)	0.459*** (0.106)	1.977* (0.538)	0.964 (0.201)
University	1.017 (0.011)	1.005 (0.006)	0.995 (0.009)	0.999 (0.006)
n	2,115	2,149	2,149	2,149

NOTE: Male associate and full professors in biology are the comparison (excluded) category. Numbers presented are odds ratios, with standard errors in parentheses.

*$p < .05$. **$p < .01$. ***$p < .001$ (two-tailed tests).

of greater discrimination illustrate that discrimination has indeed decreased as more women enter science, therefore embodying cohort effects.

Interviews

In the interviews, the rationales academic scientists use to explain the differing sex composition between biology and physics can be distilled into five narratives: natural differences, women actively discouraged from physics or discrimination, lack of role models, historical tradition of the discipline, and perceptions of the impact a career in the discipline will have on family choices. Unlike the survey, however, there was significant overlap among these responses, with respondents' often providing more than one rationale. Through understanding how these rationales overlap, we are able to use the interview data to expand meaningfully on the initial findings of the survey data.

Within these narratives, rationales were linked in different and gendered ways; scientists who stated that natural differences between men and women generate the compositional differences between biology and physics also said that women are discouraged from entering physics. Other respondents showed similar bundles of explanations that blended supply- and demand-side explanations, suggesting that scientists view the underlying causes of gender segregation in science as multifaceted. Yet even given this mix of explanations, more men stressed that discrimination very early in the science career—rather than present discrimination—keeps women out of physics. While the survey helps us understand the importance of discrimination in explaining the gender differences, such a finding from the interviews helps us comprehend more of the gendered understandings of where in the life course respondents see discrimination as having the most profound impact on women's science career choices.

Natural Differences

Biologists often explained the higher proportion of women in biology than physics by asserting that innate differences cause women to be better suited or more interested in biology than physics. These narratives differ by gender. For example, scientists who are men talked about brain differences and mathematic ability while women scientists mentioned connecting with their subjects (meaning that women are better able to connect to the subject matter of biology, such as working with animals, versus the subject matter of physics, such as working with particles).

Furthermore, women biologists often used language that demonstrated an emotional attachment to the subject. For example, an associate professor of biology[7] talked about feeling “a real sort of partnership” with the cells she researches, as if “they’re letting me in on secrets.” She went on to describe, “I’m sort of persuading them to tell me why they’re doing what they’re doing and how they’re doing what they’re doing.” Other respondents said biology is “intuitive” when discussing what they see as the innate differences that may cause women to prefer biology to physics.

Respondents also stressed disciplinary differences in outcomes, thinking that biologists were more likely to work on research that would have practical consequences. A postdoctoral fellow in biology[8] talked about the social benefits that her research might bring: “I think women … want to have more of a sense that what they are doing is helping somebody. … Maybe there are more women in … biology [because] you can be like ‘Oh, I am going to go cure cancer.’”

This respondent was intensely aware of the possible implications her research might have on society, a rhetoric that was not common among men in biology. This suggests that the perceived practical applications of biology are gendered, which may be a result of societal expectations that women are best suited to emotional labor, labor that involves one-on-one contact, helping another, particularly the production of an emotional state in another individual (Hochschild 1983).

Whereas women in biology often explained sex differences between the disciplines using reasons of emotional affinity, men stressed neurological differences as responsible for personal choices. For example, an assistant professor who self-identified as a geneticist[9]—after he asked the interviewer to reconfirm that the study was confidential—talked about “morphological differences and biological differences” that made men better at “hardcore math and physics.” A graduate student in biology[10] who is a man echoed this belief, suggesting that there are “some brain differences between men and women that explain it [the gender differences between the disciplines].” Many of the respondents mentioned the abstract nature of physics and the advanced math skills required to be successful in the field. A full professor of biology[11] spoke about “a strong correlation with, between something like [why women do not go into] biology—there’s a math gradient.” He went on to speculate about “some inherent difference between the type of thinking that is required” to be successful in physics when compared to biology. This scientist offered a supply-side explanation based on gender stereotypes that women are less skilled in math and/or abstract thinking. The narratives that the physicists used to explain the sex differences in disciplines were strikingly similar to the narratives used by the biologists, implying that the cultural gender framing of biology and physics in the academy transcends disciplinary boundaries.

Many women in physics talked about the practical applications of biology. Women physicists said biology is "involved with life and things that directly affect the way you live" (a full professor of astronomy[12]). This respondent thought such a connection appeals more to women than to men. An associate professor of physics[13] expanded on this idea: "If somebody says, 'Well, should we fund your research or cancer research?' I'd probably say cancer research whereas most physics people I know would not say that."

This statement and others like it reveal that women physicists too seem to find the practical applications of biology appealing because of the social benefits that might arise from biology research, even if such a rationale directly conflicts with funding their own research.

