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Narratives of Science Outreach in Elite Contexts of Academic Science

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Abstract

Using data from interviews with 133 physicists and biologists working at elite research universities in the United States, we analyze narratives of outreach. We identify discipline-specific barriers to outreach and gender-specific rationales for commitment. Physicists view outreach as outside of the scientific role and a possible threat to reputation. Biologists assign greater value to outreach, but their perceptions of the public inhibit commitment. Finally, women are more likely than men to participate in outreach, a commitment that often results in peer-based informal sanctions. The study reveals how the cultural properties of disciplines, including the status of women, shape the meaning and experience of science outreach.

Keywords

outreach, science communication, codification, gender

U.S. scientists face high expectations that research will yield measurable practical benefits rather than general public good (Hackett, 1990). While scholars devote a great deal of attention to the commercialization of research

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into technological and economic benefits (see Slaughter & Leslie, 1997), less attention is paid to another area of accountability in the United States for societal benefits: science outreach. Here science outreach is defined as any activity such as public lectures, interactive forums, or popular press articles in which scientists communicate their research or broader scientific concepts to those outside the scientific community.[1] Expectations for outreach are prompted by a number of factors. Historically, outreach was motivated by a "deficit model" view; scientists attempt to fill the public's perceived science knowledge gaps. A "crisis of trust" in science (Yearley, 2000) may also motivate outreach, with the objective of improving the public image of science in the wake of backlash from problems such as nuclear energy and contamination of the environment (Beck, 1992). Finally, worldwide the emphasis on the "third mission," the need for universities to connect directly to the external world, has been stressed (Enders & De Weert, 2009).

The key U.S. outreach initiative was the mid-1990s implementation of a National Science Foundation (NSF) Broader Impacts criterion, which mandated outreach work for many of the nation's researchers (NSF, 2007). This requirement states that those seeking funding must describe how the proposed research project will affect society via teaching, inclusion of underrepresented groups, creation of outreach relationships, public discussion of research findings, and general social benefits of the project.[2] In so doing, the NSF compels academic scientists to engage in public outreach, underscoring the importance of social accountability.

Given the perception that U.S. science is falling behind other industrialized nations in recruitment to science careers coupled with a federal outreach initiative to address the problem, it is surprising that scholars know little about U.S. scientists' perceptions of outreach. Most studies have relied on samples that are unusually small, with statistical analyses of outreach by U.S. scientists generally utilizing samples comprising less than 100 scientists (Andrews, Weaver, Hanley, Shamatha, & Melton, 2005; Kim & Fortner, 2008). The only qualitative study is based on interviews with 20 scientists situated in diverse organizational contexts. Studies conducted by interest groups provide insights but are neither systematically designed nor subject to peer review (Hartz & Chappell, 1997; Pew Research Center, 2009). Multinational surveys provide some U.S. data, including analyses of interactions with the media (Peters et al., 2008) and popular press articles (Bentley & Kyvik, 2011). Although valuable, these surveys provide a delimited view of outreach and obscure the meanings and motivations that scientists assign to such activities.

Here we begin to fill some of these gaps by investigating narratives of outreach among scientists at U.S. research-intensive universities. Drawing on

in-depth interviews with 133 academic biologists and physicists, we emphasize the importance of context. Research conducted in other national contexts is difficult to apply to the United States because organizational contexts are either substantially different from U.S. universities or poorly controlled in analyses. We draw on conceptual insights from the sociology of scientific work—which integrates scholarship on science, professions, and gender. Because we are studying scientists, we focus on the operation of the scientific reward system in particular, which points to the importance of professional status and organizational context. In comparing two disciplines, we consider how disciplinary codification may shape understandings of outreach. And because U.S. outreach policies emphasize women and schoolchildren, we consider how outreach may be understood as a gendered form of "care work." Results offer a fine-grained analysis of elite university contexts of science, paying special attention to how scientific discipline and gender shape scientists' narratives of outreach. These features of work are consequential for the meaning of outreach and outreach policy.

Background

Knowledge of science outreach is primarily derived from quantitative research conducted in Europe, including France (Boltanski & Maldidier, 1970; Jensen, 2011), Spain (Martín-Sempere, Garzón-García, & Rey-Rocha, 2008; Torres-Albero, Fernández-Esquinas, Rey-Rocha, & Martín-Sempere, 2011), Switzerland (von Roten, 2011), and the United Kingdom (Burchell, Franklin, & Holden, 2009; The Royal Society, 2006), in addition to multinational studies (Bentley & Kyvik, 2011; Peters et al., 2008; Shanley & Lopez, 2009). This research primarily focuses on measurement of outreach and analysis of the factors that enable and constrain commitment to outreach among scientists. For example, in a study of scientists in France, Germany, Japan, the United Kingdom, and the United States, Peters et al. (2008) find that 64% of scientists have been interviewed by journalists at least once in the past 3 years. In another study that examines popular science publishing in 13 countries, Bentley and Kyvik (2011) find that one third of academic scientists have published a popular article. Assessing broader measures of outreach in France, Jensen, Rouquier, Kreimers, and Croissant (2008) find that half of French scientists are engaged in some type of public outreach.

