CPT
Special Report
Committee on Professional Training

American Chemical Society
1155 Sixteenth Street, N.W.
Washington, D.C.

Spring 2008

Survey of Ph.D. Programs in Chemistry

Looking for more data on graduate education?

Check out the CPT website at **www.acs.org/cpt** to find reports from surveys of:

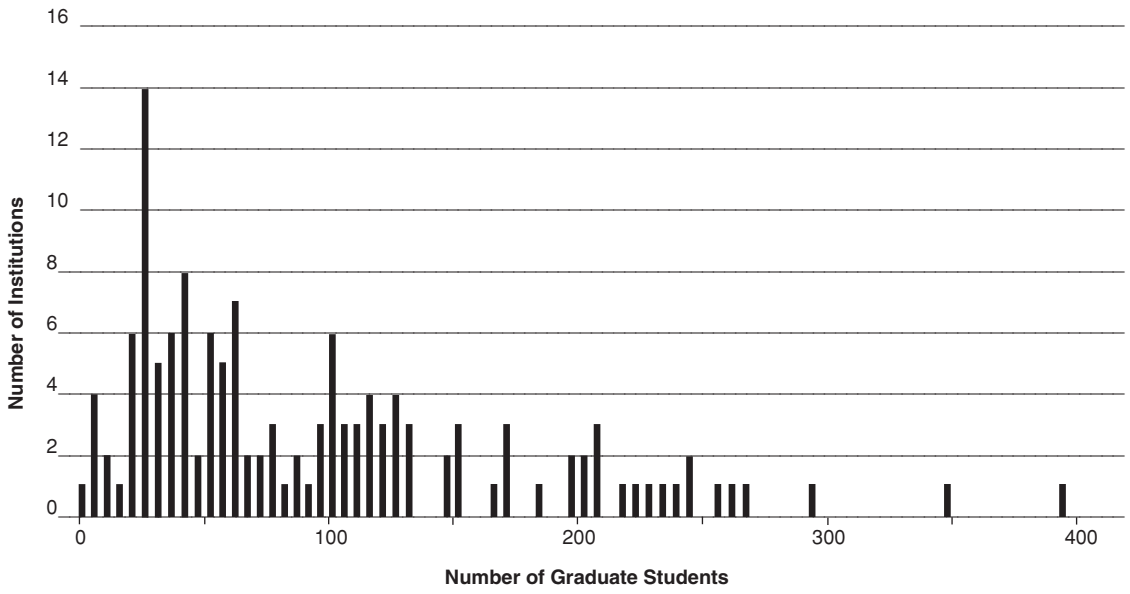
- Ph.D. Recipients in Chemistry, Part II (Fall 2000)
- Ph.D. Recipients in Chemistry (Spring 1999)
- The Masters Degree in Chemistry (Spring 1998)
- Ph.D. Programs in Chemistry (Spring 1997)

The primary objective of the Committee on Professional Training (CPT) is to facilitate the maintenance and improvement of the quality of chemical education at the postsecondary level. This includes not only developing and administering the guidelines that define high-quality undergraduate education, but also producing resources such as the *ACS Directory of Graduate Research* and publishing data on undergraduate and graduate chemical education. Included in this latter category are periodic reports on graduate education, data for which are obtained via questionnaires filled out by graduate chemistry departments.

In the fall of 2006, CPT mailed a questionnaire to all 196 Ph.D. programs in chemistry that are known to CPT, in order to obtain current statistical data and to determine current practices. By the spring of 2007, 139 of these programs had provided usable data. Reported herein is a summary of the data received, including a comparison of information received from a questionnaire fielded a decade ago (1996). An analogous survey of master's degree programs is also in progress, the results of which will be reported in the near future.