There were gender differences even among the physicists who believed that men and women have innate traits that cause them to go into different disciplines. The women who cited innate differences emphasized innate preferences, as opposed to innate abilities, yet nevertheless, even these women physicists saw entering physics instead of biology as atypical for women. An associate professor of physics[14] said she thinks "physics is more abstract and biology is more concrete. Women are less likely to like abstract things."

A biology professor[15] who is a man cited an innate lack of interest in math among women as an explanation for gender segregation in the disciplines, stating, "On balance [women are] just less interested in math." And while some of the men in physics who cited innate differences discussed the abstract nature of physics and varying interests based on gender, many more talked about the mathematical abilities necessary for advancement. As one graduate student in physics[16] posited, "physics is more difficult for girls and you need a lot of thinking, and the calculation, and the logic. So that's maybe hard for girls." While women physicists more often mentioned broader physics concepts, men focused on the specific mathematical abilities needed.

Women Actively Discouraged

Very few scientists cited innate biological differences as the only reason for the gender imbalance. Just less than half of the respondents we interviewed thought that women also are discouraged from entering physics throughout the educational process, well before they even enter graduate school. Men were more likely than women to discuss these deficits in the educational system, explaining that socialization subtly discourages girls from taking physics classes. One full professor of biology[17] said his young daughters are already experiencing subtle messages to avoid math and physics, despite his and his wife's (who is also a scientist) efforts to encourage their daughters to pursue science. Similarly, an associate professor of physics[18] reflected on his third-grade daughter's experiences as she surprisingly already worries about whether she will be able to "advance in a science career."

Scientists often mentioned the "women are not good at math" stereotype as an unjust notion that keeps women out of physics. A physics graduate student[19] described the discouragement a friend of hers faced: "[She] was always told, 'Oh, you're not good at math,' until she found herself getting As in a multivariable calculus class. You know, she was scared of math all through high school."

Nevertheless, while respondents criticized these stereotypes, they subtly persist in gendered language, as was expressed earlier by the assistant professor[20] who attributed male superiority in "hardcore math and physics" as due to "morphological differences and biological differences." In describing physics as "hardcore," his language is inherently masculine (Irvine and Vermilya 2010). Such language can have important effects on how people conceptualize and relate to a subject, even if they are not consciously aware of its gendered nature.

It was predominantly women who identified the present-day structure and environment of physics departments as discouraging women from entering physics. A woman associate professor of biology[21] speculated that women may not enter physics because they feel uncomfortable in male-dominated departments, stating, "Male-dominated departments are really unpleasant for women," and "Men can be huge jerks in those situations." An assistant professor of biology[22] reflected that her colleagues in physics who are women feel ostracized by the men in their department: "I know a lot of women who are in chemistry and physics who are excellent at what they're doing, but are often sidelined or ignored by their colleagues because there's just not very many of them [women]."

Her statement highlights that a critical mass of women scientists may encourage more women to enter certain scientific disciplines and also demonstrates how supply- and demand-side factors may overlap.

Lack of Role Models

Many respondents highlighted a lack of role models for women as an explanation for gender segregation. An associate professor of biology[23] commented, "It seems like it's a … lack of role models in different fields. I feel like I have never had a female physics professor. … I think that having a female professor makes you realize as a female student, 'Yeah, I can do that too, if she can do it.'"

Later in the interview she went on to explain that such a lack of women role models in her physics courses may have had something to do with her choice to pursue graduate study in biology rather than physics.

Indeed, 20 percent of those we interviewed cited a lack of role models as contributing to the gender difference between physics and biology. Analogizing chemistry to physics, a woman who is an assistant professor of biology[24] highlighted the perhaps subconscious role of women role models in women's choices to pursue particular disciplines:

> I took a lot of chemistry classes, and I actually really liked them, and I was really good at it, but I never really thought about going into chemistry. It just wasn't somewhere that I could see myself being. … Maybe girls have trouble seeing themselves as a physicist … in a way that they can see themselves as a biologist because, you know, they actually have females teaching them in biology.

As this narrative demonstrates, many academic scientists share the perception that having a role model—even as late as college—encourages young women to enter disciplines that they may not otherwise consider, while the absence of role models may preclude their entrance altogether.

Historical Tradition

Of our interview respondents, 12 suggested that the gender differences between biology and physics are the result of a historical tradition of gender segregation. A man who is a biology graduate student[25] suggested that "science has been a male-dominated field for a substantially long period of time, and it's going to take a while for that shift to change." Ostensibly, this historical tradition of physics would influence the way women supply themselves to physics. For example, until there is a critical mass of women in physics, there will be few women physicists to serve as role models and mentors for younger women, who are then hesitant to enter a male-dominated field. A few respondents posited such a cycle. For example, a biology postdoctoral fellow[26] speculated that the historical dearth of women in physics caused "a lack of role models and a lack of teaching in ways that women respond to," and she suggested that "maybe a few more women are getting through that filter now." While several respondents thought that parity would eventually be achieved in physics over time, none of them articulated why biology has integrated more quickly than physics.