The key contribution of these studies is the articulation of factors that enable and constrain scientific outreach. Examples of constraints include time (e.g., Poliakoff & Webb, 2007), perception of communication skills (e.g., Besley & Tanner, 2011), lack of institutional support (e.g., Kim & Fortner, 2008), and a conception that scientific outreach is an unworthy

activity for the most rigorous of researchers (Martín-Sempere et al., 2008). With respect to factors that enable scientific outreach, studies show that outreach increases over the life course of the scientific career (Jensen, 2011) and that previous science outreach participation is a strong indicator of future intent to do more (Poliakoff & Webb, 2007).

It is difficult to know how well these findings apply to the United States. Official statistics suggest that half of U.S. academic scientists are engaged in some type of public outreach (National Science Board, 2004). Multinational studies provide some insight. Bentley and Kyvik's (2011) study (comparing scientists from different nations) finds that U.S. academic scientists publish about one popular science article in a 3-year period and that only two of the countries studied have lower levels of popular publishing than U.S. scientists. Peters et al. (2008) surveyed researchers across five countries, finding that U.S. scientists, like the other countries surveyed, believe that media engagement positively influences careers.

Few survey-based studies that focus exclusively on the United States are systematically designed. The largest survey is a report published by a foundation, FreedomForum (Hartz & Chappell, 1997). A report based on a survey of 670 scientists sampled from four professional associations, the FreedomForum report characterizes scientists' agreement with negative statements about the news media. A Pew Research Center study of 2,533 members of the American Association for the Advancement of Science examines scientists' views of the public and includes only one question on outreach (Pew Research Center, 2009). Such general descriptions show what scientists think about the public (Besley & Nisbet, 2011), but the sampling strategies neglect contextually specific generalizations, such as how views vary by organizational context, scientific discipline, or gender.

Five scholarly studies focus exclusively on U.S. outreach. Dunwoody and Ryan (1985) reveal institutional and disciplinary differences in attitudes towards media interaction, but their survey does not measure outreach. Kim and Fortner (2008) survey 94 conference participants, finding that familiarity with terms in education, professional training, and age are associated with outreach. In a survey of 73 scientists at a university, Andrews et al. (2005) report that outreach varies by career stage, job type, and gender. The small sample sizes of these latter two studies, however, undermine the quantitative strategies employed. Corley, Kim, and Scheufele (2011), in a survey of 363 nanotechnology scientists, demonstrate that although nanoscientists feel a sense of responsibility for communicating research findings to the public, they view media coverage of nanotechnology as less credible than general science media coverage. Finally, D. J. H. Matthews, Kalfoglou, and Hudson (2005) conduct 20 interviews with U.S. geneticists employed by the federal

government or university medical schools. The study portrays scientists' orientation to outreach as an ethical obligation to society derived from either professional roles or federal funding (D. J. H. Mathews et al., 2005), but the narrowness of the group studied limits our ability to understand how scientists' perceptions may vary outside of the context of this specific scientific subfield.

Organizational Context and the Scientific Reward System

It is also difficult to know how well existing research applies to U.S. science because the organizational contexts studied are either substantially different or controlled for poorly. A wealth of research stresses the importance of organizational context for the performance and experience of the scientific role (e.g., Long & Fox, 1995), and both structural and cultural differences in organizational contexts hold implications for outreach. For example, many European studies of outreach comprise scientists at institutes that lack teaching duties (e.g., Jensen, 2011; Torres-Albero et al., 2011). As teaching is a common activity of U.S. academic scientists, there are structural differences in how nonresearch time can be allocated to outreach activities among U.S. scientists relative to those who work at institutes, which is more common outside the United States. This critique applies equally to studies with samples that include combinations of academic and governmental scientists (e.g., Andrews et al., 2005).

Cultural differences within organizational contexts are also likely to shape science outreach. Different strata of universities offer different constraints and opportunities, thereby generating locally specific meanings. At elite universities, scientists characterize a collective expectation of continuous productivity over the career with teaching and service marginalized; at lower tiered universities, scientists are somewhat engaged in research, but a premium is placed on the teaching and service roles (Hermanowicz, 1998).

Such a proposition about the structure and culture of outreach at elite universities corresponds to the "Sagan effect" or a professional stigma attached to doing outreach (Shermer, 2002), yet such conclusions require more careful examination. Visibility, or the extent to which a scientist and her or his work are known, is a critical dimension of status within science. Visibility is primarily accrued through publication and citation, but if certain forms of outreach enhance visibility, then one would not expect the "Sagan effect" to operate universally among elites. Moreover, despite low rewards for different forms of outreach, institutional pressures encourage participation nevertheless. The majority of U.S. grants that require broader impact criteria are conducted at elite universities. In 2009, for example, the 59 member institutions

of the Association of American Universities (a group of elite universities) accounted for approximately 60% of all NSF and National Institutes of Health funding in the United States (Association of American Universities, 2012). In the very environments where outreach may be disparaged culturally, there is a structural impetus for engagement.

From Numbers to Narratives in Context

Research conducted outside the United States generates important outreach insights, but structural and cultural differences obscure characterization of U.S. scientists. There is a belief that elite scientists look down on or reject outreach (Shermer, 2002), yet it is this elite environment of science where pressure to communicate science to the broader public may be highest. Moreover, the literature on outreach is overwhelmingly quantitative, yet understanding how scientists *interpret* outreach activities is critical to advancing knowledge and policy. Understanding narratives, the ways in which individuals attempt to organize and express meaning (Gubrium & Holstein, 2009), provides access to the meanings that scientists assign to outreach and the ways in which such interpretations may be shaped by gender or discipline.