Results and general features of Ph.D. programs in chemistry. 139 Ph.D. programs provided usable data for this survey. These programs are divided into three groups of approximately equal size, according to the total number of graduate students in the program: 44 small (defined as 0 to 40 total graduate students), 46 medium (41 to 105 graduate students), and 49 large programs (106+ graduate students). Table 6 (end of report) summarizes the results of the questionnaire, using an overall average as well as the averages for the small, medium, and large programs. For the reporting programs, the number of students in Ph.D. programs ranges from 0 to 394 (see Figure 1), with a total of 13,280 students. Eighteen depart-

Figure 1. Size Distribution of Ph.D. Programs



ments have more than 200 students, accounting for 4,460 (more than one-third of the total) graduate students in all. The 30 largest programs account for almost 50% of the total number of graduate students. The average program size is 96 students, while the median size is 67 students.

Faculty and departmental structure. The average faculty size at doctoral institutions is 23, about 80% of whom are tenured (Table 1). Smaller programs obviously have fewer faculty members, but also tend to have a greater percentage of nontenured tenure-track faculty: 27% of faculty in small programs are nontenured, compared with 20% for medium-sized programs and 18% for large programs. Women comprise 12% of all faculty, including 10% of tenured and 19% of nontenured faculty. On a percentage basis, small programs have nearly twice as many African Americans on faculty as do medium and large programs. At 1.8%, African American representation on faculty at small schools approaches the percentage of African American Ph.D.s (2.1% of the Ph.D.s in chemistry)[1] produced each year. One fact that does not bode well for future faculty diversity is that among the 49 large programs, only two (0.7%) nontenured faculty members are African American. Hispanics represent 1.7% of total faculty, regardless of program size; this compares to 2.2% of all new Ph.D.s in chemistry being Hispanic.[1]

For all Ph.D. departments, 21% of faculty obtained at least one postsecondary degree outside of the United States. This percentage does not vary appreciably by program size.

While all responding programs have regular colloquia, these are handled differently at different schools. On average, about 12% of colloquium speakers come from industry and 9% come from government, but some programs use academic speakers virtually exclusively, while others have as many as 50% nonacademic speakers. At approximately half of departments, a graduate student organization participates in selecting at least some of the colloquium speakers.

About 65% of departments have a formal graduate student organization, and many departments have graduate students serving on faculty committees. Most Ph.D. departments are still organized traditionally, but about 20% of reporting programs are not organized according to the standard divisions (organic, physical, etc.). Larger programs are more likely to be organized according to standard divisions than are small programs. More than one-third of reporting programs do not have a biochemistry division as part of their department.

Graduate student statistics and requirements. Of the doctoral students in responding programs, 27.4% are women, 5.2% are underrepresented minorities, and 42.3% are international students (Table 2). Small programs tend to have a higher percentage of underrepresented minority students (averaging 7.8%), while large programs have a higher percentage of women (28.5%) and a lower percentage of international students (37.3%). It is interesting that the percentage of women in reporting programs (27.4%) is lower than the percentage of Ph.D. degrees earned by women (32.7%).[1]

Most (71%) graduate programs require entering graduate students to take placement exams, although this requirement tends to be less prevalent as program size increases. The average program requires a minimum of 20 credits (semester hours, corrected for programs on the quarter system) of course work; this number does not vary significantly among programs of different size.

More than 80% of students choose a research advisor within six months of entering graduate school; the percentage is even higher (87%) in large programs. As seen in Table 3, the average number of graduate students per faculty member for all programs is 4.4. As might be expected, this ratio increases significantly as program size

Table 1. Demographics of Faculty Members by Program Size

	- All Schools -			- Small Programs -			- Medium Programs -			- Large Programs -		
	Total Faculty Faculty	Tenured Faculty	Nontenured Faculty	Total Faculty Faculty	Tenured Faculty	Nontenured Faculty	Total Faculty Faculty	Tenured Faculty	Nontenured Faculty	Total Faculty Faculty	Tenured Faculty	Nontenured Faculty
Avg. #	23	18	5	15	11	4	20	16	4	33	27	6
% AA	1.1	1.0	1.4	1.8	1.6	2.3	0.8	0.6	1.6	1.0	1.0	0.7
% Hisp.	1.7	1.4	2.9	1.6	1.2	2.6	1.7	1.7	1.6	1.7	1.3	3.8
% NA	0.2	0.2	0.2	0.5	0.5	0.6	0.0	0.0	0.0	0.2	0.2	0.0
% Women	11.9	10.0	18.9	12.9	11.2	17.0	10.2	8.4	16.9	12.5	10.4	21.3
% Obtaining a post-secondary degree outside the United States	21			23			20			21		

[1] National Science Foundation, Division of Science Resources Statistics. 2006. *Science and Engineering Doctorate Awards: 2005*. NSF 07-305. Susan T. Hill, project officer. Arlington, VA. Values are based on averages for the years 2001 to 2005.

