

Hiring Criteria in Biology Departments of Academic Institutions

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We surveyed faculty in the biology departments of US institutions of higher education to compare the experience and training valued by faculty at hiring institutions with the experience and training most graduate students receive. Our data show that associate, baccalaureate, and master's institutions value teaching experience and skills more highly than research skills. In contrast, doctoral institutions place a higher value on the ability to publish research and obtain outside funding. These findings provide quantitative and qualitative insight into discrepancies between the values of those who train graduate students in biology and the expectations of the institutions likely to hire these individuals.

Keywords: graduate education, teaching, career development, academic job market, biology education

In recent years, numerous studies have addressed the academic and nonacademic job market for scientists, as well as graduate training for PhDs entering such jobs (Council on Graduate Education 1998, Nyquist and Woodford 2000, Freeman et al. 2001, Golde and Dore 2001, DeNeef 2002, NSF 2003). These studies point to a highly competitive job market for PhDs who wish to enter academia, and to inadequacies in the graduate training received by many doctoral students.

Preparing graduate students in biology for the academic job market

PhDs who pursue an academic career face a competitive job market, because there are more PhDs produced than there are faculty positions available (Nyquist and Woodford 2000, Freeman et al. 2001). Further, jobs within academia span a range of types of institutions of higher education, so those PhDs who are successful in securing an academic position may well spend their careers at institutions that differ greatly from the ones in which they were trained as scientists. Therefore, graduate students need a diversity of skills to attain and succeed in academic positions. While there has been relatively little study of the distribution of faculty members at different academic institutions, available data suggest that among full-time faculty in a range of disciplines, 42 percent are at doctoral institutions, 25 percent at comprehensive (master's) institutions, 7 percent at liberal arts (baccalaureate) institutions, and 20 percent at community colleges (associate institutions; Golde and Dore 2001). In all, more than half of current full-time faculty members are employed at nondoctoral

institutions. Further, of all faculty, 43 percent are employed in part-time positions, which are more likely to emphasize teaching (Golde and Dore 2001).

Currently, graduate training at most institutions focuses heavily on research skills. A 1999 study of graduate students in a range of fields at 27 different US universities indicated that 72 percent of students felt confident conducting research in their field (Golde and Dore 2001). In contrast, only a minority (19 percent) of molecular biologists felt prepared to teach (Golde and Dore 2001). Other data show that graduate students want more pedagogical training (DeNeef 2002).

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Several national initiatives have arisen to address how to better prepare graduate students for teaching and for diverse types of faculty life (e.g., Woodrow Wilson National Fellowship Foundation 2005). One of the most notable of these programs is Preparing Future Faculty (PFF). PFF, which began in 1993, provided funding to programs to promote graduate student development at 45 doctoral institutions. Although PFF no longer makes grants, its programs continue, including relationships with local partner institutions (representing a range of nondoctoral institutions), pedagogical training, mentoring, and preparation for the job search and for the “roles and responsibilities of faculty” (DeNeef 2002, PFF 2005).

One biology-specific example of a similar program is the Certificate in Teaching College Biology (CTCB) at Duke University, for which we serve as leaders. The CTCB was initiated as a result of a PFF grant in 2000, with the aim of enhancing graduate student professional development by (a) helping graduate students gain skills and knowledge in teaching and learning and (b) raising graduate student awareness of what faculty life is like. Given these goals, we were interested in obtaining quantitative information about the desires of diverse academic institutions for their new faculty. Our assumption is that doctoral institutions are likely to train graduate students in the areas that they most value in job candidates, which may not be optimal for faculty at other types of institutions. Previous studies (Nyquist and Woodford 2000, Golde and Dore 2001, DeNeef 2002) give some indication of the nature of graduate training and address alternatives to academic careers, but no studies have provided a comprehensive overview of the needs of different types of academic institutions with respect to science faculty. Thus, we set out to quantitatively address the question, Do the characteristics that training institutions (doctoral institutions) value in new faculty match the characteristics that academic hiring institutions (including doctoral, master’s, baccalaureate, and associate institutions) value in new faculty? More specifically, do the values of doctoral institutions differ from those of associate, baccalaureate, and master’s institutions?