One study in the United States does focus on how scientists interpret outreach (Mathews et al., 2005), but its design entails interviews with 20 scientists who work in federal or university medical labs in 14 different cities. Such an approach may nicely describe how various scientists view or experience outreach, but it is unable to portray how the experiences of members of the same group are indicative of an institutionally specific culture of outreach. Davies (2008) offers a more robust design, focusing on one British university, but she offers few details on the composition of her sample except that it included seven focus groups comprising 3 to 10 participants, drawn from engineering, life sciences, physics, chemistry, and medicine. Whereas the work of Mathews et al. (2005) offers details on outreach within one discipline while obscuring organizational context, Davies (2008) characterizes one organization while limiting insight into distinctive disciplinary cultures of outreach.

These studies are important because they encourage researchers to account for subjectivity and context. An important step in this direction is to closely examine the influence of discipline. Survey-based studies (e.g., Bentley & Kyvik, 2011) compare outreach practices by discipline, yet scholars have not closely examined how scientists' narratives of outreach may differ across these groups. The rationale for comparison by field is the level of codification, or the extent to which empirical knowledge is consolidated into succinct and interdependent theoretical formulations (Merton & Zuckerman, 1973).

Some scholars suggest that outreach is less common in highly codified disciplines due to the challenge of translating esoteric knowledge into plain language for a public (Bentley & Kyvik, 2011).

An alternative explanation may be derived from consensus, another aspect of codification, referring to the extent to which scientists agree on what problems are most important for research, which theories and methods are appropriate, and what constitutes a successful career. Highly codified disciplines exhibit clear and rigid definitions of success, while low-consensus disciplines possess ambiguous and varied definitions of achievement (Hermanowicz, 2009). Correspondingly, scientific outreach may be less acceptable in high-consensus disciplines because it is not considered an important parameter of success. By the same logic, outreach may be more prevalent and accepted in low-consensus disciplines because scientists have more bases from which success may be derived. When comparing outreach across such groups, it is not only the difficulty or ease of translating empirical knowledge that shapes outreach but cultural features of disciplines that influence outreach too.

There is also reason to expect differences in how male and female scientists engage in and interpret outreach because gendered processes are a pervasive feature of science. At U.S. universities, for example, elite institutions are less likely to employ women scientists (Long & Fox, 1995). As of 1998, the proportion of full-time female faculty at research universities was 27.7%, whereas the proportion at 2-year colleges was 48.8% (Schuster & Finkelstein, 2006). Gender differences also exist in positions held and activities performed within organizations. Across all university sectors, female professors are more likely than male professors to be more engaged in teaching and less involved in research (Schuster & Finkelstein, 2006). How universities structure activities differently for male and female scientists may influence engagement in and narratives of outreach.

Gender is often included as a variable in surveys of outreach. Jensen (2011) finds that among French scientists, women are slightly more active in outreach. Crettaz von Roten (2011) finds that women and men share a positive view of outreach, but women perform fewer activities. To date, von Roten's study provides the most detailed survey-based study of gender differences in outreach, but important work remains. Male and female scientists may offer distinctive rationales for outreach that are not easily captured in surveys. Differing rationales may result from position or the gender composition of a discipline, but they may also be the result of a broad cultural interest in the United States to promote the participation and status of women in science.

Indeed, one of the key objectives of the NSF's broader impacts criterion is to increase the participation of women in science, often through activities in primary and secondary educational settings. Science outreach may thus

potentially be associated with emotional labor, which emphasizes relational and interactive "soft skills" that are tied to personality, attitude, and behavior rather than technical knowledge (Steinberg & Figart, 1999). Women often consider this form of work an amenity because they have been socialized to believe the work is appropriate or feminine (Correll, 2004; Ecklund, Lincoln, & Tansey, 2012). If the notion of female scientists as role models is viewed as integral to attracting women to science, then women may either self-select into outreach roles or face greater pressure than men to engage in outreach. This perception may also lead male scientists to eschew outreach or view it as inappropriate. Cultural beliefs about gender are potentially an important aspect of context that shapes how scientists differentially experience and interpret outreach.

Method

The sample is a subset from a larger study, Perceptions of Women in Academic Science (PWAS), which included a survey (N = 2,503) and in-depth interviews (N = 150) with scientists at all career stages randomly selected from the top 20 biology and physics/astronomy graduate programs as ranked by the National Research Council (1995). The study was presented to participants as an examination of crucial experiences in the science career trajectory to limit bias inherent in presenting the study as specifically about *women* in science. Survey and interview questions focused on scientists' perceptions of the challenges they have faced throughout their careers. Acknowledging that studying career perceptions in two disciplines cannot be construed as representative of science overall, we note that doing so follows a well-established precedent in sociological studies of scientists. Numerous important studies have focused on one to two disciplines, for example, to illustrate stratification (Cole & Cole, 1973), productivity and recognition (Reskin, 1977), and career adaptation (Hermanowicz, 2009).

