

ACS Report on Graduate Education

by Morton Hoffman

The ACS recently released the report of the Presidential Commission on “Advancing Graduate Education in the Chemical Sciences,” where the term “chemical sciences” is used to encompass chemistry, chemical engineering, biochemistry, molecular biology, materials science, polymer science, nanoscience, and other activities that focus on molecules, chemical reactions, and chemical properties. The Commission, appointed by ACS President, Bassam Shakhshiri, consisted of distinguished chemists and other scientists from academia, industry, and governmental and non-governmental organizations. The work of the Commission was supported by a grant from the National Science Foundation and the ACS, mainly through its Presidential Discretionary Fund, and is available online at <www.acs.org/gradcommission>.

Charges to the Commission

- What are the purposes of graduate education in the chemical sciences?
- What steps should be taken to ensure that important societal issues are addressed as well as the needs and aspirations of graduate students?

Major Conclusions

- 1) Current educational opportunities for graduate students, viewed on balance as a system, do not provide sufficient preparation for their careers after graduate school.
- 2) The system for the financial support of graduate students, as currently operated by private, institutional, state, and federal funds, is no longer optimal for national needs.
- 3) Academic chemical laboratories must adopt best safety practices; such practices have led to a remarkably good record of safety in the chemical industry and should be leveraged.
- 4) Departments should give thoughtful attention to maintaining a sustainable relationship between the availability of new graduates at all degree levels and genuine opportunities for them; replication in excess is wasteful of resources and does injustice to the investment made by students and society.
- 5) Postdoctoral training and education is an extension of graduate education that is important for success in a variety of career paths, particularly for faculty appointments; a postdoctoral appointment should be a period of accelerated professional growth that, by design, enhances scientific independence and future career opportunities.

Recommendations for Each Conclusion

1) Preparation for careers

- Departments are encouraged to undertake greater oversight over the progress and opportunities of individual graduate students.
- Graduate programs should be more active in diagnosing and remediating deficiencies in the preparation of first-year students.
- Beyond core academic competency, additional skills are critical for a future career; specific activities should be offered that would enhance students’ abilities.
- Four years should be the target for completion of the Ph.D., with the departmental median time less than five years.
- Every department should constitute a doctoral committee for each student composed of several faculty who will be intimately involved in the student’s graduate education, and make an individual development plan a standard part of every doctoral student’s experience.
- Departments should require at least two original research proposals, one with a focus outside the student’s immediate field of study.
- Faculty should encourage students to engage in projects requiring collaboration that broadens the student’s field of study, especially interdisciplinary and multidisciplinary team approaches to complex problem solving.
- Students interested in entrepreneurship should have access to a curricular option providing an introduction to relevant topics; one or more formal courses should be developed for the more explicit

preparation of students who intend to seek academic employment.

- ACS is encouraged to undertake an extensive survey of representative graduate programs at selected major universities to ascertain requirements, expectations, and organizational structures that best facilitate the educational goals of the Commission.
- 2) Financial support of graduate students**
- Public and private funding agencies and universities should take steps toward the uncoupling of student-support funds from specific research projects by experimenting with a new strategy for “graduate program grants” to support graduate students.
 - The U.S. Department of Education should make the GAANN (Graduate Assistance in Areas of National Needs) Program more generally useful.
 - Faculty members should view work by graduate students as teaching assistants much more strategically as an opportunity – and an obligation of the program – to enhance the professional development of the student.
 - Government sources should rebalance fellowship programs to make more awards available to students in the second year of graduate school and beyond, rather than primarily in the first year.
 - Many of the nations that send graduate students to the U.S. have strengthened financially; departments and programs should place increased emphasis on having international students supported by their home countries.
 - The timetable for graduate work should include support for all students for two months during the summer before the start of courses to receive initial training in professional skills, including instructional skills, and to begin exploring research opportunities.
- 3) Best safety practices**
- Safety as a *culture* must be consistently led by example in all graduate programs in the chemical sciences.
 - A natural supporting step would be to establish a safety performance partnership between industry and academic institutions, whereby corporations share best practices with students and faculty on a regular basis.
 - Leadership from the top of an institution is essential for a sound safety culture to take root and thrive, and faculty members in the chemical sciences can and should take the lead toward best practices, advocating for support at the highest institutional levels.
- 4) Availability of new graduate students**
- Given that the employment opportunities for new Ph.D.s are and will continue to be uncertain, departments are urged to adjust their program sizes to reflect those opportunities for graduates that are truly attractive.
 - Faculty members and other academic leaders in every graduate program, whether at the master’s or doctoral level, are urged to reassess and to focus the program distinctively toward its competitive advantages.
 - To encourage and help guide needed changes, it is recommended that the ACS collect and publish aggregated, privacy-protected data, organized by graduate program, on post-degree outcomes for all graduates, including time-to-degree, types of job placements, salaries, and overall student satisfaction with the graduate experience and employment outcome.
 - Programs should build the domestic fraction of their graduate enrollments as a high priority; at the same time, it is recognized that great contributions have historically been made in our graduate programs and in our national technical enterprises by international citizens who were first attracted to the U.S. as graduate students.
 - To take advantage of the nation’s whole talent pool, graduate programs must place an emphasis on attracting and empowering students from underrepresented groups.
 - Communications to undergraduates should point out that not only is graduate education in the chemical sciences free to them, but that they will receive a stipend, as well.

5) Postdoctoral training and education

- Institutions and departments, as well as faculty mentors, should take greater responsibility for ensuring that postdoctoral associates develop professionally.
- All funding agencies should require general mentoring plans of applicants seeking support for postdoctoral associates.
- Foundations and other funding agencies should re-explore programs for “teaching postdoctoral associates,” so that trained professional instructors become an alternative to the current reliance on doctoral students for so much of a department’s undergraduate teaching responsibility.
- A feedback mechanism linking the size of Ph.D. programs to job availability is needed to minimize bulges in the career pipeline at the postdoctoral level.

Summary Statements

- The Commission hopes to free departments and programs from feeling the need to be nearly identical. There is room for greater variation in program design than has been recently typical in American graduate education in the chemical sciences. It is believed that the field would benefit from more venturesome design and greater experimentation.
- The Commission explicitly discourages any form of checklist for graduate programs or any analogue to the ACS Committee on Professional Training, which serves usefully to approve undergraduate chemistry programs.
- The Commission’s charge certainly includes master’s level education. The distinctive role that the M.A. degree level fulfills in our society suggests that there is room for fuller use of it in the development of the professional workforce. The master’s degree needs to be reconsidered as the diversity of opportunities in the chemical sciences increases.
- The Commission also understands that progress on several of the dimensions addressed among its conclusions and recommendations will require modifications to the reward structure for faculty members participating in doctoral programs.
- The Commission has focused on the goal, rather than the path toward improving graduate education in the chemical sciences. The emphasis on experimentation is an acknowledgement that many new paths will need to be explored as progress is sought along various dimensions of graduate education.
- In the effort to improve and reform, the Commission expects that there will be successes and successive stages. Pioneering departments and practices will emerge and become exemplars. Subsequent commissions and task forces will be needed to address topics in greater depth or broader imagination than was possible now, or to revisit strategies in the light of results from actual trials. Its most earnest hope is that our field will brilliantly renew its vigor and intellectual strength.