We queried individuals in the biology departments of 545 institutions to assess the qualities they expect in job candidates. We assembled results from 1585 respondents (a 76.5 percent response rate) and grouped responses on the basis of the institution’s Carnegie classification (doctoral, master’s, baccalaureate, or associate) (McCormick 2001). The institutions in our survey represent a substantial proportion of the total number of institutions in their respective categories (table 1). In this paper, we discuss the data with respect to the expectations of hiring institutions in the broad categories of candidates’ overall experience, publication record, and pedagogical training.

Our results show significant differences between biology departments’ expectations at doctoral institutions and at all other institution types, suggesting strongly that many jobs in academia require experience and prowess not just in research but also in teaching. This finding can provide guidance to graduate students hoping to prepare themselves for the academic job market and also inform graduate student advisers and policymakers that for students to compete for faculty jobs, they will need to demonstrate proficiency in a range of skills, among which teaching plays an important role.

Types of experience valued

In the “experience” category, we asked respondents about general candidate experience with respect to teaching- and research-related categories. Participants were asked to consider the importance of teaching experience, teaching evaluations, research experience, publication record, and grant record, and to rate each on a scale of 1 to 5 (with 1 being “not important” and 5 being “very important”). Not surprisingly, we found that doctoral institutions on average valued research experience, publication, and grant records significantly more than did other types of institutions, while respondents at nondoctoral institutions valued teaching experience and teaching evaluations more highly than did those at doctoral institutions (permutation test, $p < 0.003$; figure 1). We address the teaching and publication categories in more detail in the remainder of this paper.

Table 1. Composition of sample in this study (faculty in biology departments at US institutions of higher education, responding to a survey on the experience and training valued in job candidates).

Type of institution	Number of respondents in the sample	Number of institutions represented by respondents	Institution proportion within sample (percentage)	Institution proportion among total Carnegie institutions in category (percentage)
Doctoral	321	59	11.4	22.6
Master's	600	176	32.1	22.8
Baccalaureate	376	163	29.7	26.9
Associate	288	147	26.7	8.8
Total	1585	545	99.9	24.6

Note: “Institution proportion within sample” represents the number of institutions of a given type (e.g., doctoral) represented in the survey relative to the total number of institutions in the survey. (The percentage does not total 100 because of rounding.) “Institution proportion among total Carnegie institutions in category” represents the number of institutions of a given type (e.g., doctoral) represented in the survey relative to the total number of institutions of this type present in the United States (according to the Carnegie classifications of US institutions of higher education).