This article focuses exclusively on the qualitative data, which were collected from 2009 through 2011 after completion of the survey. Outreach activities were not a component of the quantitative survey. Therefore, the present study cannot be informed by any Perceptions of Women in Academic Science survey measures. Interview participants were randomly selected from survey participants and asked to participate in a follow-up interview. Early in the qualitative data collection process, outreach emerged thematically in discussions of career challenges. We began to systematically include specific questions on outreach in subsequent interviews. For the purposes of this article, the sample includes the 133 respondents who were specifically asked about outreach, with 67 male respondents and 66 female respondents.

The respondents include 74 biologists and 59 physicists of various ranks (see the appendix). And it should be noted that we oversampled on women. The following questions about outreach were included:

1. I wonder if you are involved in any work aimed at translating science to individuals outside the academy or the scientific community. Could you tell me a little about these efforts?
2. Do you think scientists in general are doing a good enough job at translating science to broader communities? Why or why not?
3. [If no to above] How could they be doing a better job?

Through these questions, we were interested in discovering not only scientists' own reasons for participation (or not) in outreach activities but also their perceptions of why other scientists do or do not participate in outreach. In short, we wanted to examine the dominant ways that scientists talk about outreach in order to reveal the discourse framing engagement (M. S. Evans, 2009). This methodological approach follows a well-established precedent in the sociological study of science. Recent studies, for example, have examined scientists' narratives of ambition (Hermanowicz, 1998), gender equality (Smith-Doerr, 2004), and boundaries between religion and science (Ecklund, 2010).[3]

All of the interviews were recorded, transcribed, and coded for analysis. Our coding process entailed two stages. First, paid research assistants coded whether or not individuals participated in some form of outreach and the type of activity—resulting in a reliability statistic of 1.0 because these patterns were explicit and did not require interpretation. The second stage of coding, conducted by the first author, focused on substantive patterns identified in these categories. A subset of the interviews was analyzed to generate a coding scheme. Codes such as "status," "discrimination," "public_religion," and "public_antiscience" were developed as themes presented themselves in each comparative category. This stage of coding coupled theory-driven analysis and inductive coding to classify the ways in which scientists understand outreach. Once complete, the coding scheme was applied uniformly to all of the interviews. The goal of this modified inductive approach was not to prove or disprove arguments in the literature by scholars whose work influenced ours; instead, we sought to use existing and new categories together to explore the issue of science outreach. For example, we are not trying to test predictions suggested by the codification thesis, rather we use elements of the codification literature (e.g., disciplinary culture) to inform our analysis and offer afterward a consideration of our findings for understanding of the relationship between codification and outreach.

Table 1. Outreach Activities of Scientists.

	Physics	Biology	Overall
Total participants in outreach	41	39	80
K-12	29	21	50
General public	10	10	20
Civic organizations	3	11	14
Public policy/government	3	6	9
Media	3	5	8
Industry	1	1	2
"Citizen Science"	0	1	1

Note: Less frequently, scientists discussed advising public policy, print or online media publications, industry, or participatory research projects with citizens.

The main focus of our discussion is discipline- and gender-specific narratives of outreach that constituted modal patterns in the data. Because scientists' commitment to outreach varied along these dimensions, we describe the outreach activities of scientists and then provide a brief description of the demographic correlates of outreach activities in which scientists are engaged.

Results

Outreach Activities of Scientists and Demographic Correlates

Sixty percent of the respondents are involved in some type of science outreach.[4] Conceptually, a broad typology of science outreach exists, including one-way modes of communication such as lectures and two-way modes that emphasize dialogue, interactivity, and collaboration between scientists and citizens (Zorn, Roper, Weaver, & Rigby, 2010). Our focus in this article is on outreach activities that scientists noted as having participated in at least once, which we present in Table 1. The scientists' outreach efforts predominately target children in primary and secondary educational contexts, such as performing experiments at high schools, bringing students to their labs for tours, and training high school teachers. One fourth of scientists engaged in outreach noted participation in public talks or other activities prepared for the general public. For example, three astrophysicists noted occasions in which they set up telescopes in state parks for citizens to "stargaze." Giving talks to civic organizations (e.g., the American Cancer Society) was a somewhat common activity—but more among biologists than among physicists.

Commitment to these activities varies considerably by gender and discipline. Overall, women are more involved in outreach (75%) than are their male counterparts (46%). When compared to men in their disciplines, women

in both biology and physics have significantly higher rates of involvement in outreach. The difference is larger in biology, where 73% of women but only 35% of men do outreach work. In physics, 78% of women are engaged in some type of outreach, as compared to 60% of men. Correspondingly, it is important to note that while proportionally more women than men in physics do outreach, the overall number of women in the field is very small. At these universities, less than 7% of full professors in physics are women.

Cultures of Outreach: Physics

Cultures of disciplines may influence cultures of outreach. For example, documenting the history of how physics became the preeminent discipline, Morus (2009) describes a longstanding view of physics as "alien" and having a "disconnectedness from mundane affairs" (p. 4). Such disconnectedness is observable today, as outreach in physics is culturally peripheral. In the bundle of tasks that constitute the professional role of the physicist—for example, research, instruction, reviewing, or advising work—outreach activities are not considered a core component of work. And those who do embrace outreach activities are often perceived as occupying a marginal status. Coupled with limited societal connections and low public understanding of physics, this collective orientation to outreach constrains the opportunities for dialogue and interaction between physicists and the public.

