CPT Report: Survey of Ph.D. Programs in Chemistry Spring 1997

The principal emphasis of CPT has always been on undergraduate education in chemistry, but the responsibility of monitoring and evaluating graduate education also falls within its purview. Recently, concerns have been expressed about the health of our graduate programs, in response to which ACS president Ronald C. Breslow convened a conference at Columbia University in November 1995 to discuss the present state of Ph.D. education in chemistry. Arising from the discussion at that conference was a list of desirable qualities for a good Ph.D. program, and these were reported in an ACS Comment by President Breslow that appeared in *C&EN* (December 11, 1995, pp 6566).

At this point it became apparent that it would be highly desirable to determine just what the current practices are among the 190 Ph.D. programs in chemistry that are known to CPT. Thus, in cooperation with President Breslow, CPT composed and distributed a questionnaire, which was mailed to all the Ph.D. programs in May 1996. By late summer, responses had been received from 155 of these programs and CPT was able to present a preliminary analysis of the data at the Presidential Event, "Graduate Education in Chemistry-Are Changes Needed?", which was held at the 212th ACS National Meeting in Orlando. This preliminary analysis will be presented here in somewhat greater detail. An analogous survey of master's degree programs has been conducted, and the results will be published at a later time.

Results of survey of Ph.D. programs in chemistry.
The results are summarized in the Table where averages of the responses are reported. There are two averages. The first is simply the sum of the responses divided by the number of reporting programs. The second is a weighted average in which the response for each school is multiplied by the number of students in that program, a sum is taken over all of the schools and that sum is divided by the total number of students. The weighted average provides an indication of whether or not a given practice is more prevalent in the larger programs. For example, 19% of the programs have a foreign language requirement (unweighted average) while the weighted average response was 15%. Thus, only 15% of the students are in programs that have a language requirement whereas 19% of the schools have such a requirement. Thus, it is probably true that larger schools are less likely to have a language requirement than are the smaller programs. Both weighted and unweighted averages are provided in the Table, but only unweighted averages will be discussed in what follows.

General features of Ph.D. programs in chemistry.
There is a tremendous range in size of Ph.D. programs-from 3 to 338 students for the 155 reporting schools (see Figure). The 30 largest schools enroll almost half of the chemistry Ph.D. students in the reporting programs. There are also many smaller Ph.D. programs with about 50 institutions reporting fewer than 50 students. The average program size is 84 students and the average size of the graduate faculty is 22. Students in Ph.D. programs are supported in a variety of ways. The schools were asked what fraction of graduate student support was in the form of teaching assistantships, and the average of the reporting schools was 50%. The average percent support from faculty-generated research funds was 38%, university or departmental fellowships 7%, government fellowships 4%, with other sources making up the difference. The departments reported that an average of 7% of the total graduate student support comes from industry.

Educational breadth of the Ph.D. program.
Participants in the Columbia conference felt that in addition to developing a mastery of a specific area of chemistry, students should take a significant fraction of courses outside their area and participate in other activities to provide educational breadth. Some of the questions asked of the Ph.D. departments were related to this issue. Of the reporting schools, 81% require placement examinations to judge the breadth and soundness of the undergraduate training. The schools

reported that on average Ph.D. students take 22 semester credit hours of course work and 37% of these are outside the student's area of specialization. The survey found that 96% of the schools have department-wide colloquia, which include speakers from a variety of areas. On average, the schools estimated that 57% of the individuals attending these colloquia were from outside the area of the speaker. The schools also reported that 16% of their colloquium speakers were from industry.

About 17% of Ph.D. graduate students in chemistry participate in interdisciplinary programs involving other departments, and 26% of the programs allow or require students to spend short periods of time in several laboratories before selecting a research advisor. All of these questions shed some light on the breadth of the educational experience.

Development of communication skills and creative thinking.
This was identified as one of the crucial components of a strong Ph.D. program. When asked how many oral presentations a student made during the course of Ph.D. study (other than those made to the student's own research group), the schools reported an average of 2.8. Almost all graduate students (93%) are reported to serve as teaching assistants sometime during the Ph.D. program, but of these only 40% taught discussion sections which, unlike laboratory sections, are highly likely to involve a formal oral presentation.

The creation and defense of one or more original research proposals was a required feature of 84% of the programs, while the requirement of a final oral presentation of the thesis was almost universal (92%). These responses reveal some of the ways that development of communication skills and creative thinking are being encouraged in Ph.D. programs in chemistry.

Other requirements.
Cumulative examinations are required by 73% of the reporting schools, 53% require an oral preliminary examination, 33% require a comprehensive written examination, and 44% indicate that a comprehensive oral examination is a part of the Ph.D. program. The foreign language requirement now exists in only 19% of the schools. The practice of naming an advisory committee to monitor the progress of the Ph.D. student is followed by 89% of the programs. The survey revealed that 68% of the departments put an upper limit on the time permitted for achieving the Ph.D. degree, and the average upper limit was 7.2 years. Also, about two-thirds (71%) of the programs put a limit on the number of years of financial support that a Ph.D. student can receive, and the average limit is 5.5 years. Finally, the schools reported that an average of 5.1 years was required for their students to complete the Ph.D.