Family Choices

Several respondents argued that physics is an especially labor-intensive and demanding field and suggested that women may leave physics because of family demands. Such respondents reasoned that women may think that physics departments, in particular, desire scientists who are willing to sacrifice family responsibilities; as a result, women may choose to pursue careers in disciplines perceived as more flexible for family choices. A woman biology professor[27] suggested that in physics, “women feel like it’s too hard to … wear all of these hats. And so they’ve opted out.” And a woman associate professor of physics[28] talked about the difficulty she sees in balancing family demands with a physics career: “It’s not going to be solved until we figure out how to help mothers figure out how to do the career and the kid thing.” A biology postdoctoral fellow[29] who is a man speculated further that “women have to make a choice [because] the woman ends up being the primary caregiver if they have children.”

Although these scientists argued that there may be something in particular about physics (compared to biology) that makes it more difficult to balance family life with an academic career, our survey data demonstrate that women scientists in both disciplines work approximately the same number of hours per week: Male scientists reported working just less than 55 hours per week while female scientists said they worked just more than 56 hours per week, and these results hold among scientists with children. This provides some evidence that career-family difficulties may not actually be unique to physics as a discipline but rather that the perception of the structure of physics itself may cause tension between career and family responsibilities.

CONCLUSION

Here we have examined the understandings scientists at elite research universities provide for gender segregation in physics and biology. From our survey, we find that gender and stage of career—not discipline—are the most salient predictors of scientists’ explanations for the difference in sex compositions of physics and biology. In particular, both men and women cite preferences and mentoring as explanations, while women are more likely to note discrimination, suggesting that perceptions of discrimination in science are highly gendered. During in-depth interviews, academic scientists volunteered a broader range of reasons to explain the gender differences between biology and physics. They focused on inherent differences between men and women as an explanation, although most scientists who offered this reason bundled it with another reason. And regardless of discipline or gender, approximately half of all the scientists interviewed thought that at some point in the educational life course, women are discouraged from pursuing a career in physics. We found that women also emphasized continued forms of discrimination that may be more pronounced in physics than biology, whereas men stressed discrimination only in early science education.

Some scholars have argued that being a scientist is a kind of "master status," an identity that overrides other identities in shaping narratives and practices (Downey 1988; Knorr-Cetina 1999). These results reveal that gender is more of a master identity status—influencing perceptions of the gender differences in composition of science disciplines—than being a scientist. Here we have extended into an important professional sphere the long-standing sociological assertion that gender acts as a master status (e.g., West 1984) shaping human experience. We found that scientists, regardless of the gender composition of the discipline they inhabited, used gendered reasoning that stressed innate differences between men and women as well as personal choices to explain the gender composition differences of the two disciplines. For example, women scientists often used language that signified emotional attachment to their research subjects and described their own engagement in emotional labor through science as ways to explain why there are more women in biology.

More broadly, this research highlights how arguments about emotional labor may be related to science. Instead of comparing the experiences of men and women in different occupations, we expand existing emotional labor work to look at men and women in the same occupation but within different subfields or disciplines. Even in science, which is traditionally understood as a male endeavor (Keller 1995), we find that specific disciplines (regardless of the actual subject matter examined in research) are typed as more closely related to emotional labor; our respondents linked biology to feelings (both their own and their subjects') and physics to hard, abstract math, even when most scientists in both did basic research. This also confirms other research (Bellas 1999) that shows that the reward structure in academia is gendered, with tasks that are associated with emotional labor (thought of as traditionally feminine), such as teaching, being poorly rewarded. While our study does not directly examine the rewards of emotional labor in academic science, these findings do show that scientists themselves (both men and women) connect women's higher representation in biology to the perceived emotional content of biological research. Our data further contradict research showing that men and women largely perceive natural science achievement to be based on supply rather than demand factors (Jaschik 2006; Mahlck 2001). Our interview respondents stressed demand factors (such as departments' favoring men) more often than they did supply factors (such as inherent ability levels). And women scientists in both disciplines believe that women in physics face more structural discrimination than women in biology. In some cases, our respondents cited women mentors in physics as important for encouraging young women to explore specific opportunities, and most emphasized the importance of having role models—knowing there are other women who have succeeded in the discipline. Unfortunately, the relative dearth of women in physics limits the availability of women role models and mentors, and women's presence in a discipline does not mean that they act as mentors. Therefore, the presence of women may be a necessary but not sufficient condition for increasing the overall proportion of women in a discipline.

