Graduate Education Newsletter

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Getting More Out of the Mentoring Experience: The Scientific Method is the Key!

Saundra Y. McGuire, Louisiana State University

November 16, 2007 was one of the highlights of my thirty-five year career as a faculty member in chemistry. On that afternoon, I stood in the Oval Office with ten colleagues from around the nation to meet President George W. Bush and to receive the Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring (PAESMEM). The award ceremony was the culmination of a two-year process that began with a nomination from Professor Isiah Warner (a past winner of the award) and concluded with trips to the National Science Foundation and to the White House. During those two years, I spent a great deal of time reflecting on mentors who had guided me over the years and on students and colleagues whom I had mentored. From my experiences, I distilled several key elements crucial for successful mentoring, and it became apparent to me that successful mentors lead their protégés toward academic and professional success in much the same way that the scientific method leads scientists to discover the secrets of nature.

The LA-STEM (Louisiana Science Technology Engineering and Mathematics) Program at Louisiana State University, for which I serve as a co-PI with Isiah Warner, focuses on mentoring as a means of increasing the number of students who successfully pursue Ph.D.s in science and technology. In the LA-STEM program, funded by the National Science Foundation with a supplement from the Louisiana Board of Regents, faculty members mentor postdoctoral associates, who in turn mentor graduate students, who mentor undergraduate students, who mentor high school students. Faculty and students at every juncture of the pipeline need to understand the qualities of effective mentors as well as the characteristics of successful protégés. Because everyone involved is quite familiar with the scientific method, applying this process is an effective means of improving the mentoring at all stages of the continuum.

Steps in the Scientific Method

The scientific method provides a standard protocol for posing questions and conducting studies to find answers to those questions. Consider the following eight-step version of the method.

1. Define the problem and ask a question.
2. Gather background information relevant to the problem.

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3. Pose a hypothesis.
4. Design and carry out experiments to test the hypothesis.
5. Analyze the results of the experiments.
6. Repeat steps 3 through 6 if hypothesis proves false.
7. Draw a conclusion if the results of the experiments support the hypothesis.
8. Report results.

Applying the Scientific Method to Mentoring

1. Define the Problem.
The process begins with posing the appropriate question. In the mentoring experience, the overarching questions for the mentors and protégés, respectively, are: "How can I provide the best guidance for *my protégé's particular needs?*" and "How can I help my mentor provide the best guidance for *my particular needs?*" The emphasis must be on the particular individual because the best advice for one person might be the worst advice for another, depending upon the specific characteristics, backgrounds, personalities, and prior experiences of those students. When the guiding question focuses on student-specific advice rather than "tried and true" advice, the chances for a successful mentoring experience are enhanced.

2. Gather Background Information.
How can mentors offer student-specific advice without learning as much as possible about their protégés? I encourage mentors to learn about a student's career goals, cultural background, prior educational experiences (not just grades and GRE scores!), Myers-Briggs personality type, and sensory learning style preference (whether the student prefers to process information in a visual, aural, reading and writing, or kinesthetic way). The mentor should also take the personality and learning style tests so that she or he can best understand how the protégé differs from the mentor. Personality tests are available at college and university career centers, or they can be taken on-line (please see www.personalitypathways.com/type_inventory.html or www.humanmetrics.com/cgi-win/JTypes1.htm). A popular inventory of learning styles (VARK) can be found at vark-learn.com. I am not suggesting that effective mentoring cannot be accomplished without having all of this information, only that the more detailed information the mentor has about the protégé, the more likely the guidance will fit the protégé's needs.

3. Pose a Hypothesis.
Of all the steps, this one is most often overlooked. Mentors give advice and take for granted that the advice is good because it worked for them and for others they have advised. Instead of the mentor thinking, "My *hypothesis* is that this advice will work; we'll see if it *does work* after the protégé tests it," many mentors think, "This is what the protégé *must* do—no ifs, ands, or buts about it!" However, in almost forty years of mentoring I have found that advice that is perfect for some students can be disastrous for others. For example, the suggestion to form study groups with peers is generally great advice, but not for students who are very introverted, or who have had bad prior experiences with study groups. Other learning strategies should be tried until the student is secure enough in his or her own self-knowledge and comfort with the subject matter to confidently interact with other students in study groups.

4.–6. Design and Carry Out Experiments, Analyze Results, and Pose New Hypotheses.
When mentors and protégés have an effective relationship, the guidance provided by the mentor is in the form of suggestions, not directives. Protégés understand that the suggested course of action is to be tested, with particular attention paid to the results obtained. And if the results do not support the hypothesis, other hypotheses can be devised (with the active participation of the protégé), and other experiments tested. With each iteration, the mentor and protégé can analyze the results of following the advice, after which new data-driven hypotheses can be tested. For example, if participating in study groups did not work, try studying with one friend. If that doesn't work, individual study sessions may be the solution. Coordinating study sessions with a friend and checking in with each other by phone at study breaks may be the answer.

7. Draw Conclusions.
I have often felt deeply rewarded as a mentor when students have reported that suggestions or strategies I offered were key to their success. But when my advice is not helpful, I always accept the challenge to dig deeper and invent new, untested strategies until I find something helpful for a student. When a new strategy proves effective with one student, I know that it will also help many other students. Drawing conclusions means connecting the dots between student characteristics (learning style, cultural background, etc.) and helpful learning strategies so that you can make a stronger hypothesis about what will help your next protégé. After forty years as a successful mentor, I still invent new strategies and draw new conclusions on a regular basis. The discovery never ends.

8. Report Results.
There are a wide variety of venues in which effective (and ineffective) mentoring strategies can be presented. These include local, regional, and national meetings, as well as print and on-line publications. When mentors have a variety of mentoring tools available, and protégés actively engage in the process, successful and satisfying mentoring experiences ensue.

Masterful Versus Misguided Mentors

Often, mentors do not view their actions through the eyes of their protégés and are not aware of how their protégés see them. If we mentors could transport ourselves back in time to when we ourselves were graduate students, we might have some useful suggestions for our current selves!

Masterful mentors

A. provide nonjudgmental information about the culture and expectations of the department, institution, faculty, etc.;
B. brainstorm with the protégé to devise effective strategies to solve problems that arise;
C. provide coaching, feedback, and constructive criticism in a positive, supportive manner;
D. serve as a confidante for personal crises and problems only where appropriate;
E. demonstrate complete confidence in the protégé's ability to excel (not just succeed);
F. put the protégé's interests and goals first when helping the protégé plot a career path;
G. let protégés make their own decisions after the mentor has discussed alternatives; and
H. genuinely care about the protégé's welfare.

Misguided mentors

A. act in a controlling and manipulative manner, wanting the protégé to blindly accept any advice given;
B. are self-centered and interested primarily in what the protégé can contribute to the mentor's activities;
C. exhibit a lack of respect for the protégé's intelligence and ability;
D. use personal information to undermine the protégé and the protégé's relationships with others;
E. are unwilling to remain on a professional level with the protégé; and
F. view the protégé as "just another student."

Proactive Versus Problematic Protégés

Mentors should discuss with students how they can best contribute to the mentor–protégé relationship. This conversation can take place at the first mentor–protégé mentoring session or at a later date, whenever the expectations of both the mentor and the protégé are discussed.

Proactive protégés

A. are interested in actively participating in brainstorming alternatives and are receptive to advice,
B. accept constructive criticism,
C. spend time preparing for mentoring sessions,
D. are unafraid to ask probing questions, and
E. do not react defensively to suggestions or advice.

Problematic protégés

A. regularly miss appointments or arrive late repeatedly,
B. fail to heed advice,
C. refuse to take responsibility for their actions,
D. generally have an unenthusiastic and negative attitude,
E. rarely, if ever, express appreciation, and
F. fail to give credit to the mentor for his or her assistance.