Summary.
This analysis of the survey data provides a general picture of the shape and dimensions of Ph.D. education in chemistry as practiced in the graduate schools of the United States. After learning what the average requirements and practices are in our graduate programs, we can begin the more important task of formulating answers to the question raised in President Breslow's Presidential Event: "Graduate Education in Chemistry-Are Changes Needed?"

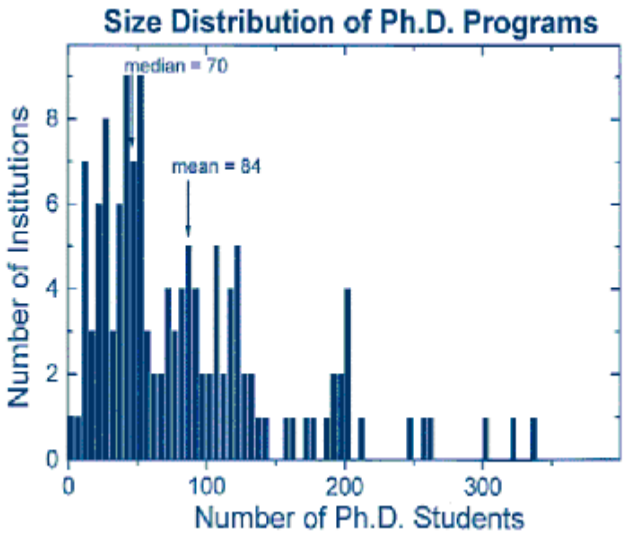

Table. Results of Survey of Ph.D. Programs in Chemistry[a]				
Question				**Average[b]**
1.	Number of graduate students in the Ph.D. program Number of graduate faculty		84 22	c c
2.	Do your entering graduate students have to take placement exams to determine their preparation for graduate study?	yes no	81% 19%	77% 23%
	If so, are there programs designed to correct any deficiencies detected?	yes no	88% 12%	85% 15%
3.	How many semester credit hours do your students typically spend in formal graduate courses, not including research and seminar?		22hr	22hr
4.	Approximately what percentage of the courses are taken outside the student?s own field, e.g., organic chemistry?		37%	34%
5.	Do you have regular department-wide colloquia?	yes no	96% 4%	93% 7%
	If so, approximately what percentage of those attending are from outside the field of the speaker?		57%	51%
	What percentage of the speakers come from industry?		16%	16%
6.	Typically how many seminars or other presentations (exclusive of		2.8	2.6

	the thesis defense) does a student give during the Ph.D. career to audiences other than the student?s own research group?			
7.	Do you require your graduate students to create and defend original research proposal(s)?	yes no	84% 16%	84% 16%
8.	What percentage of your graduate students get some experience as teachers?		93%	91%
	What percentage teach discussion sections?		40%	48%
	Do you give them some formal instruction in teaching before they start?	yes no	86% 14%	91% 9%
9.	What percentage of your graduate students participate in interdisciplinary programs involving other departments?		17%	14%
10.	What is included in your Ph.D. examination system?			
	Cumulative examinations Oral preliminary exam Comprehensive written exam Comprehensive oral exam Research proposal(s) Thesis defense	73% 53% 33% 44% 86% 97%	70% 61% 29% 46% 85% 94%	
11.	What percentage of your students select a research advisor within			
	2 Months 6 Months Later		20% 72% 33%	19% 75% 27%
	Do advisors speak about their research to the entering students as a group?	yes no	68% 32%	77% 23%
	Do you require or permit laboratory rotations before a final advisor is chosen?	yes no	26% 74%	26% 74%
12.	Do you have a language requirement for the Ph.D.?	yes no	19% 81%	15% 85%
13.	Do you have a limit on the amount of time allowed for achieving a Ph.D.?	yes no	68% 32%	63% 37%
	If yes, how many years?		7.2yr	7.2yr

	Do you have a limit on years of support (of any kind)?	yes no	71% 29%	70% 30%
	If yes, how many years?		5.5yr	5.6yr
	What is the mean time to degree? (years)		5.1yr	5.5yr
14.	Does each graduate student have an advisory committee that follows his/her progress through graduate study and whose members serve on the final Ph.D. committee?	yes no	89% 11%	86% 14%
15.	Does each graduate student give a public final oral presentation of the thesis?	yes no	92% 8%	89% 11%
16.	What approximate percentage of your total graduate student support is by[d]			
	Teaching assistantships Faculty-generated research funds University or department fellowships Government fellowships Training grants, interdisciplinary Training grants, chemistry Other	50% 38% 7% 4% 2% 2% 6%	44% 43% 6% 4% 3% 3% 4%	
	Of the total support of graduate students, what percentage comes from industry?		7%	7%

[a] Based on 162 responses received by January 1, 1997. Not all respondents answered each question.
[b] Unweighted average: sum of responses divided by the number of institutions responding to that question.. Weighted average: sum of responses, each multiplied by the number of students in the program, divided by the total number of students in all programs responding to that question.
[c] Equal by definition to the unweighted average.
[d] Responses were approximate, explaining why percentages in question 16 do not sum to 100%.