A useful concept for understanding the place of outreach in physics is professional jurisdiction, which connotes an "occupational turf" organized around a knowledge base that is exclusively controlled by a professional group (Abbott, 1988). High-status tasks such as research constitute the core of jurisdiction, whereas lower status tasks are at the periphery, where work is often eschewed or allocated to lower status occupational groups. To understand why physicists believe that outreach is not, or should not be, a component of their professional "turf," we consider the account of a female postdoctoral fellow in physics,[5] who has occasional involvement in outreach:

> I don't think [scientists] would say that a large part of their duties is to explain what they are doing to the public. I think they would say that there are organizations whose job it is to do that, and then they could interact with them, but I don't think they would be particularly fond of giving public lectures or going to museums or interacting with the general public, so if we come up with a definition that it is the role of a professor to interact with the public, then I would say that probably most professors don't do that. But then we really have to decide on what is the job of the professor (laughs). Is [it] just mainly research or does it also have this additional role?

Although this orientation is occasionally part of some scientists' rejection of outreach, many scientists who view outreach as outside of their role were those who noted involvement or satisfaction in these activities. The accounts suggest a couple of explanations for this view. Some described outreach work as outside of the scientific skill set, distant from research skills and different than teaching. One physicist,[6] for example, noted that the material that one covers in teaching is clear, whereas what one discusses in outreach activities is unclear. Another reason outreach is seen as outside of the scope of the scientific role is that some physicists have been exposed to or work with paraprofessionals whose work is dedicated to outreach. This view is indicative of a subordinate jurisdiction in a complex division of labor, in which tasks are delegated to lower status occupations (Abbott, 1988). This is especially the case among physicists who work at large research facilities with numerous grants that are pooled together to fund outreach paraprofessionals. Outreach programs at universities that are primarily enacted by graduates and undergraduates may also foster this belief. Others view science communication as the job of science reporters.

Another pattern is the perception that science outreach should be avoided because it is a low-status task. This theme figured prominently in the accounts of outreach-oriented female physicists as they described their peers' views. The accounts depict a high level of consensus on what it means to be a successful physicist. Exposure to this aspect of physics is highest during graduate training, as the institutional goal of professional socialization is to enhance commitment to research. Consider, for the example, the account of a female postdoctoral physicist:[7]

> I'm actually really interested in doing more in education and outreach . . . things where I can still do science but also have more of a focus on the educational side. I said as much to my thesis committee at some point . . . and that turned out to be a big mistake. Rather than giving me useful advice, [they] ended up basically saying I was setting myself up to not be successful.

Among scientists who have achieved positions in elite physics departments, this view leads individuals to reject outreach altogether or to allocate outreach activities to personal time. Consider how a female physics graduate student[8] presents this dilemma:

> You end up doing outreach either on your own time, with the time that you would otherwise be out canoeing or something, or you start getting people talking behind their hands, you know "Does she want to do research or does she want to do outreach?"

The scientist's account signifies the importance of projecting a professional identity that is consistent with collective definitions of success in physics. Because outreach is considered a low-status task, visible commitment to it threatens one's reputation because it signals a departure from conformity to norms of research commitment in elite contexts.

Although physicists marginalize outreach, they are aware of the role it could play in quelling tension between professional autonomy and public accountability. Historically, physicists experienced substantial autonomy, in part due to their role in the development of the atomic bomb, which functioned as a symbol of serendipity that indicated the importance of funding basic research (Herken, 1992). Although funding started to decrease in the 1970s, physicists enjoyed a period of time with limited accountability in terms of directly meeting societal needs (Kevles, 1978). This historic autonomy and its contrast to a current perception of societal pressure for accountability emerged in several interviews. The comments of an associate professor of physics[9] capture these views:

> During the Cold War era, physics really benefitted from the umbrella of money that came in through the Cold War. I think to some extent, it became not responsible enough about communicating why the government should fund basic research and why it's good for somebody who isn't very interested in science. . . . Now that we're out of that Cold War era and the country is facing big problems, not only should we, but in physics we'll have to do a better job of describing to the public why it's important—even when the country's in crisis—to put money into basic research.

The instrumental emphasis of such accounts is noteworthy. The objective presented is the legitimation of professional autonomy. Only implicitly does public knowledge of science enter into such narratives, insofar as scientists suggest the need for the public to understand how basic research may lead to long-term societal gains. Missing from these narratives is any emphasis on communicating factual knowledge of physics. To be sure, a subset of physicists who are actively engaged in outreach do focus on outreach activities with the goal of attracting women to physics, as we will see below. When outreach is discussed in terms of the role of the physicist in society, however, the objective is the legitimation of autonomy.

Cultures of Outreach: Biology

Compared to physics, a slightly lower proportion of biologists are engaged in outreach (approximately 55%). Biologists embrace a much more neutral

view of outreach activities relative to physicists. The following comment by a female assistant professor of biology,[10] who participates in outreach, nicely captures the sentiment:

> It is something that is not going to count for that much in a tenure package, although it doesn't count for nothing. But it doesn't count for that much compared to another publication. I don't really feel like people discourage it, but I don't feel like it's really encouraged a whole lot, either.

Data from interviews with physicists showed more emphatic rejections of outreach from the bundle of tasks that constitute the scientific role. What, then, constrains outreach among biologists?