Improving Mentoring for All Students

Each year hundreds of students drop out of graduate programs in STEM disciplines. Many of these students would still be pursuing their graduate degrees if appropriate mentoring had been available to them. I strongly believe that applying the scientific method makes mentoring more effective and yields happier, more successful protégés. Mentors and protégés should work together to develop hypotheses about protégé-specific issues and weaknesses, jointly develop a menu of strategies and implement them, analyze the successes, develop conclusions about the efficacy of specific strategies, and subsequently modify those strategies based on the results. Taking these steps will ensure an enjoyable and satisfying mentoring experience for both protégé and mentor.

After my very heady trip to the Oval Office in the fall of 2007, I returned to Baton Rouge determined to continue improving my mentoring strategies. Applying the scientific method to each new student interaction enabled me to invent strategies that I used with my protégés during the spring 2008 semester. The extra effort paid off, and I was overjoyed when I got an e-mail from a student who had been placed on academic probation after the fall semester. When she received all of her spring-semester grades, she e-mailed me to say that she had gotten all A's, was now off probation, and was confident that she would succeed in getting her Ph.D.! ■

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Editor's Column: Thoughts on Mentoring

Marjorie C. Caserio, University of California, San Diego

Few can deny that doctoral education in the chemical sciences is critically important for the preparation of our nation's future scientists and scholars. It is also true that doctoral education relies on effective mentoring of doctoral students by their faculty advisers. So the burden of responsibility for ensuring the nation's intellectual health weighs heavily on the faculty of our doctoral institutions. The *Newsletter* takes a closer look at the status of mentoring in chemistry doctoral programs through the eyes of both faculty and students.

On reading the articles that we proudly include here, you may realize as we did that mentoring is difficult to define in structured terms and involves highly individualized relationships. Besides expertise, a mentor requires a level of selflessness and appreciation for the interests of others that is uncommon. These qualities are well described in the several commentaries by our faculty authors. Also, it is deeply gratifying that outstanding mentoring is deservedly recognized at a national level (please see articles by award winners McGuire and Larive, pages 1 and 15).

The big question is whether current mentoring standards in graduate school universally achieve the excellence needed to ensure a high level of student success. There are signs that we fall short of this ideal. The many thoughtful responses made by graduate students and postdocs responding to our questionnaire (please see page 10) identify some of the problem areas. Likewise, the article, "Apprenticeship Reconsidered," by Chris Golde (please see page 4) draws on the results of the recent five-year study of the doctorate by the Carnegie Foundation (www.carnegiefoundation.org/CID); to quote a cogent statement "The master–apprentice system—even at its best—falls short of what is required to develop scholars for the twenty-first century." Several constructive suggestions for change are described.

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One area that stands out as being neglected is the need to better prepare

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faculty for their mentoring and advising responsibilities. Running a research group requires management skills few faculty are initially experienced enough to undertake. New graduate students also need better guidance in the selection of a research adviser. These are needs that departments can and should accommodate. Some do, of course. An exemplary summer undergraduate research fellowship (SURF) program at Caltech probably owes its success to the care the program takes in selecting advisers and research projects (please see the article by Candace Rypisi, page 6). The *Newsletter* also includes a list of mentoring resources that faculty and students may find helpful. We note especially that the ACS has taken the lead in articulating *Academic Professional Guidelines* for professional standards in chemistry education (please see page 19). These complement the broader ACS *Professional Employment Guidelines* (please see page 19).

It seems to me that our educational system makes ever-increasing demands on the faculty. Pressures to fund and sustain a productive research program; publish; teach; supervise; advise; mentor; meet professional, public, and university service obligations; and offer and undertake training in research integrity, sexual harassment, and mentoring create unrealistic expectations.

It is all too easy to point fingers at the faculty for defects in the advising system. It seems to me that our educational system makes ever-increasing demands on the faculty. Pressures to fund and sustain a productive research program; publish; teach; supervise; advise; mentor; meet professional, public, and university service obligations; and offer and undertake training in research integrity, sexual harassment, and mentoring (as here suggested) create unrealistic expectations. Maybe it is time to reconsider the priorities in graduate education and research and then assign mentoring the importance it deserves. ■

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Apprenticeship Reconsidered

Chris M. Golde, Stanford University

From 2001–2006, the Carnegie Foundation for the Advancement of Teaching sponsored the Carnegie Initiative on the Doctorate (CID), an action and research project to support selected academic departments' efforts to improve the effectiveness of their doctoral programs. The CID focused on only 6 disciplines, one of which was chemistry. There were 11 participating departments, whose faculty and students met regularly at the Foundation to share their work. More information can be found in the Chemical & Engineering News *article, "Evolving the Doctorate: Carnegie Initiative Inspires Reshaping of Ph.D. Programs to Fit Modern Times."*[1] *At the conclusion of the CID, the Carnegie Foundation staff wrote a book on doctoral education*—The Formation of Scholars: Rethinking Doctoral Education for the Twenty-First Century.[2] *This article is derived from Chapter 5, "Apprenticeship Reconsidered."*

One of the sturdiest and most distinctive features of doctoral education is that so much of the important teaching and learning takes place in a one-to-one apprenticeship between student and faculty member. "Elbow learning" in seminars and labs has its roots in medieval guild culture and has been the prevailing pedagogy of graduate education throughout its evolution in American universities.

When they are good, these mentoring relationships can be very good. As historian William Cronon explains, "This master-apprentice relationship remains utterly central to doctoral education at its best… . When it works, it produces intensely personal relationships that can last a lifetime. Those of us lucky enough to have had generous and inspiring graduate mentors know how essential they were to our success. We owe a debt to them that can never be repaid, save by working as hard as we can to pass along the same kind of gifts to our own students."[3]

Unfortunately, when the relationship is bad, it can be horrid. Apprenticeship tends to be a reproductive model of mentoring. From chemists in the CID we heard repeatedly that the prevalent system in which students affiliate early with one faculty member and his or her ongoing line of laboratory research means that students may graduate unable to formulate their own line of inquiry. More insidiously, apprenticeship often means complete dependence on one faculty adviser, who, through ignorance, convention, or malice, neglects, abuses, or exploits the student. At its worst, it has contributed to murder and suicide, but more common problems are student attrition and the demise of passion and love for the field.


Chris M. Golde

On the other hand, students who have had positive advising relationships often refer to themselves as "lucky," highlighting the almost random and haphazard access to high-quality advising and mentoring. Surely, effective teaching and advising of doctoral students should not be a matter of luck!

Classic apprenticeship, done well, is a powerful experience, but in a forward-looking examination of doctoral education one must ask: Is this the best way to support the formation of scholars in the twenty-first century? Our answer is that it is not. The master-apprentice system—even at its best—falls short of what is required to develop scholars for the twenty-first century.

Combining a vision of what is required for doctoral recipients today with known ways to foster that learning leads to a new model of apprenticeship. Simply put, we propose a shift of prepositions: from a system in which students are apprenticed to a faculty mentor, to one in which they apprentice with several mentors.

Our model of doctoral education is a more expansive conceptualization of teaching and learning than is generally practiced today. The form of apprenticeship we propose is a theory of learning and a set of practices that inform and strengthen all aspects of the doctoral program—during advanced classes, in the course of working in the lab, while having conferences in an office, or in hallway conversations.

Three features of this vision of apprenticeship and mentoring

are highlighted below.