Table 2. Demographics of Graduate Students by Program Size

	All Schools*	Small Programs	Medium Programs	Large Programs
Avg. # of students	96	25	70	183
% International	42.3	53.0	52.6	37.3
% African American	2.4	3.2	2.5	2.3
% Hispanic	2.5	4.2	1.8	2.5
% Native American	0.3	0.4	0.3	0.3
% Women	27.4	21.6	26.1	28.5

* Two programs reported their total number of students without giving a demographic breakdown of these students. Therefore, 28 students were removed from the total number of students from all schools.

Table 3. Ratio of Ph.D. Students to Faculty by Program Size

		Small	Medium	Large
	All Programs	(0–40)	(41–105)	(106+)
Graduate students	13,280	1,105	3,224	8,951
Faculty	3,036	599	876	1,561
Graduate students/faculty	4.4	1.8	3.7	5.7

increases: 1.8 students/faculty in small programs, 3.7 in medium programs, and 5.7 in large programs.
In 91% of programs, each graduate student has an advisory committee that follows his/her progress through graduate study. Cumulative examinations, an oral preliminary exam, a comprehensive oral exam, and/or a comprehensive written exam are required by 58%, 54%, 50%, and 31% of programs, respectively. All four of these exams are required by 7% of programs; 17% of programs require three; 43% of programs require two; 28% require one; and 4% of programs require none of these exams. Large programs require cumulative exams less often and oral exams more often than small or medium programs. Only four programs (3%) have retained a language requirement for the Ph.D.

Graduate student support and progression. The mean time to the Ph.D. in reporting programs is 5.1 years, which does not vary by program size nor by public vs. private institution (data not shown). Most (73%) programs have a time limit on the amount of time allowed to achieve a Ph.D. (average of 7.8 years), and most (60%) place a limit on the number of years of support allowed a student (average of 5.9 years).

As seen in Table 4, monetary support for graduate students comes from teaching assistantships more often than from research assistantships at small and medium programs, but from research assistantships more often at large programs.

Development of student skills. Just as the development of student skills, such as communication, critical thinking, and teamwork, is important for undergraduate education in chemistry, as identified by CPT, so are these skills vital for graduate students. All but six programs require graduate students to make presentations (exclusive of the thesis defense) to audiences other than their research group; the average number of required presentations is 2.4, with little variation by program size. In 74% of all programs, students must create and defend original research proposal(s); 80% of large programs have this requirement. When asked whether any graduate students receive student skills training outside of formal course work, 67% responded that at least some students receive specific training in communications; 59% in ethics/scientific integrity; 43% in grant writing; 37% in mentoring, 37% in intellectual property/patents; and 18% in business/economics. Students in large programs are more likely to receive some training in these skill areas than are students in medium or small programs.

Table 4. Teaching and Research Assistantships for Graduate Students

	% on TA	% on RA
Small programs	62	28
Medium programs	55	40
Large programs	45	51
All programs	54	40

While almost all graduate students serve as teaching assistants sometime during the Ph.D. program, only about half teach discussion sections which, unlike laboratory sections, are likely to involve formal oral presentations. The percentage of graduate students teaching discussion sections varies greatly by program size: 32% in small programs, 41% in medium programs, and 60% in large programs.