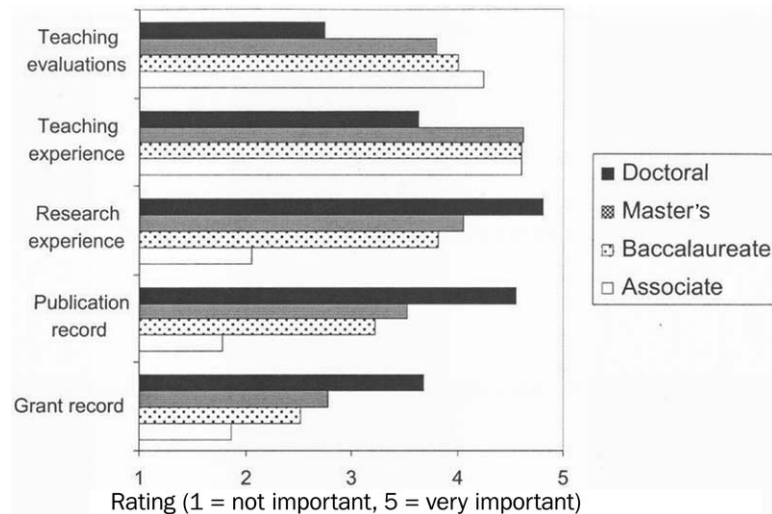


Figure 1. Importance of different characteristics for job candidates in biology at US institutions of postsecondary education. Respondents were asked to “rate how important the following items are in deciding if an applicant will get an interview to be a faculty member in your department,” selecting one rating for each characteristic on a scale of 1 (not important) to 5 (very important). Results for each question are plotted as the mean for each institution type. Data were analyzed using permutation tests, based on the Jonckheere-Terpstra test statistic, to assess the significance of the ordering among grouped responses ($p < 0.003$).

Role of publications

Many doctoral institutions place high significance on regular and frequent publication (figure 1). This emphasis often extends to expectations for graduate students, who may be encouraged or required to produce one or more publications before completing their degree. Further, more than half of graduate students report that they feel comfortable and confident in publishing their research findings (Golde and Dore 2001). To assess the value of this emphasis on publication for students interested in careers at nondoctoral institutions, we asked participants about the importance of publication, and about the expected number of publications for successful job candidates. As expected, more than 90 percent of respondents at doctoral institutions rated publication as important for a successful job candidate, whereas at least as many respondents at associate institutions rated existing publication record as unimportant. Between these extremes, 41 percent of respondents at baccalaureate institutions rated publication as important, while respondents at master’s institutions were nearly evenly split over the importance of this factor (figure 2a), showing a significant difference among institution types (permutation test, $p < 0.003$).

Consistent with the above results, the expected number of publications for successful job candidates was significantly higher at doctoral institutions than at all other institution types. The largest number of respondents from doctoral institutions (47 percent) expected 4 to 6 peer-reviewed publications, with another 14.5 percent expecting 7 to 9, and 14.5

percent expecting 10 or more. However, more than half of respondents at master’s and baccalaureate institutions expected only 1 to 3 publications, and fully half of respondents at associate institutions expected no publication record (figure 2b). Nonetheless, respondents at schools that did place importance on the number of publications often emphasized that quality mattered more than quantity, so these results do not necessarily indicate an emphasis on publication simply for publication’s sake.

Respondents’ comments on the issue of publication number pointed to some important additions to the data in figure 2, including the importance of work with undergraduates and the integration of teaching and research. Individuals at a number of baccalaureate and some master’s institutions stressed the importance of a research program incorporating undergraduates. Respondents at master’s institutions, in particular, stressed the importance of scholarship as related to teaching; comments referred to the usefulness of publication in showing clear thinking and communication skills, and stressed the importance of faculty having experience that would help them mentor undergraduates’ research and train future scholars. For instance, one respondent at a master’s institution noted, “If I chair a search committee, we hire strong scholars who see

teaching and research as an integrated activity. Excellent research skills are necessary in order to teach the hands-on, process-oriented curriculum we are moving towards.” Conversely, respondents at doctoral institutions seemed to focus more on publication as representative of a scholar’s impact on his or her field.

There are key differences at varying institutions in what is considered acceptable as a publication. Some individuals at nondoctoral institutions (especially baccalaureate institutions) considered abstracts or presentations at meetings as acceptable publications, unlike most doctoral institutions, where only publications in significant peer-reviewed journals were viewed as acceptable. One respondent from a baccalaureate institution noted, “We define ‘professional development/activity’ quite broadly. We want a colleague who has attended (ideally, presented at) meetings; has published a little.” This position was echoed by other baccalaureate respondents and suggests that the disparity in publication expectations may be even greater than our data indicate. Further, comments from many respondents at associate institutions, and some respondents at baccalaureate institutions, indicated that a significant publication record might actually be detrimental to a candidate unless the applicant demonstrated an interest in changing career paths to focus on teaching.