1. Intentional Teaching

The fundamental goal of doctoral education is for students to develop expertise and to learn to exercise their expertise independently. In teaching the elements of being an expert researcher and scholar, mentors must deliberately make visible and explicit those aspects of scholarly and professional expertise that are typically taken for granted and thus unarticulated—and this is no easy task. It requires that faculty mentors understand and explain the constituent parts of expert practice and demonstrate how the parts fit together in a whole. Mentors devise assignments so that students can practice components in low-stakes, carefully designed situations. These might be simulations (defending a grant proposal to a mock panel review), or problems with known solutions (as is done in mathematics), or well-designed small components of a larger work (a course on scholarly publication or dissertation proposal writing).

The student engages in repetitive practice with coaching and feedback. By sequencing tasks and using scaffolding appropriately, mentors guide students to the expert level of performance as the students transfer their knowledge and understanding to increasingly diverse settings. Mentors must provide many opportunities for the novice to practice the skill being developed. With repetition and success, students move from simple to complex tasks, from low- to high-risk situations, and to settings of increased ambiguity in which they must exert independent thinking and decision-making.

2. Multiple Relationships

Vital to this rich vision is the concept of multiple mentoring relationships for every student. There are too many arenas for development for one super-mentor to serve each student. This is especially true with increased interdisciplinary studies and research projects. Even if a student's interests closely parallel those of a single professor who becomes his or her adviser, novice learners benefit from seeing the field through different theoretical or methodological perspectives represented by different members of the department. As with other aspects of re-envisioned apprenticeship, expecting students to engage in multiple mentoring relationships requires rethinking customary practices and cuts against prevailing practices and funding imperatives—particularly in fields such as chemistry. Nevertheless, every student should seek out multiple mentors. In addition, it is important to recognize that not all the mentoring must be provided by faculty members. Students can mentor each other. And groups—courses, research labs, writing groups, cohorts—are important mini-communities for learning.

3. Learnable Skill

In the survey of CID faculty members we asked, "Is there someone whose advising you try to emulate?" Most respondents identified their own primary adviser as a model (38%), but the most striking finding was that "no one" was the second most common response (33%). We did not ask how many had an "anti–role model," although several survey respondents volunteered that fact. Being a good mentor is not an innate talent or a function solely of "chemistry." Mentoring techniques can be learned. Not only is it important for current faculty members to work to improve themselves as mentors; tomorrow's professors can also seek out resources to learn to become better mentors throughout their careers. (Please see the sidebar to find out more about mentoring resources for graduate students.)

Enacting this vision of apprenticeship learning demands an investment of time and energy because apprenticeship relationships are truly personalized education. They demand of both parties that they know themselves and each other well. All students bring to graduate school a unique combination of knowledge, skills, prior experiences, goals, beliefs, personal identity, education, and family background that affects how they learn. In addition, because of their diverse backgrounds, students have different needs, motivations, and ways of responding to challenge. Conditions that some find inspiring leave others feeling daunted and even alienated; challenges that motivate some to greater achievements are dispiriting to others. Mentoring demands that the faculty member understand each of her students and individualize instruction. Likewise, the student can be expected to learn about and understand the preferred working styles of the faculty mentors he works with. The time this takes pays off with greater learning.

But knowing each other is only half of the equation. Good working relationships are easier when each party knows herself well enough to understand and express her own needs. Self-knowledge is largely the product of iterative reflection and openness to input and feedback. The tangible benefit is ever-increasing fluidity in dealing with a wide variety of other people. These attitudes inspire a cycle of positive change.

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MENTORING RESOURCES FOR GRADUATE STUDENTS

Adviser, Teacher, Role Model, Friend: On Being a Mentor to Students in Science and Engineering, *by Committee on Science Engineering and Public Policy.* National Academies Press, 1997. http://books.nap.edu/catalog.php?record_id=5789#toc
Short handbook on mentoring and advising for faculty members.

Effective Postgraduate Supervision. Improving the Student/Supervisor Relationship, *by Adrian R. Eley and Roy Jennings.* Open University Press: Berkshire, U.K., 2005.
A set of case study scenarios with focused questions and suggestions for resolution. Many of these case studies are based on real-life examples and relate to research.

Entering Mentoring. A Seminar To Train a New Generation of Scientists, *by Jo Handelsman, Christine Pfund, Sarah Miller Lauffer, and Christine Maidl Pribbenow.* University of Wisconsin Press: Madison, WI, 2005. http://scientificteaching.wisc.edu.
Syllabus and materials for an eight-week course on teaching graduate students to mentor younger students. It has also been valuable as a seminar for faculty members.

A Graduate Student Guide: Making the Most of Mentoring, *by Carol Mullen.* Rowman & Littlefield Education: Lanham, MD, 2006.
Book for graduate students on getting the most out of graduate school by taking an active and assertive approach to career planning and seeking mentorship.

Working Effectively with Graduate Assistants, by *Jody Nyquist and Donald Wulff.* Sage Publications, Inc.: Thousand Oaks, CA, 1995.
Taking a developmental approach, this book gives practical advice for meeting the variety of challenges inherent in supervising graduate teaching and research assistants.

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Apprenticeship also challenges prevailing mindsets and habits of work for students. Too many students approach doctoral education as if it were a continuation of the prior sixteen to eighteen years of schooling, with the student as the relatively passive recipient of the knowledge ladled out by faculty members, and with success measured by correctly completing well-defined assignments in a fixed time frame. Instead, doctoral students must be active managers of their own careers, purposefully charting a course and asking for what they need, while remaining open to new ideas, input, and opportunities heretofore unimagined. Although many students enter graduate school relatively unaware of what is demanded of them, ignorance is no excuse. Students must also actively combat the fear that reasonably arises from financial and intellectual dependence. Admitting feelings of ignorance and fear to colleagues and acting collectively is an essential strategy.

Changing customary practices requires courage and risk taking, but the positive benefits are many. We are convinced that doctoral education must change to meet new pressures, and that this vision—based on the best of the learning sciences—will allow American doctoral education to develop in a positive direction. ■

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The Impact of Mentoring Undergraduate Student Researchers

Candace Rypisi, California Institute of Technology

This summer Caltech will celebrate the 30th anniversary of our Summer Undergraduate Research Fellowships (SURF) program. Since 1979, SURF has provided nearly 6,000 students with the opportunity to conduct original, hands-on research with world-class faculty. At the core of SURF is the relationship between students and their mentors. Students must collaborate with prospective faculty mentors to define and develop a project, and then they must prepare a research proposal for competitive review. Upon receiving a SURF award, students become full colleagues in the research process and carry out their work over a 10-week summer period. Faculty mentors provide research guidance and support, offer academic and professional advice, and introduce students to the culture of the discipline.

While the faculty mentorship is critical to the success of the students and their projects, over the past ten years we have seen a growth in the support and guidance provided by what we now call co-mentors. A co-mentor is most often a graduate student, postdoctoral scholar, or staff scientist responsible for the day-to-day oversight of a summer student. In 2007, of the 335 SURF students, 285 were each assigned a co-mentor.

Last year, we conducted a pre- and post-summer survey to better understand the impact of co-mentoring and how we could better support the co-mentor experience. The pre-survey conducted during the first week of the summer yielded a 35% response rate and a post-survey done in November yielded a 45% response rate. Of the respondents:

- 76% co-mentored one student, 15% worked with two, and 6% worked with three students;
- 41% were postdocs, 37% were graduate students, and 22% were staff; and
- 60% were first-time co-mentors.

Of course, the co-mentor experience varies greatly based on the co-mentor's discipline and position, and upon her or his own research and academic experience. However, one goal of the survey was to capture a picture in time of the impact of program participation on one group of co-mentors. What we heard was that co-mentoring is a positive and useful experience. Co-mentors indicated that their research was positively affected by the experience and that they gained critical skills that will help them in future faculty employment, professional positions, or both.