The primary issue that influences outreach among biologists is the connection between biological knowledge and society. Whereas physicists describe themselves as "walled off" from society, the problems that biologists describe originate from the relevance of biological knowledge to issues of interest among the public. Sociologists have shown that when social circumstances increase the ability of clients to control the work of professionals, there is a tendency for "professional regression" (Abbott, 1981), where experts avoid tasks that involve interaction with the public and instead work on tasks in the knowledge base of professional work, far removed from clients. The connection of biology to public health, medicine, and environmental issues, for example, could presumably facilitate outreach, because when compared to physics, biology may seem less esoteric and more relevant to the lives of citizens. It is this very interaction that constrains commitment to science outreach, however.

One reason that the overlap between biology and societal issues causes problems is due to potential misinterpretation of the meaning of outreach work by other scientists. The following statement by an assistant professor of biology,[11] who moderately participates in outreach, described why his subfield does a poor job of doing outreach:

> In our field [ecology], there is a real challenge between being seen as an activist and a scientist. As soon as you stick your neck out, you risk losing a lot of credibility, because you become an environmentalist, as opposed to a scientist. That may gain you a broader audience, but you lose a lot of scientific credibility if you're seen as an advocate rather than a scientist.

Note here the difference between physics and biology. Outreach is not rejected primarily because it is of lower prestige than research. Outreach is constrained because of the ambiguity surrounding what role a scientist is committed to (scientist vs. advocate) and the implications for credibility and

professional identity in doing so. The close overlap between biological knowledge and issues of policy or public interest generates professional barriers to outreach.

More generally, however, the interface of biological knowledge and public understanding of science creates an ironic problem. A goal of science outreach is to improve societal interest and understanding of science, yet biologists who disparage outreach frequently emphasized low public understanding of science as a barrier. There are two dimensions to this orientation. The most general is the perception that the public is not interested in science—a conclusion that some scientists reach through general interactions with strangers. An assistant professor of biology[12] explained,

> No one wants to know about what we do anyways. So, not only can we not explain it to them, they don't want to know anyways. I am shocked if, I'm in a bar or something, just talking to people, and someone [asks] "What do you do?" I have a series of sort of standard answers. And what I'm doing is trying to suss out whether they actually want to know. And nine times out of ten, they really don't. As soon as you mention the word RNA, they're running for the exits. And then every once in a while you'll find someone who actually really wants to know what you're doing and that's fine. I like doing that, but it's rare. So, is it our fault? Us, being scientists, I don't know.

Other biologists noted that the public lacks a concept of what a scientist does and that, as a consequence, citizens are unable to understand what it means to validate a fact, making it easy to dismiss scientific research.

The second aspect of biologists' perceptions of public understanding of science is the belief that a portion of society holds antiscience attitudes. Some scientists suggested that scientific knowledge has become politicized, attributing public views to "corporate interests masquerading as science" or the political interests of conservative politicians.[13] Most commonly biologists' view of the public as antiscience is derived from the science-religion relationship. The following account of a professor of biology[14] represented this pattern:

> I don't think we do a very good job. There is a gap in vocabulary for one thing, but it's more than that. It's a way of thinking. Too many people out there who believe that prayer will cure their illness or that angels are guiding their decision making. The simple results that are in the press about discovering new genes? They don't know how to even think about that.

Scientists recognize deficiencies in the outreach efforts of the field, but they are more likely to attribute barriers to successful outreach to public

religiosity. Biologists' perceptions of conflict with the public may be related to long-standing antagonisms generated by biotechnology controversies such as genetically modified food and genetic engineering (Bauer, 2002). Indeed, research shows that some religious groups reject genetics on moral grounds (J. H. Evans, 2011) or because they see scientists as "playing god" (Dragojlovic & Einsiedel, 2012), meaning that many biologists may be reluctant to engage with society, despite the overlap between biology and public interests noted above.

Is Outreach Gendered?

There are three dimensions of scientific work that allow us to assess the ways in which outreach is gendered. The first is simple participation. As we observed in examining the demographic correlates of outreach, we saw that women are disproportionately more involved in outreach relative to men in both disciplines.

A second dimension by which outreach is gendered is in the nature of the activities themselves. Female scientists were more likely than men to perform activities that are motivated by the goal of increasing the participation of women in science. In the process of describing the outreach programs she is involved in on a yearly basis, for example, an associate professor of physics[15] listed two conferences for undergraduate women in physics and a weekend program for girls in middle school. She noted,

> Some of the young women who stick with the program throughout their undergraduate career get a huge amount out of the experience in terms of teaching. And you know the feeling of reward that you get after each one . . . that's been really rewarding, for them, too.

Twenty-one percent of female biologists were engaged in activities with the objective of attracting women to science, while 30% of female physicists participated in activities with this aim. The higher prevalence of this pattern among female physicists is unsurprising, given the lower proportion of women in the discipline. Only one male physicist, an associate professor, emphasized that he does outreach because it is important for attracting women to science.