Importance of teaching experience

In addition to differences in the value of publications, the results in figure 1 point to a difference in expectations about

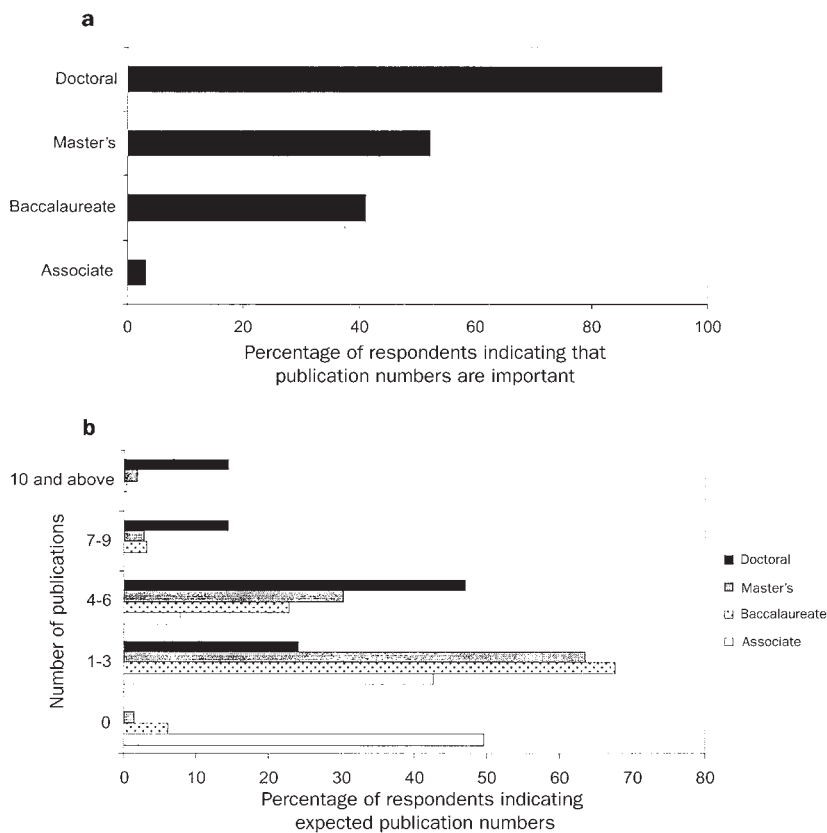


Figure 2. Importance of publication record for academic job candidates in biology. (a) Respondents were asked, “Is the number of publications important?” and could choose either “yes” or “no.” Data are presented by institution type. Data were analyzed by permutation tests, based on the Jonckheere-Terpstra test statistic, to assess the significance of the ordering among grouped responses ($p < 0.003$). (b) Respondents were asked, “How many publications would you expect from an acceptable candidate?” and responses were binned in the categories shown.

teaching experience. We wanted to determine a more quantitative measure for this difference in expectations among associate, baccalaureate, and master’s institutions relative to doctoral institutions. We found that 57 to 67 percent of respondents in nondoctoral institutions expected candidates to have been the primary teacher of at least one class, while only about half as many (34 percent) of respondents at doctoral institutions expected this (table 2). More generally speaking, we found that respondents at nondoctoral institutions all expected significantly more teaching experience than doctoral institutions (permutation test, $p < 0.003$; figure 3a).

Beyond the amount of teaching experience, we also wanted to know what particular teaching skills job candidates were expected to possess. We asked respondents to

rate the importance of the following qualities: designing a syllabus, designing course learning objectives, designing case studies, designing lectures, leading class discussion, facilitating small group work, and writing exams. When respondents were asked to rate these qualities (collectively categorized as “teaching skills”), those at doctoral institutions rated all skills as significantly less important than did respondents at all other institution types (composite shown in figure 3b; permutation test, $p < 0.003$, individual ranks not shown). Interestingly, however, the means for all institutions showed a consistent trend in the relative importance of each skill in the composite. Respondents at all institutions rated designing lectures and leading classroom discussions as most important; exam-writing, facilitating small group discussions, designing a course syllabus, and designing course learning objectives as somewhat important; and designing case studies as least important (figure 3c). These findings suggest that all institution types tend to focus on traditional day-to-day activities (lectures and discussions) more than on long-term planning (course objectives and syllabus) or more innovative or nontraditional teaching styles (case studies).