Impact on Research

Several survey questions were aimed at better understanding the impact of co-mentoring on a co-mentor's own research activities. Survey respondents indicated that co-mentoring is very time intensive. This comes as no surprise to those who have mentored before! Co-mentors reveal that working with students was most time intensive in the first two weeks. During that period, 55% of co-mentors interacted with their summer students at least 15 hours per week, with 19% spending more than 30 hours. Interestingly, for that same period, 56% indicated that they spent at least 25 hours a week on their own research. One respondent wrote, "Having co-mentored for the past two summers, I do not regret the time I spent on it, but it does take a serious toll and increases my workload." Another co-mentor was more blunt: "It's a time sink." Yet another shared, "It pushed me to work even harder and more efficiently, because I would take time to work with the student."

However, despite the time away from their own work, most co-mentors suggest that their own research was positively impacted by working with students. Fifty percent of respondents indicated that being a co-mentor enhanced their research by allowing them to broaden their scope or work on a project that they might not otherwise have done. One co-mentor remarked, "I was unable to focus on the final work for a publication, but did get work done on the next project to follow the publication." Another shared, "My undergraduate was amazing—she helped so much, doing some background reading I hadn't had time to do and summarizing it for me, and then translating it into a code that is the basis of our data analysis (and then teaching me how to code it too)." Fifty-four percent of respondents indicated that acting as a co-mentor

ANNUAL ACS NEW GRADUATE SALARY SURVEYS

***Jeffrey R. Allum,* Research Manager, American Chemical Society**

Have you heard the news about salaries of recent chemistry and chemical engineering graduates? According to the most recent American Chemical Society (ACS) new graduate salary survey, the news was good. According to Mike Heylin, author the June 2, 2008 article in *C&EN,* "college graduates … who received their degrees between July 2006 and June 2007 were lucky with their timing." Will you be as lucky in the years to come when you graduate?

It's too early to know for sure, but ACS is tracking the latest labor market indicators to keep tabs on the job market. In 2007, median salaries for newly minted B.S. degree chemistry and chemical engineering graduates increased by 4%. Salaries for master's degree–level chemists and chemical engineers held steady with 2006 levels, and Ph.D.-level chemists' and chemical engineers' salaries rebounded to the 2005 level after a dismal 2006.

The new graduate salary survey, along with the annual ACS employment and salary survey, represents one of the largest and most consistent data collection efforts of its kind. The findings are frequently used by the U.S. Department of Labor as a source of data for their labor market projections. The figures also furnish data for the ACS Salary Comparator (acs.org/careers), a database that can help ACS members see salaries based upon field of work, geographic region, and level of experience.

The annual new graduate salary survey is issued every fall, usually in October. The survey is typically sent to approximately 13,000 newly minted chemistry and chemical engineering graduates. The findings are confidential and reported in the aggregate, and they are made available during the spring to early summer of each year.

Please check out the most recent article for yourself at http://pubs.acs.org/cen/acsnews/86/8622acsnews1.html. And for those of you who are graduating, keep your eyes open. The annual ACS survey of new graduates will be mailed to you soon. By sharing your most recent employment status, you'll be providing information for the next class of chemistry graduates, just as the previous class did for you.

did not detract much from their research in terms of the amount they could get done during the summer period.

Impact on Career

Overall, survey respondents indicated that mentoring supported their own academic and professional development. It prepared them to manage students and student projects, thus building strong teamwork skills, and it also helped them understand their own research better as a result of having to coherently articulate it to someone else and guide that person through it. One co-mentor wrote, "Being a co-mentor has dramatically increased my mentoring experience and improved my skills to communicate with younger minds in the lab." Another shared, "Teaching and mentoring are important aspects of science. Mentoring SURF students will help prepare me to run my own research program someday."

Going into the summer, co-mentors were asked to rate their preparedness in the following skills: teaching laboratory techniques; counseling a researcher about his or her career path; helping a student interpret results; and helping a student write a paper, oral presentation, or both. Although the co-mentors felt that they were strongly prepared in these areas overall, the post-survey suggests that after the summer they felt even better prepared in each of the areas. They reported a 6% increase in preparedness for teaching laboratory skills, a 4% increase for offering academic and career counseling, and an 8% increase both for helping students interpret their results and for helping them prepare to communicate them. As one co-mentor put it: "I strongly encourage all postdocs and graduate students to be co-mentors, because we are developing important 'soft' skills for being managers in science."

The Value of Mentoring

It is important to note that the most common feedback from the co-mentors was not about the impact on their own time, research, or career development. Instead, it concerned their commitment to give back and help train a younger set of future scientists and engineers. Here is what a few co-mentors had to say.

"Why am I a mentor? Someone trained me, so I feel obliged to help others find their passion—if it's organic synthesis!"

"Co-mentoring is not everyone's cup of tea. Being a co-mentor for the last three years has been a rewarding experience for me. I just wish that co-mentors would realize the opportunity they have been offered and would make the best use of it. Often the research that students do is not productive, but I feel that the program is meant to train students/give them a taste of a career in research."

"This is something that any graduate student/postdoc should do prior to deciding on a career in research academics. If you can't get excited about teaching other students your science and motivate them to work in a research laboratory, then serving as a scientific mentor to young professionals is not the right career path for you."

"I feel I am able to give back for all the mentoring that was given to me over the years."

Final Words of Wisdom from the Co-Mentors

- Patience is key. "It's not about getting results by the end of the ten-week period; it's about learning something new!"
- Plan ahead. The more time you put into planning the first few weeks, the better the experience will go.
- If possible, meet with your students before the summer begins. They can then start to read necessary literature, plan experiments, order supplies, etc., so they can hit the ground running.
- Treat the students as colleagues in the research process.
- Early in the program, set clear expectations about work schedule and style.
- Encourage students to participate fully in the life of the lab by attending group meetings, giving reports, attending group lunches, and so on.

The author wishes to thank Carolyn Ash, Rich Wildman, the SURF Administrative Committee, and past and present members of the SFP Co-Mentor Advisory Council for developing the survey, analyzing the results, and supporting all of our co-mentors. Candace Rypisi ■

Candace Rypisi is Director of the Caltech Student-Faculty Programs Office, including the Summer Undergraduate Research Fellowship (SURF) Program. Further information on SURF is available at www.surf.caltech.edu.

Thank you, Marjorie!

Dr. Marjorie Caserio, University of California San Diego, has been a consultant to the ACS Office of Graduate Education (OGE) almost since its inception in 2001. Marjorie has provided insight and leadership to the OGE in many ways. These include conceptualizing and developing innovative programming that OGE—in partnership with other ACS offices, committees, and Divisions—has provided at ACS National and Regional Meetings. Her invaluable skill in crafting grant proposals has helped make programs like our Academic Employment Initiative a reality. In addition, Marjorie conceived of and originated this *Graduate Education Newsletter* and has been its Editor through all 13 issues to date. Now she is retiring as OGE consultant and *News-letter Editor.* This is her final issue and this short article is a remembrance and farewell (and a surprise for Marjorie) from a few of us who have worked most closely with her.

The policy oversight body for the OGE is the Graduate Education Advisory Board (GEAB), now chaired by Dr. Alvin Kwiram, University of Washington, who comments that "Marjorie has provided the corporate memory for the GEAB, served as the key liaison with the many other parts of the ACS, and has done an outstanding job as the founder and Editor of the *Newsletter.* Her selection of topics and identification of contributors for articles have been both timely and informative. Marjorie has been enormously helpful during my time as chair of the GEAB, not only by serving as a sounding board for ideas but also for her good sense about the context in which the GEAB operates and her insights regarding strategic directions for the organization. She has done all this with laudable efficiency in the face of the many other obligations she was managing, including her recent role as interim Senior Vice Chancellor—Academic Affairs at UCSD" (the administrative position from which she had just retired when she was recruited to be OGE consultant).