Table 5. Selected Comparisons of Results from 1996 and 2006 Ph.D. Program Surveys

	1996	2006
Number of graduate students in Ph.D. program		
Mean	84	96
Median	70	67
Number of graduate faculty	22	23
Entering graduate students taking placement exams	81%	71%
Minimum number of credit hours of formal graduate courses required for Ph.D.	22 hours	20 hours
Student requirements for degree		
Foreign language	19%	3%
Cumulative examinations	73%	58%
Create and defend original research proposal	84%	74%
Average number of seminars (other than thesis defense and to own research group)	2.8	2.4
Require or permit laboratory rotations before a final thesis advisor is chosen	26%	44%
Choose thesis advisor within first six months in graduate school	72%	81%
Mean time to Ph.D. degree	5.1 years	5.1 years
% graduate students supported by:		
Teaching assistantship	50	38
Research assistantship	54	40

Trends observed over the past 10 years. Table 5 compares some of the key results of this survey to those from the 1996 survey. During this period, larger programs increased in size: The number of reporting programs with >200 graduate students grew from 11 to 18. As a result, the mean number of students in reporting programs increased from 84 to 96 students, while the median program size remained about the same (70 in 1996 vs. 67 in 2006). Average faculty size in reporting programs has remained about the same.

There is a definite trend among reporting departments in the past 10 years for fewer requirements for the Ph.D. Most dramatic is the virtual elimination of a language requirement, falling from 19% of programs in 1996 to 3% in 2006. The percentage of programs requiring placement exams for incoming students has dropped from 81% to 71%; cumulative exams from 73% to 58%; research proposals from 84% to 74%. The required number of credit hours of course work has also dropped somewhat. The percentage of programs that require or permit laboratory rotations before a final thesis advisor is selected has risen from 26% to 44%, while the percentage of programs in which students choose an advisor within their first six months has risen from 72% to 81%. Despite the perception by some that time to degree has been increasing, this has remained constant over the past 10 years at 5.1 years and, importantly, does not vary by program size.

Summary. This analysis of the survey data provides a snapshot of current practices of Ph.D. education in chemistry in the United States. It highlights differences among small, medium, and large programs and offers some insight into changes in programs over the past decade.

Table 6. Summary of Selected Results of Chemistry Ph.D. Programs Survey

		Average for All Programs	Averages by Program Size		
			Small (0–40)	Medium (41–105)	Large (106+)
Number of graduate students in the Ph.D. program		96	25	70	183
Number of tenured faculty in department		18	11	16	27
Number of not tenured, but tenure-track faculty in department		5	5	4	6
What is the average starting salary for new assistant professors (9- to 10-month basis; rounded to nearest $50)?		$60,500	$54,650	$60,650	$65,850
Average starting salary for public institutions		$59,250	$54,650	$58,100	$64,400
Average starting salary for private institutions		$63,900	$54,700	$66,550	$70,600
What is the average start-up package for new assistant professors (rounded to nearest $5,000)?		$430K	$235K	$410K	$650K
Average start-up package for public institutions		$405K	$240K	$330K	$625K
Average start-up package for private institutions		$500K	$220K	$590K	$730K
Is your department organized divisionally (organic, physical, etc.)?	Yes	81%	67%	86%	88%
	No	19%	33%	14%	12%
Does your department have a biochemistry (or similar) division?	Yes	68%	68%	63%	72%
	No	32%	32%	37%	28%
Does your institution/department have any procedures in place to provide family services (e.g., child care, extended tenure decision or parental/family leave) for the faculty?	Yes	67%	55%	58%	85%
	No	33%	45%	42%	15%
If so, are graduate students able to use any of these services?	Yes	77%	69%	82%	77%
	No	23%	31%	18%	23%
Do your entering graduate students have to take placement exams to determine their preparation for graduate study?	Yes	71%	79%	70%	65%
	No	29%	21%	30%	35%
If so, are there programs designed to correct any deficiencies detected?	Yes	26%	27%	31%	19%
	No	74%	73%	69%	81%
What is the minimum number of credits of formal graduate courses required to graduate with a Ph.D.?		20 cr	22 cr	20 cr	19 cr
Approximately what percentage of the required credits is taken outside of the student's own field (e.g., organic chemistry)?		11%	11%	11%	12%
Do you have regular department-wide colloquia?	Yes	96%	95%	98%	96%
	No Response	4%	5%	2%	4%
What percentage of the speakers comes from industry?		12%	12%	13%	10%
What percentage of the speakers comes from government?		9%	9%	8%	9%
Typically how many seminars or other presentations (exclusive of the thesis defense) does a student give during the Ph.D. career to audiences other than the student's own research group?		2.4	2.4	2.5	2.3
Do you require your graduate students to create and defend original research proposal(s)?	Yes	74%	72%	70%	80%
	No	26%	28%	30%	20%
What percentage of graduate students receives some formal preparation for a faculty position?		25%	28%	20%	28%
What percentage of graduate students teaches discussion sections?		45%	32%	41%	60%
Do you give graduate students some formal instruction in teaching before they start?	Yes	75%	46%	85%	89%
	No	25%	54%	15%	11%
What percentage of your graduate students participates in interdisciplinary programs involving other departments?		20%	19%	20%	21%
What is included in your Ph.D. examination system?					
Cumulative examinations		58%	58%	73%	45%
Oral preliminary exam		54%	37%	53%	69%
Comprehensive written exam		31%	37%	27%	31%
Comprehensive oral exam		50%	44%	47%	59%
Dissertation defense		98%	98%	100%	96%
Other		32%	30%	31%	35%
What percentage of your students select a research advisor within:					
Two Months?		20%	23%	17%	21%
Six Months?		81%	76%	80%	87%
One Year?		98%	97%	100%	100%