Comments from respondents at all institution types emphasized the importance of teaching, with many individuals commenting, “The more, the better.” Respondents at associate, baccalaureate, and master’s institutions particularly emphasized the importance of applicants having had full responsibility for designing and teaching their own course and laboratory section. Comments included “TA experience is simply NOT enough” (emphasis in original), and “Very difficult to obtain a position with only TA experience.” Those at associate institutions particularly emphasized the unique needs of their student population and the importance of having ex-

Table 2. Amount of teaching experience expected of job candidates in biology at US institutions of higher education.

Type of institution	Teaching experience expected		
	None (percentage)	Teaching assistant (percentage)	Primary teacher (percentage)
Doctoral	22	44	34
Master's	16	24	61
Baccalaureate	15	27	57
Associate	21	13	67

Note: Numbers represent percentage of respondents at each institution who selected the corresponding category ($n = 1585$, including 321 from doctoral, 600 from master’s, 376 from baccalaureate, and 288 from associate institutions). Percentages for some institutions do not total 100 because of rounding.

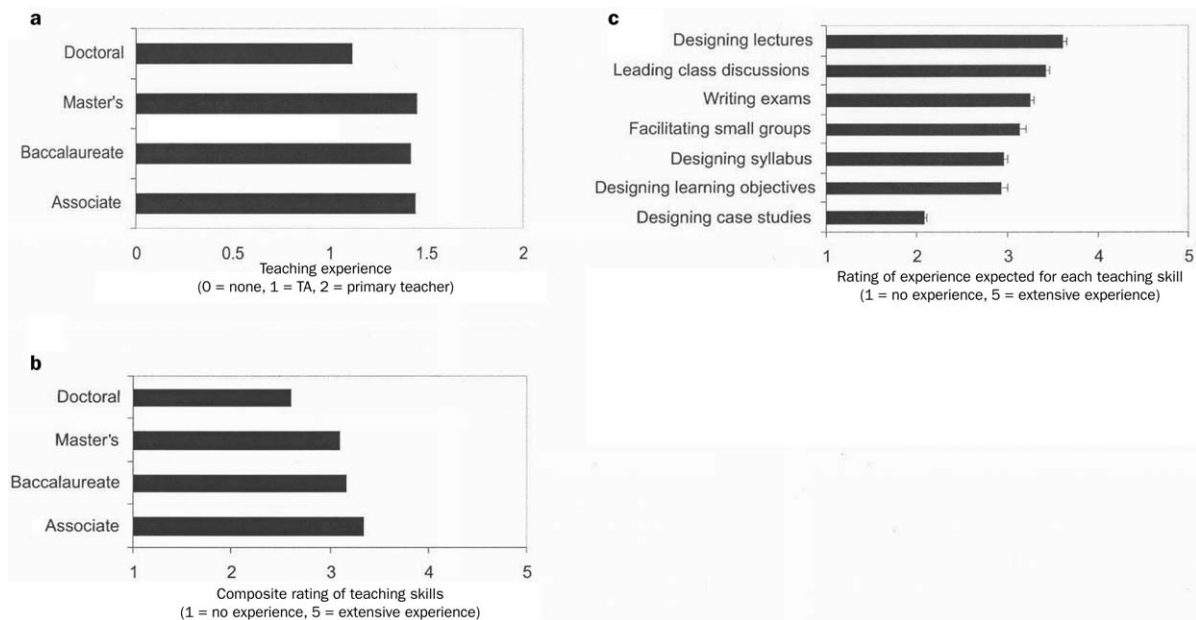


Figure 3. Types of teaching experience and skills desired in academic job candidates in biology. (a) Respondents were asked to complete a statement beginning, “The typical amount of teaching experience of a candidate would be” by choosing “no minimum requirement,” “TA 1–2 courses,” “TA 3 or more courses,” “primary teacher of 1 class,” or “primary teacher of more than 1 class.” Results were binned to combine all TA (teaching assistant) responses and all primary teacher responses, and represent the mean for each type of institution (doctoral, master’s, baccalaureate, and associate). (b, c) Respondents were asked to “rate how much experience in the following areas you expect a job candidate to have,” and to rate the importance of each skill. (b) Average means for an aggregate of all skills, by institution type. Data in (a) and (b) were analyzed by permutation tests, based on the Jonckheere-Terpstra test statistic, to assess the significance of the ordering among grouped responses. (c) Mean for individual skills, aggregated for all institutions. Error bars represent 95 percent confidence intervals.

experience at a comparable type of institution. Those at baccalaureate institutions placed particular emphasis on designing laboratory courses, something our survey did not address directly. Baccalaureate respondents also noted that opportunities were available for “on-the-job training” and teaching mentorships. Respondents at master’s institutions noted more flexibility in the teaching requirement, based on a candidate’s current position (graduate student, research postdoc, visiting professor, etc.) and field (with those in molecular biology generally having less teaching experience than those in ecology and organismal biology). Most respondents at doctoral institutions noted that, while teaching experience was desirable, research was a more significant consideration in the hiring process.

However, even a number of respondents from doctoral institutions suggested that more teaching experience would be valuable. A number of respondents at both master’s and doctoral institutions noted that they would prefer to see candidates with more experience in this area, or that they saw a trend toward increasing emphasis on teaching experience and skills. For example, one noted, “We would really prefer that a candidate have been the primary teacher for at least one class, but very often they have only had TA experience.” Thus, although the numbers show that teaching skills are valued less at doc-