Marjorie's direct interactions with graduate students are probably best captured in the recollections of Drs. Marta Gmurczyk and Corrie Kuniyoshi, both of whom had recently finished their doctoral work when they joined the OGE. Marta recalls "meeting you for the first time, and being quite overwhelmed. You were so very well known and recognized and I was so new to ACS—but after a few short moments, I knew it would be a great experience to work with you. You had so much perspective and knowledge, and cared so deeply about graduate education; I had a lot of energy and passion for this new program, which felt like a blank page to be filled in. Together we worked on important programs in graduate education, including the *Newsletter,* which I always felt was your favorite project. You reached out to include contributions from distinguished scholars who reflected on current trends and issues in chemistry graduate education. The *Newsletter* has chronicled initiatives in graduate education, offering many original insights and points of view, and I truly believe it will become a landmark contribution to ACS programs."

Corrie's first experience might have been even more nerve-wracking, since she lived in California and we arranged for her to meet Marjorie even before she moved to start her new job in Washington, DC. Indeed, she says she "was somewhat nervous about this meeting—a simple Web search on Professor Caserio somewhat increased my anxiety. She was a distinguished professor—a well-esteemed scientist, author, educator, and senior UC administrator. When we met she took me to lunch at a nice restaurant. As expected, she exuded sophistication and formidable intelligence, but on top of this she had a clarity of purpose and a breadth of honesty that I had not anticipated. Something even more unexpected was that she spoke to me as a colleague, not as the awkward, gawky student I felt like. She impressed upon me the importance of the work we would be

Marjorie Caserio

doing together. I came away from our first meeting feeling refreshed and excited about the job that lay ahead. Throughout the last few years, as I have had the pleasure of working with Marjorie, she has proven to be all the things I had experienced in our first meeting and more. Always a consummate professional and mentor, she has contributed selflessly to the betterment of science education and those it touches."

Editors work closely (though not always harmoniously) with copy editors, who bring to a publication a special expertise in the use (and misuse) of language—we could not have hoped for a more supportive relationship between Marjorie and our copy editor, Susan Robinson. Susie comments, "It has been a great honor and a deep pleasure to work with Dr. Caserio. Her first query on my first issue snapped me to attention: Rarely had I encountered such meticulous standards or such a penetrating mind. Over the succeeding issues, attempting to keep up with Dr. Caserio constantly sharpened my editorial skills, as I had known it would from the outset. What dawned more gradually was a sense of the vast erudition, wide-ranging scientific accomplishment, and selfless commitment both to science and to mentoring its nascent practitioners that she

"It will be difficult to find a successor who will bring the same level of experience, thoughtfulness, and sound judgment that has characterized Marjorie's career.

Aalok Mehta/C&EN

(From left) Ena Castro, Christine Pruitt, Jerry Bell, Chuck Casey, Marjorie Caserio, Jura Viesulas and Marta Gmurczyk at the first AEI poster session held at the 228th ACS National Meeting in Philadelphia, Fall 2004.

brought to every aspect of our endeavor. It is rare indeed to find such a high degree of professional accomplishment wedded to an equally great commitment to helping others. One of the things I have appreciated most deeply about working with Dr. Caserio is the professional courtesy and consideration she has so generously extended. Dr. Caserio embodies the highest ideals of professional attainment, academic service, courtesy, and concern for others."

Susie's last sentence captures a sentiment we all share and express from our own perspectives. From an administrative point of view, Alvin says. "It will be difficult to find a successor who will bring the same level of experience, thoughtfulness, and sound judgment that has characterized Marjorie's career. She has given much more to GEAB and OGE than we could rightfully expect, and therefore we are especially grateful for her dedication and stellar service." And Corrie sums up our deep personal debt in observing that "I don't think she'll ever know the extent of the positive effect she has had on people's lives. While I congratulate her on all she has accomplished, I wish her also to know how I will miss her and am grateful for all she has taught me."

Therefore, we thank you, Marjorie, for all you have meant to us and wish you a wonderful (perhaps third) retirement. We hope this one really takes, but we also know that it will not mean a lack of service to others, as you have so eloquently demonstrated for us.

Edited by Jerry A. Bell, Senior Scientist, ACS Education Division with heartfelt contributions from the others referenced in the article.

Student Perspectives on Advising and Mentoring in Graduate School

Marjorie C. Caserio, University of California, San Diego

In any assessment of mentoring in universities, it is essential to receive input from both the faculty advisers and their student protégés. In an effort to poll student opinion, the Office of Graduate Education sent a questionnaire to some 2,000 current and recent chemistry graduate students in the United States and received 186 replies, a 9% response rate. Although this is on the low side, the tenor of the responses and the specific comments provide valuable insight into students' views of graduate school, students' priorities, and students' expectations of research advisers. We greatly appreciate the cooperation of those who completed the questionnaire. Their responses form the basis of this report.

We asked the students to rate the importance of mentoring and the various responsibilities of a graduate research adviser.

The results are revealing. Some 84% of respondents rated effective mentoring as *very important* to student retention and success in graduate school (Chart 1).

Not surprisingly, the adviser's role in providing intellectual leadership was rated highly on the importance scale of 1–5 (Chart 2). There were signs of ambivalence about the importance of the adviser's *active* guidance in student research (Chart 3) that may possibly be a reaction from some respondents to excessive direction.

Other responsibilities of an adviser that ranked high on the importance scale include:

- Providing letters of recommendation in a timely manner (93%)
- Supporting students at a professional level (88%)
- Providing students with opportunities to publish and present their research (85%)
- Assisting in career preparation (83%)
- Ensuring that students acquire needed "soft skills" (83%)
- Ensuring that students' progress is timely and within time-to-degree limits (82%)
- Seeking financial support for students' graduate study and research (81%)
- Ensuring that students receive guidance on research integrity (80%)
- Providing networking opportunities with relevant professionals and faculty (78%)
- Actively assisting students in seeking postdoctoral positions and postgraduate employment (68%)