No scientists offered a rationale that suggested that attracting women to science through outreach is a task that female scientists alone are uniquely suited to perform or that somehow women are more effective than men in performing, but female scientists' accounts of outreach were often gender specific. The scientist quoted above indicated that the 20 university volunteers on her outreach program for middle school girls were all women. In

another example, when one physicist[16] was asked elsewhere in the interview whether she thought she would achieve tenure, she responded by describing her husband as "what a physicist looks like" and then stated,

> [That] is what the physicist should be like, and I am not so much [that]. . . . That kind of different persona, I've always wondered about that. For example, I try to do various outreach things in the department, you know, *get the women together and do stuff*. I've been told on the side that I do too much outreach, but on the other hand, I get put on outreach committees, so I have a lot of mixed messages about how I am doing.

The account suggests a predicament. On one hand, some female scientists may intrinsically value outreach efforts. On the other, outreach activities are inconsistent with collective definitions of success among the scientific elite, such that there are distinctive professional identities that indicate what a successful or unsuccessful scientist "looks like."

The predicament is exacerbated when outreach is viewed by scientists as a feminized occupational task, a third pattern by which outreach may be viewed as a gendered activity. Prevalent only among physicists, outreach activities emerged in the interview when female physicists were asked about discrimination or challenges they faced in their work environments. To illustrate, we begin with the comments of one physicist[17] whose account suggested that women should conceal their involvement in outreach:

> I was getting advice from [a senior female scientist] who's a very famous physicist . . . a groundbreaker. . . . And she would always say don't advertise your outreach because if women advertised that they do outreach, women in particular, it looks sort of soft.

The emphasis on "women in particular" and the characterization of outreach by women as "soft" suggests a gendered construction of the outreach role. Here again the construction of a particular professional identity emerges: When women perform outreach, a "soft" rather than "hard" scientist identity is projected, with negative implications for one's reputation.

Other accounts reveal similar patterns. Scientists suggested that in some organizational contexts of physics, such as large laboratories characterized by hierarchy, outreach is perceived as a stigmatized task that is delegated to women. A female assistant professor of physics,[18] discussing challenges in the workplace for women, noted,

> [A major physics facility]—it's famous for . . . I don't think it's a secret, but there were many women who were famous and were still being treated as—[they] didn't get the full scientist position. For many years they were supposed to do public outreach things and got half their salary.

This is an illustration of what sociologists of gender and work refer to as an "occupational ghetto" (Roos & Reskin, 1992), which describes how women's entry into professions often results in internal stratification, such that women occupy "ghettoized" positions that offer lower prestige and rewards. Some scientists speculated that this culture of outreach has changed, but interviews with graduate students in physics suggest that this may not be the case. When asked whether there had been any particular difficulties in her science career related to discrimination, one graduate student[19] explained that discrimination still exists but is less overt:

> The thing is, most of the time now people aren't stupid enough to be obvious. It's more the subtle things. . . . Among the people I know, women are more likely to have other things that they really value in their lives. . . . The institutional structures and attitudes that denigrate that affect women disproportionately. Even things like outreach. Outreach is an interesting thing because in theory it's encouraged, but in practice it's often not because it takes away from research. Certainly a disproportionate number of the people who care about outreach are women, so when that sort of gets—[*gasps mockingly*] "oh you're wasting your time" or "that's not really important," it's those people who feel like what they care about contributing to the field or to society is not valued.

The emphasis in this account is on culture: Institutional beliefs about what is valued are seen as a basis of discrimination. It is not simply that discrimination is directed toward women, because men also participate in outreach activities (here, it seems, to a lesser extent). Rather, the local legitimacy of outreach is contested along gender lines.

Discussion

Our findings show that gender and discipline matter in science outreach. Among both biologists and physicists at top research universities, women are more involved in outreach than men, and a larger proportion of physicists are involved in outreach than biologists. The attributes of outreach activities that scientists noted (see Table 1) offer a suggestive comparison between outreach at elite U.S. universities and science outreach in Europe. The rich ecosystem of types of outreach that in exist in the European context appears to be much more diverse than what we find among U.S. scientists at elite research universities. The Royal Society Survey (2006) in the United Kingdom, for example, lists 11 different modes of engagement, but the scientists in our sample overwhelmingly engage in outreach to children and the public in events organized on campus. And while dialogue or interactive modes in which citizens work actively with science knowledge is idealized in

the practitioner and scholarly literature (Zorn et al., 2010), elite scientists in the United States generally engage in one-way presentations to the public.

Narratives of outreach differ by discipline. Prior research suggests that the operative discipline-based constraint to outreach is codification. Our comparison of physics and biology provides mixed support for this argument and for different reasons from what other scholars have offered. Bentley and Kyvik (2011) argue perceptions of public ignorance may be greater in highly codified disciplines where terminology must be translated into plain language for communication to the public. Although we employ different methodologies and examine different contexts, we are able to offer two variants to this argument. First, this would lead us to expect that terminology would matter more in physics than biology, because physics is the more highly codified discipline. For the physicists in our study, however, terminology was less important than the historic boundaries between the discipline and the public. The level of autonomy physicists have experienced has engendered a relationship in which accountability to the public is unimportant beyond the discipline's ability to sustain federal funding. Furthermore, *lower* terminological barriers actually may operate as a constraint to outreach. This was clear in the case of biology, not because of the difficulty of explaining biological concepts to the public but because scientists reject the conversation that they perceive the public is having about religion and biology. The public is able to enter into a dialogue with biological knowledge due to overlap between biology and particular societal issues, but biologists' perceptions of antiscience religious views undermine commitment to communication with the public. More generally, common ground for communication between biologists and the public functions as a barrier due to the risk of being seen as an activist rather than as a scientist. Terminology operates in a different direction than scholars of outreach have argued.