toral institutions, they *are* still valued at many of these institutions. The comments of individuals at all types of institution point to a significant gap in the teaching experiences and skills possessed by new PhDs relative to the level of experience desired by most hiring institutions.

Discussion and suggestions for graduate education

Anecdotal evidence suggests that research universities are placing an increasing emphasis on teaching quality (Magner 1998) and that liberal arts institutions are placing an increasing emphasis on research opportunities for undergraduates. However, our results clearly show that there are still significant differences between the expectations of different types of institutions for their faculty. Master’s, baccalaureate, and associate institutions place a premium value on teaching, while doctoral institutions place higher emphasis on research experience and grant and publication records. Further, our data highlight differences among master’s, baccalaureate, and associate institutions that emphasize the varying missions and hiring needs of each institution type.

The strong research focus at doctoral institutions is critical to the training of PhDs. One aim of doctoral education is to prepare stewards of the disciplines who have the responsibility to advance the disciplines by generating new

knowledge (Carnegie Foundation 2005), and in many cases this seems to be the primary focus of graduate programs (Golde and Dore 2001, DeNeef 2002). However, according to our data, an exclusive focus on research—characteristic of many graduate programs—does not best serve the large number of PhDs who will assume faculty positions at non-doctoral institutions. More specifically, our data suggest that publication of a paper or two from a dissertation may suffice for many baccalaureate and master's institutions (figure 2), and that a heavy publication record may be a detriment at some associate institutions (see "Role of publications," above). "Respondents' comments suggest that for a candidate interested in a nondoctoral institution, attending professional meetings (something most graduate students do), working with undergraduates (something some graduate students do), and designing and teaching one's own course (something few graduate students do) are of equal or greater importance" than publication (Fleet and Lemons 2005).

Some of the skills we have shown to be desired by non-doctoral academic institutions are also desired by employers of science PhDs in the nonacademic sector. This sector employs 43 percent of PhDs in the biological sciences and includes jobs in the private sector, government, and nonacademic education-related fields (NSF 2003). Employers across non-academic fields have expressed a desire to see PhD training include more teaching experience and more interaction outside academia (Nyquist and Woodford 2000, Woodrow Wilson National Fellowship Foundation 2005). More specifically, those in government agencies express a desire to see PhDs with broader experiences such as teaching, internships, or co-ops; the ability to do applied and interdisciplinary work; and a focus on contributing to society rather than just accumulating knowledge (Nyquist and Woodford 2000). Those in industry express expectations that PhDs be able to communicate well, work in groups or teams, and have an awareness of international markets (Nyquist and Woodford 2000).