Although the results confirm the traditional view that intellectual leadership

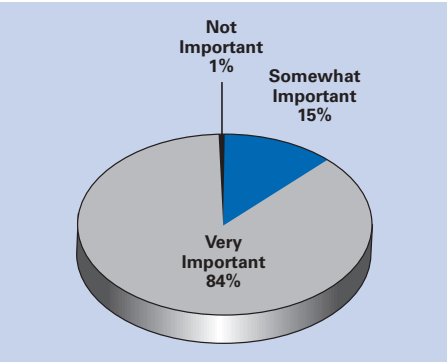
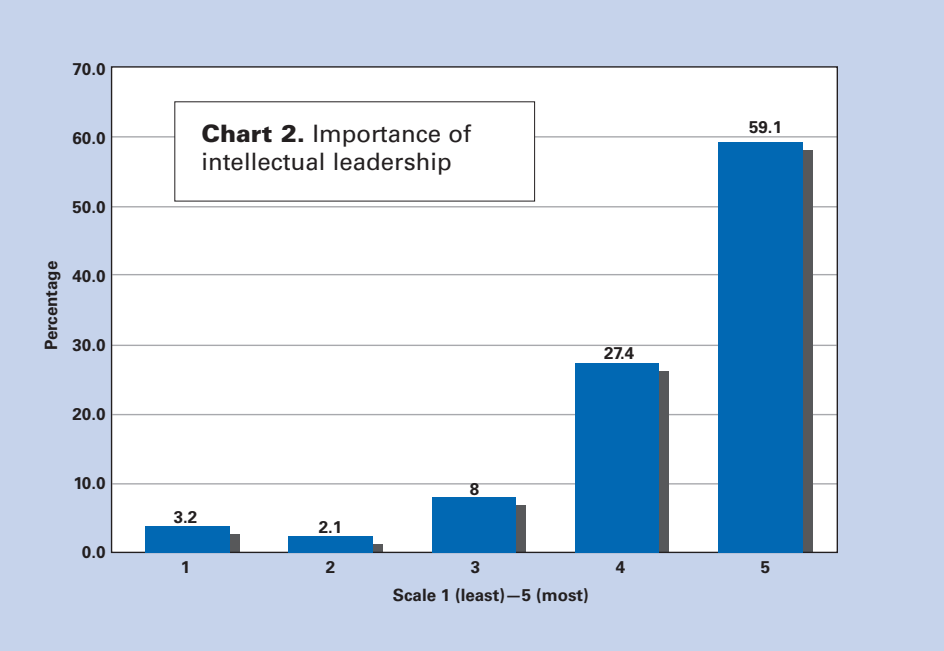
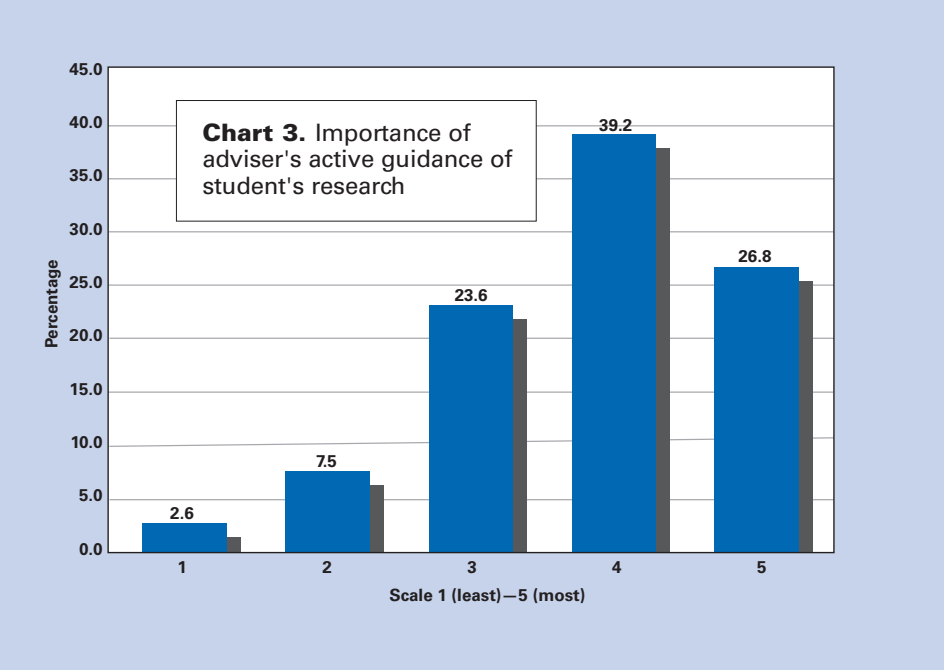


Chart 1. Importance of mentoring in student retention and success in graduate school





and research direction are prime responsibilities of a graduate research adviser, they also make clear that the respondents expect more of an adviser, notably in areas that will help them transition into successful careers.

We asked the students to tell us what they thought were the most important things for a prospective graduate student to look for when choosing a research adviser. What should the student avoid when choosing a research adviser?

The responses were remarkably consistent, reflecting widespread agreement. They could be grouped into two categories: personal compatibility and exciting research.

Personal Compatibility

The most striking point, expressed many times over, was the importance of selecting an adviser with whom the respondents would be compatible. The penalty for not doing so, they said, could be five or six years of conflict. Many elaborated on the elements to look for in an adviser that would promise compatibility or the "right chemistry" between student and supervisor. Things to look for include shared research interests, mutual respect, trust, honesty, and intellectual integrity. The adviser's approachability, availability, and genuine interest in the student's development as a researcher and professional were viewed as primary considerations.

Survey participants frequently referred to the importance of engaging in self-analysis before choosing an adviser because student needs vary and advisers' management styles differ. One respondent commented, "This is probably the only time in a student's career that they will have the opportunity to choose their boss instead of the other way around. They need to figure out what qualities they would like in a boss." The student needing close supervision, especially in the first year, might benefit from someone with a "hands-on" approach in the lab; but one who is more independent might do better with a "hands-off" adviser. Either way, the need for an adviser to be there for the student when needed was paramount. The students were forthcoming about ways to assess whether a particular adviser would be compatible. Apart from the essential one-on-one meeting with the adviser that usually reveals whether you "click" or not, first-year students should assess the other students and postdocs in the research group to see how well they are doing. If there are problems such as personality conflicts, poor retention of students, slow graduation rates, poor advising, inadequate funding, or poor lab dynamics, they are likely to be conveyed in some way to the prospective student.

Equally forthcoming were suggestions about what type of adviser to avoid. Incompatibility is an obvious negative, but a number of others were spelled out as well. They include advisers who micromanage; treat students as workers (not thinkers); or are unsupportive, arrogant, never there, inaccessible, unethical, discriminatory, culturally insensitive, too busy, always traveling, or disinterested in the student's needs. The list goes on to include advisers who have too many students or foster competition among group members. It is hard to believe that such egregious behaviors exist, but given their frequent mention, they may be more prevalent than academia as a whole has realized. Increased availability of guidelines for selecting a research adviser and sustaining a strong student–adviser relationship might help students make informed choices, but the survey question addressing this issue revealed that access to guidelines was more the exception than the rule (Chart 4).

Others stressed the need for an adviser who provides leadership, guidance, and freedom to develop as an independent researcher. Additionally, the adviser should allow the student to pursue more than one research project; clearly communicate the work expectations; encourage conference attendance, proposal writing, and publication of the student's research; and offer career guidance.

Exciting Research

As expected, research is considered to be of prime importance in choosing an adviser. There are some interesting perspectives to note. Many respondents stated that the first priority for prospective students is to select the type of research that really interests them, that they find exciting, stimulating, and motivating. Five or six years spent in research that they won't like will never work. After identifying potential advisers whose research interests they share, students' next priority is to look for one who has a strong research reputation, who publishes high-quality research in leading journals, and whose research is well funded. The funding issue was mentioned both as evidence of external recognition of the group's research projects and as essential financial support for the students. In addition, students warned that it takes longer to graduate without RA support. Some respondents commented that choosing where to go to graduate school should be based on whose research is of interest rather than on the reputation of the institution. Others stressed the need for an adviser who provides leadership, guidance, and freedom to develop as an independent researcher. Additionally, the adviser should allow the student to pursue more than one research project; clearly communicate the work expectations; encourage conference attendance, proposal writing, and publication of the student's research; and offer career guidance.

Advisers to avoid were identified as those with limited research activity, no recent publications, and uncertain funding. There were cautionary comments about certain types of research groups, such as those that were very large, very small, dysfunctional, or run by postdocs. "New" or untenured professors and professors nearing retirement were also viewed with suspicion by some, probably because of anxiety regarding whether the adviser would still be around by the time the student graduated.

To get some perspective on the overall quality of advising, we asked the

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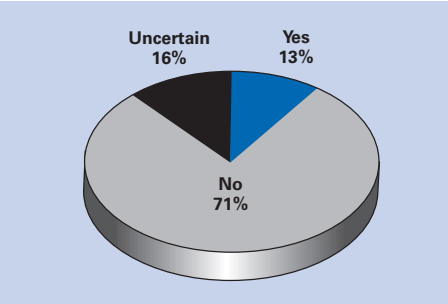

Chart 4. Were guidelines available on the selection of a research adviser and how to sustain a strong student–adviser relationship?

Continued from page 11

students: ***How well do most advisers meet graduate student needs?*** The results are shown in Chart 5 and convey a somewhat middle-of-the-road rating.