Table 6. Summary of Selected Results of Chemistry Ph.D. Programs Survey (continued)

		Average for All Programs	Averages by Program Size		
			Small (0-40)	Medium (41-105)	Large (106+)
What percentage of advisors speaks about their research to the entering students as a group only?		2%	3%	2%	0%
What percentage of advisors speak about their research to the entering students individually only?		31%	58%	26%	14%
What percentage of advisors speaks about their research to the entering students both individually and as a group?		67%	40%	72%	86%
Do you require laboratory rotations before a final advisor is chosen?		13%	10%	12%	16%
Do you permit laboratory rotations before a final advisor is chosen?		33%	33%	28%	37%
Do you neither require nor permit laboratory rotations before a final advisor is chosen?		56%	58%	60%	47%
Do you have a language requirement for the Ph.D.?	Yes	3%	2%	4%	2%
	No	97%	98%	96%	98%
Do you have a limit on the amount of time allowed for achieving a Ph.D.?	Yes	73%	78%	69%	73%
	No	27%	23%	31%	27%
If yes, how many years?		7.8 yr	7.8 yr	8.1 yr	7.4 yr
Do you have a limit on the number of years of support (of any kind)?	Yes	60%	70%	56%	55%
	No	40%	30%	44%	45%
If yes, how many years?		5.9 yr	5.5 yr	6.1 yr	6.2 yr
What is the mean time (years) to degree?		5.1 yr	5.0 yr	5.2 yr	5.1 yr
What is the annual TA stipend for your Ph.D. students (rounded to nearest $100)?	Low	$18,000	$16,000	$18,200	$19,500
	High	$19,900	$18,500	$20,400	$20,700
Does each graduate student have an advisory committee that follows his/her progress through graduate study?	Yes	91%	93%	93%	88%
	No	9%	7%	7%	12%
Do all advisory committee members serve on the final Ph.D. committee?	Yes	89%	93%	93%	83%
	No	11%	8%	7%	17%
Does each graduate student give a final oral presentation of the thesis?	Yes	94%	95%	98%	90%
	No	6%	5%	2%	10%
Where do students obtain information on careers and/or skills needed to obtain jobs or postdoctoral positions?					
Department events		63%	55%	53%	78%
University placement/career center		71%	55%	67%	90%
Department bulletin boards		88%	79%	89%	94%
Department websites		42%	21%	47%	55%
American Chemical Society		79%	71%	87%	80%
Research advisor		99%	98%	100%	98%

The complete questionnaire sent to Ph.D. programs can be found on the CPT Web site at www.acs.org/cpt.