In addition, time spent in academic science is related to the type of explanations scientists offer for gender segregation. Senior scientists are more likely to offer demand-side explanations, while junior scientists are more likely to offer supply-side explanations. Since supply and demand explanations are not mutually exclusive, it may be that scientists are less likely to recognize the importance of demand-side factors until they have invested considerable time in their careers, instead assuming that anyone can enter any scientific discipline. More specifically, younger scientists may not encounter significant gender discrimination until they decide to start families, and those who do may leave the discipline quickly.

In contrast, supply-side explanations, such as preference, may become less meaningful as scientists advance up the career ladder. Senior scientists may be more likely to reject explanations based on differences in natural aptitude because they have spent more time around highly gifted scientists of both genders. Yet we cannot reject the possibility that cohort differences may also be responsible; perhaps younger individuals have a different perception of demand-side factors than do those in older age groups. It is possible that the younger cohort of scientists in these universities have less experience with a demand-side factor such as discrimination; certainly, some of the oldest respondents were acutely aware of the gender discrimination that occurred when academic science first began to integrate women.

These findings have immediate outreach and policy implications. For example, if it is important to some women for their scientific labor to have a practical application that benefits society, more women might be encouraged to pursue careers in academic physics if the possible social benefits that will arise from physics research are stressed more effectively in early physics education. Furthermore, at the university level, the continuing underrepresentation of women in physics implies that they face barriers that women in biology do not. Some form of action is required to overcome such barriers. That few men in either discipline emphasized the present discrimination that women in science may face (and that men in physics hold a much larger share of senior faculty positions) suggests that discrimination is not being adequately addressed in physics departments at top research universities. Since most science disciplines are male dominated, the support of men in implementing programs designed to create a department environment conducive to scientific success for women will be crucial.

APPENDIX

Descriptive Statistics for Interviews

	Men		*Women*	
	Biology *% (n)*	*Physics* *% (n)*	*Biology* *% (n)*	*Physics* *% (n)*
Graduate student	55.6 (10)	61.5 (8)	44.4 (8)	38.4 (5)
Postdoctoral fellow	43.8 (7)	25 (2)	56.3 (9)	75 (6)
Assistant professor	42.9 (6)	37.5 (3)	57.1 (8)	62.5 (5)
Associate professor	33.3 (5)	60 (6)	66.6 (10)	40 (4)
Full professor	56.2 (9)	50 (8)	43.8 (7)	50 (8)

NOTE: The sample was overselected for women in interviews.

NOTES

1. We realize that there are fairly fine theoretical distinctions regarding what is "gender" and what is "sex." Since in this article we are generally not talking about differences based on biology, on the suggestion of the editor we have opted to use the language of "gender segregation" rather than "sex segregation."

2. See, for example, http://www.nap.edu for publications of the National Academies Press on the dearth of women in science.

3. We thank an anonymous reviewer for suggesting that mentors can be from all stages in a career and that scholars should not presume that full professors are mentors even if they are advisors. For more on this point, see Hirschfield (2011).

4. See Bellas (1999); Cole (1987); England et al. (2007); Fox (2001, 2010); Kulis, Sicotte, and Collins (2002); Preston (2004); Settles et al. (2006); Shauman and Xie (1996); Smith-Doerr (2004); Sonnert and Holton (1995); Xie and Shauman (2003); and Zuckerman, Cole, and Bruer (1991) for notable exceptions.

5. There were no gender, rank, or disciplinary differences (models excluded for brevity).

6. Age is highly correlated with career rank, especially for graduate students and postdoctoral fellows, and is thus excluded from the models.

7. Bio53F, interviewed on June 8, 2010.

8. Bio6F, interviewed on June 19, 2009.

9. Bio4M, interviewed on June 10, 2009.

10. Bio35M, interviewed on March 10, 2010.

11. Bio37M, interviewed on March 11, 2010.

12. Phys32F, interviewed on April 26, 2010.

13. Phys9F, interviewed on August 31, 2009.

14. Phys5F, interviewed on June 17, 2009.

15. Bio31M, interviewed on September 3, 2009.

16. Phys16M, interviewed on February 5, 2010.

17. Bio31M, interviewed on September 3, 2009.

18. Phys31M, interviewed on April 23, 2010.

19. Phys2F, interviewed on June 10, 2009.

20. Bio4M, interviewed on June 10, 2009.

21. Bio25F, interviewed on August 7, 2009.

22. Bio24F, interviewed on August 6, 2009.

23. Bio33F, interviewed on February 4, 2010.

24. Bio49F, interviewed on May 24, 2010.

25. Bio9M, interviewed on July 14, 2009.

26. Bio15F, interviewed on July 27, 2009.

27. Bio11F, interviewed on July 15, 2009.

28. Phys26F, interviewed on April 2, 2010.

29. Bio12M, interviewed on July 16, 2009.

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