We asked the question: ***What do you consider the most prevalent conflicts that arise between graduate students and research advisers? How might these conflicts be avoided?*** The sources of conflict most commonly identified were as follows.

Lack of Communication, Miscommunication

The overwhelming majority of respondents identified this problem as the source of most conflicts. In their view, it manifests itself in many phases of graduate work, most commonly as a misunderstanding between student and adviser regarding goals and expectations. In the context of research, conflicts arise when student and adviser have not communicated a clear research plan or research direction.

Time Management

This is related to the communication issue and appears to be a widespread problem. One example relates to disagreements over workload expectations (time invested for the results obtained). One respondent felt that conflicts stem from advisers having an unrealistic notion of how long certain processes take. The problem is evident in both TA and RA workloads. Another example relates to unclear expectations over the time to complete the degree. Students struggle when there is no clear timeline for completing a project or when the adviser drags the project on without declaring a completion plan.

Mentoring, or Rather, the Lack of It

Respondents expressed this problem in terms of advisers failing to provide guidance in research and professional development, giving poor attention to the student, engaging in poor mentoring styles, and showing disinterest in the student and the project. Some survey participants were forthright in saying that some faculty advisers have only their own interests at heart.

Not surprisingly, the responses about how to avoid these conflicts mostly stressed the need for more and better communication between student and adviser. This necessity could be met in a variety of ways, but particularly by the adviser's devoting more time to the student and meeting with him or her on a regular basis. Group meetings are good but insufficient. Students need individual attention. Many respondents felt that a clear plan outlining goals and expectations is essential and should be articulated at the outset of graduate study, even before the choice of adviser is finalized. Such a plan would include a timeline and a schedule for periodic updates on the progress toward completion. Communication is a two-way street, and the respondents were clear about the need for *both* parties to communicate their goals and expectations clearly. Nevertheless, the shortcomings in the advising relationship were attributed largely to the advisers.

Communication is a two-way street, and the respondents were clear about the need for both parties to communicate their goals and expectations clearly. Nevertheless, the shortcomings in the advising relationship were attributed largely to the advisers. One comment gets to the point: "Academia is one of the few places in the world where the people in charge have absolutely zero training in managing people."

One comment gets to the point: "Academia is one of the few places in the world where the people in charge have absolutely zero training in managing people. Universities should offer short courses for new professors on methods to effectively run a research lab."

Our respondents rated mentoring as being *very important* to success in graduate school (Chart 1, above). They also provided the following constructive suggestions in answer to the question: ***What can departments do to ensure that their graduate students receive proper mentoring?***

Ensure That Students Have Additional Mentoring Options.

Approximately 51% of survey participants responded that they had had the benefit of multiple mentors in graduate school.

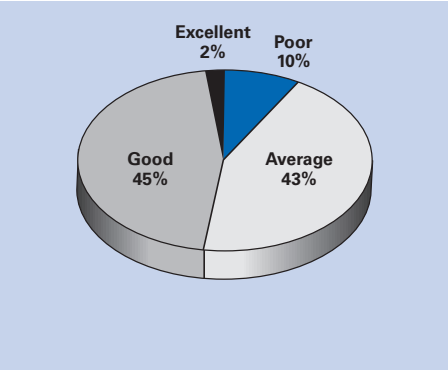

Chart 5. How well do most advisers meet graduate students' needs?

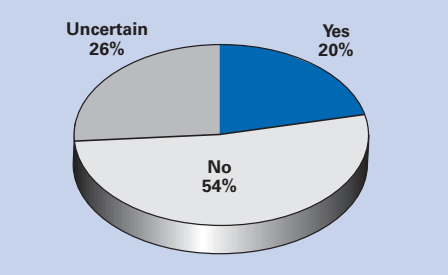

Chart 6. Does the department offer incentives to encourage excellence in mentoring (awards, for example)?

The additional mentoring could be provided by a faculty mentor who was not the primary adviser, a dissertation committee, an ombudsperson, or the department graduate coordinator or adviser. Respondents also recognized the value of mentoring by senior graduate students and postdocs. Additionally, they referred to problems relating to inadequate mentoring of students who were women, members of underrepresented minority groups, or both. Departments need to recruit and retain more students and faculty from these groups. The special mentoring needs of international students must also be recognized.

Provide Mentoring Guidelines

Both faculty and students ought to receive mentoring training, including workshops, short courses, formal training programs (these would be particularly important for new faculty), or all of the above. Departments should also be more proactive in providing career guidance for both graduate students and postdocs.

A significant point was raised about the importance of educating faculty and students about mental health issues, especially how to recognize depression and where to find treatment for it. This should be part of any training program.

Provide Incentives

Survey participants mentioned mentoring awards in particular. It appears that few departments encourage excellence in mentoring through an awards program (Chart 6).

Many respondents suggested making mentoring effectiveness a factor in faculty performance reviews. Various suggestions offered ways for students to evaluate faculty advisers; these methods often kept the protection of students in mind. Clearly, though, students are wary about criticizing faculty. Several respondents noted that even when mechanisms are in place, students feel reluctant to report grievances because departments seldom challenge their faculty. The perception that departments fail to maintain a high level of professionalism led one respondent to suggest that this would be different if departments screened new faculty for their standards of professionalism before hiring them.

Choosing the Right Adviser

This point was also addressed in the context of personal compatibility (above), but it resurfaced in the context of a department's role in mentoring. A significant number of respondents recommended that departments institute a system of lab rotation in the first year of graduate study. As one person put it: "Rotation programs would help…. Biochemists do it, why can't chemistry departments?"

In analyzing the responses to this survey of advising and mentoring, we made every effort to convey the student perspectives correctly. Any voluntary survey carries inherent flaws and may solicit more response from those with criticism than those with praise. We did receive comments, though, from students who had high praise for their advisers and their overall experience in graduate school. Identifying both the strengths and imperfections of the advising system is the first step toward improving it. Therefore, we submit that the student commentaries should be heeded. Students have little authority to implement change, at this stage of their careers, but they can certainly influence those who can do so and are willing to listen. ■

Dr. Marjorie Caserio is a consultant to the ACS Office of Graduate Education and Editor of the *Graduate Education Newsletter.*

The Many Modes of Mentoring

Joseph S. Francisco, Purdue University

The term *mentor* originates from Homer's mythic tale of Odysseus, King of Ithaca. Before sailing off to the Trojan War, Odysseus appointed his friend Mentor as a guardian for his son and household. But it was Athena, the Greek goddess of wisdom and war, who in the guise of Mentor guided and counseled both Odysseus and his son in their epic journeys. It was through the French author de La Mothe-Fénelon's retelling of Homer's epic that Mentor arose as the trusted adviser, teacher, friend, role model, wise man, and nurturer. (Please see *Adventures of Telemachus—the Son of Ulysses* by de La Mothe-Fénelon, ISBN 9780820318202)

Today the term "mentor" describes someone who is less a teacher than a provider of guidance and counsel. Mentoring is essential to promoting both the professional and personal development of the mentee. In the academic context, academic advising and mentoring are sometimes indistinguishable because of the significant overlap between the two. Advising undergraduate students generally implies providing guidance in curriculum and departmental requirements. Mentoring, on the other hand, implies guidance of a deeper sort.