Beyond the expectations of those hiring biology PhDs, previous studies on graduate education, performed by surveying graduate students and recent PhDs, suggest that graduate students have a strong desire to know more about the job market that awaits them after graduate school and that, in general, this type of information is lacking from their PhD training (Golde and Dore 2001, DeNeef 2002). Our study addresses this desire by presenting prospective science PhDs with a rigorous assessment of what potential academic employers are looking for in new faculty. We expect this study to be a touchstone for any science PhD who is weighing the options of employment in various academic settings, providing a guideline for understanding the expectations of different institutions and an impetus for further personal investigation of these differences.

Our data also make a compelling and clear case for action on the part of graduate school faculty and administrators. Faculty and administrators need to broaden their thinking about the education they provide to their students, specifically by

helping students to gain more appropriate training and experience in teaching. Too often the opportunity to gain valuable teaching training and experience in graduate school is haphazard and depends entirely on the initiative of the graduate student. One way graduate schools and departments could improve this situation is to carefully plan the types of teaching experiences that are provided to graduate students. For example, graduate students could be offered increasing classroom responsibility as they advance in their graduate programs, taking teaching assistantships early in their careers and working independently as the instructors of their own courses by the end of their graduate careers. Ideally, these teaching experiences would be mentored so that at each stage students receive appropriate training and feedback from more experienced and knowledgeable teachers. This could culminate in the opportunity to serve as the primary teacher of a course, responding to the hiring expectations of many nondoctoral institutions (table 2).

A related way to improve the training of graduate students would be for graduate schools to offer and for graduate faculty to encourage participation in programs such as PFE, CTCB, and others described in the Woodrow Wilson National Fellowship Foundation's 2005 report *The Responsive PhD: Innovations in US Doctoral Education*. These programs provide graduate students with the opportunity to learn about faculty life at diverse institutions, to be mentored by faculty at these institutions, and to gain teaching experience and knowledge (Woodrow Wilson National Fellowship Foundation 2005). Other programs provide opportunities for graduate students to form partnerships with professionals outside of academia and to explore and prepare for the diverse hiring market (Woodrow Wilson National Fellowship Foundation 2005). These types of changes will improve graduate education substantially by better preparing graduate students for the expectations that await them after their PhD training.

Our study adds two major elements to the existing body of information about graduate education. First, it presents the views of faculty from all categories of US institutions. To the best of our knowledge, this vantage point has not previously been presented in a study of graduate education. Second, the study is based upon survey responses from a large number of faculty, representing a significant sample of the overall faculty in US institutions of higher education. Thus, it allows for clear and compelling conclusions to be drawn.

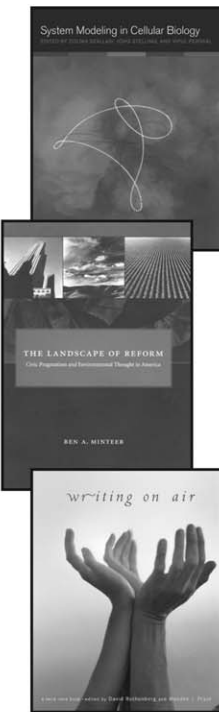
The main conclusion is this: Training for teaching, and primary teaching experience, matter. This conclusion is consistent with a comprehensive understanding of the purpose of doctoral education—one that sees PhDs not only as generators of new knowledge but also as stewards of the discipline who will insure that knowledge is represented and communicated effectively (Carnegie Foundation 2005). In a society in which new knowledge is growing at such a rapid rate, PhDs should be able not only to generate new knowledge but also to represent and communicate that knowledge well.

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