A second variant to the codification argument is that highly codified conventions of what it means to be a successful scientist shape narratives of science outreach. Although more physicists than biologists in our sample were actually engaged in outreach, narratives of outreach in physics revealed a stronger rejection of tasks that depart from research than we observed among biologists. Research remains the key basis of status in biology (as it does in physics), but the informal sanctions such as disapproval of one's peers are higher in physics.

The relevance of gender to outreach is especially salient and may be tied to gendered duties within departments. Female academic scholars more often engage in activities that are feminine typed than do their male counterparts (Bellas, 1999); science outreach is just one example of such activities. Women are more likely to take on service work within academic departments

and outside of the university. These gendered activities are often low in prestige and respect, as they appear to need little advanced training and go unrewarded within the department or university (Bellas, 1999). Although we could not "control" for gender completely, it seems that women are more likely to take on outreach work than are men. This finding differs from the work of Crettaz von Roten (2011) who found that among Swiss scientists, women are much less involved in outreach efforts than men. This difference in von Roten's finding and our results is difficult to explain due to differing methodologies. In examining outreach qualitatively, we add to the literature on gender and science by revealing that some of what motivates women, namely, to attract other women to science, does not seem to be shared by men in science. And engagement in such activities may reinforce the notion that outreach is a feminized task.

Public translation of science may be seen as outside of the responsibilities of the university scientist, an understanding tied in large part to institutional norms that value research productivity over other types of contributions (De Rond & Miller, 2005). Adherence to these norms limits scientists' ability to take on other projects and even creates disincentives for participation in outreach, in the form of peer disapproval. It is likely that this negative regard for outreach may be tied to a "Sagan effect" such that a scientist's research quality is thought to be inversely proportional to the amount of outreach work he or she does. Scientists who popularize or make science too accessible are suspect by their peers in the research community (Jensen et al., 2008). Finally, a significant minority of scientists is concerned about what they perceive as the American public's general ignorance of science and disinterest in scientific topics.

Despite its strengths, this study has limitations. First, by focusing on physicists and biologists located a numerous elite universities in the United States, we shed more light on the influence of gender and discipline than we do the role of specific universities, departments, or institutional types. As noted when we discussed organizational context, expectations for outreach are likely to differ according to institutional type. Future research should examine how outreach differs at elite, middle-, and lower tiered universities. Second, while we have attempted to provide a detailed account of the meaning of outreach in elite contexts of U.S. universities, there is a need for more systematic quantitative research to verify patterns we found. Future research should utilize surveys to test the proposition that scientists' negative views of the public constrain commitment to outreach. Finally, we emphasize that expectations and experiences of outreach may be very different across the physical sciences, natural sciences, and humanities. While some scholars include disciplines outside of the physical sciences (e.g., Bentley & Kyvik,

2011), work in this area is primarily quantitative. Future research should examine interpretations and experiences of outreach in the social sciences and humanities, which would offer insight into the meaning of outreach in low-consensus fields such as sociology and history.

Nevertheless, our results suggest strategies for policy makers interested in improving communication between scientists and society. Biologists' perceptions of public religious groups that are antiscience suggest a need for targeted constituent outreach strategies. Although some religious groups lack confidence in *scientists*, research indicates that religious individuals are no different than nonreligious individuals in terms of knowledge of or interest in *science* (J. H. Evans, 2011). This suggests the need for modes of outreach—such as forums that bring together groups of scientists and citizens that are more alike than either group may be aware. Universities may also reduce the impact of disciplinary constraints to outreach by incentivizing outreach through internal grants, awards, and resource provision.

Appendix

Descriptive Statistics for Interviews

	Biologists		Physicists	
	Men	Women	Men	Women
Graduate student	10	8	10	7
Postdoctoral fellow	8	7	2	6
Assistant professor	8	7	2	5
Associate professor	4	9	6	3
Full professor	6	7	11	7
Total	36	38	31	28

Note: The sample was overselected for women in interviews.

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Notes

1. See Burns, O'Connor, and Stocklmayer (2003) for a discussion of the definition of science communication and its intended impact on the public.
2. See http://www.nsf.gov/pubs/gpg/broaderimpacts.pdf
3. Methodologically, our approach is similar to Davies (2008), who employs "discourse analysis," which as she states emphasizes how meanings are constructed about outreach.
4. Our use of percentages in this article indicates proportions of scientists in our sample who in interviews described involvement in outreach.
5. Phys25F, April 2, 2010.
6. Phys63F, November 29, 2010.
7. Phys29F, April 15, 2010.
8. Phys2, June 10, 2009.
9. Phys24, March 16, 2010.
10. Bio45F, April 23, 2010.
11. Bio75M, August 20, 2010.
12. Bio4M, June 10, 2009.
13. Bio66M, August 9, 2010.
14. Bio48F, April 29, 2010.
15. Phys24F, March 16, 2010.
16. Phys9F, August 31, 2009.
17. Phys24F, March 16, 2010.
18. Phys52F, October 28, 2010.
19. Phys2F, June 10, 2009.

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