Joseph S. Francisco

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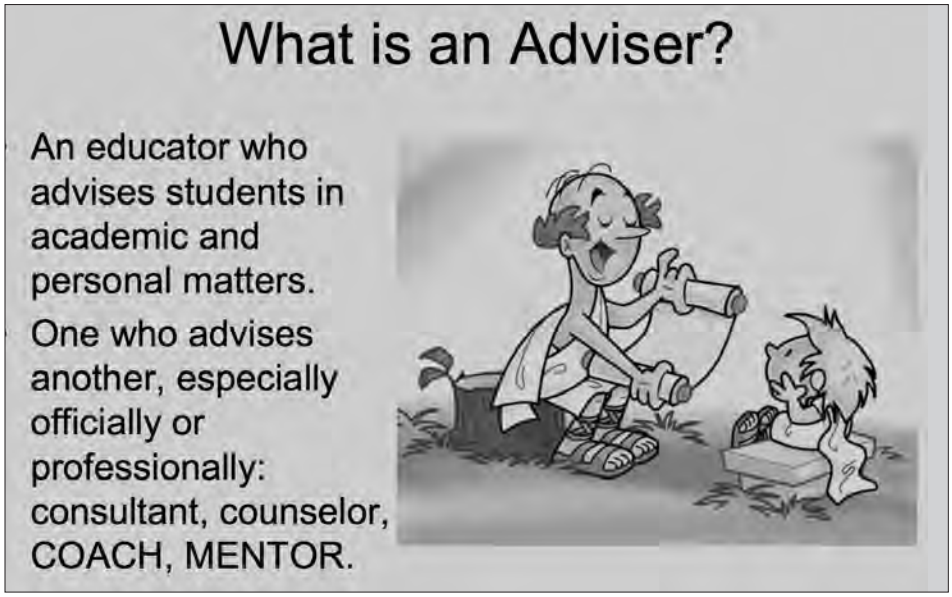

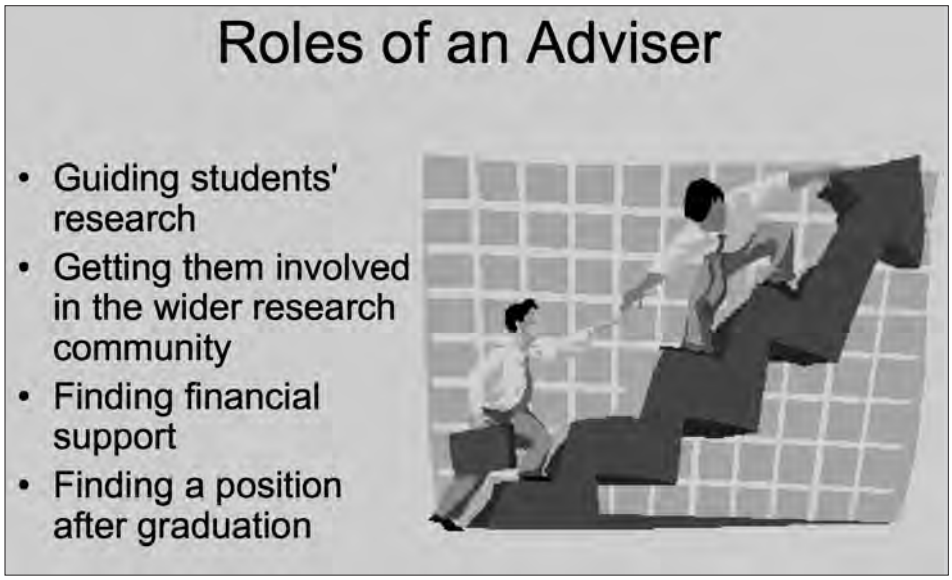

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Forms of Mentoring

Mentoring is part of creating a supportive environment for students that will help them explore the academic landscape more successfully, take advantage of educational resources, and enhance their career choices. It helps them develop skills necessary for a productive transition to life after graduation. Effective mentoring requires that faculty understand and appreciate the personal needs of each student, and that departments create venues where faculty and students can meet regularly and consistently. For undergraduates, this means meeting more often than once a semester or quarter to sign forms and receive advice about the appropriate courses to take. It means a continuum of interactions between student and faculty member. At a minimum, mentors and mentees should meet regularly, preferably once a month, for at least a year. Responsible mentoring can take many forms: one-on-one mentoring meetings, group mentoring, team mentoring, peer mentoring, and e-mentoring. Regardless of the format, the mentoring relationship focuses on student progress and helping the student develop employable skills.

One-to-one mentoring is the traditional form with which most faculty are familiar. It usually involves the faculty member and student meeting in the former's office Regardless of the setting, effective mentoring requires that the one-to-one context of the interactions between student and faculty member allow a productive mentoring relationship to grow. Departments with small student-to-faculty ratios can be effective in this type of mentoring. The challenge for large departments is to find enough qualified faculty to mentor relatively large numbers of students. Mentoring requires faculty to be accessible to students and to recognize their different needs. Some large universities provide academic or departmental advising, or both, with designated counselors, particularly at the beginning stages of the undergraduate program. This is fine, but students still need contact with the faculty who are the best role models for them as aspiring young professionals.

Group mentoring, where the faculty mentor meets regularly with up to four students, can create a nurturing environment for students within a larger, seemingly impersonal environment. Such group meetings require a definite structure to be effective and should provide activities that build a sense of community but also include time for personal sharing.

Team mentoring involves several faculty members meeting with a small group of students in which there are no more than four students per faculty member. Like group mentoring, this format must be structured. Unlike group mentoring, the student benefits from having "multiple mentors" and thereby gains greater exposure to the subcultures of chemistry.

Peer mentoring is another avenue for providing guidance and direction to students early in their programs. Having juniors or seniors mentor freshmen and sophomores can create a "connectedness" or community among students that reduces feelings of isolation and hierarchical barriers. Moreover, young mentors are often viewed as positive peer role models. Those who have engaged in peer mentoring comment on the satisfaction of helping another young colleague through the program, as well as that of building new friendships that often last a lifetime.

E-mentoring is a new and innovative direction in which the mentoring relationship is conducted via the Internet or through e-mail. Such distance mentoring usually supplements existing programs and is most effective if structured around the curriculum, career counseling, and career-related topics. Mentoring networks can also be developed. A good example of a large-scale e-mentoring network is MentorNetACE, which pairs women students in engineering and science with professionals in industry through e-mail conversations (www.awis.org/pubs/magazine/33-4.html). External mentors provide an element of impartiality that is valued by mentees, in part because they find characteristics not available to them in their faculty mentors. For example, underrepresented minorities may seek a minority mentor for discussing career directions and challenges. Creating a network of department alumni is another e-mentoring opportunity that departments can provide.

There is much evidence to show that providing young people with consistent support through well-supervised, frequent, and long-term mentoring improves their performance, self-esteem, and retention in programs. Considering the importance of effective mentoring to student success, it is well worth the time, commitment, and dedication it requires from the department and its faculty. ■

Dr. Joseph Francisco is the William E. Moore Distinguished Professor of Physical Chemistry, Purdue University. He is a member of the ACS Committee on Professional Training and a Member of the ACS Graduate Education Advisory Board.

Advising and Mentoring

Thomas W. Smith, Rochester Institute of Technology and member of the ACS Society Committee on Education


Thomas W. Smith

I am pleased to share a few thoughts on my experience as an adviser—and perhaps a mentor—to graduate students and postdoctoral fellows who have worked with me during my industrial and academic career. I will comment most specifically on the expectations and responsibilities in the adviser–student relationship and on the differences between the roles and responsibilities of an adviser and a mentor.

It seems that we fall into advising and mentoring much as we fall into parenting. At least for me, advising, mentoring, and parenting are roles that I assumed with little substantive forethought and no training. In each of these roles, my student protégés and my children would no doubt have benefited if I had gone through some structured training. After more than 20 years of on-the-job training in industrial research management and a half-dozen years in academia, I can only hope that at worst I have done no harm and at best I have met expectations and been a positive influence in the lives of my protégés. In choosing a research adviser, students should be aware that the venerable scientists with whom they have chosen to work may indeed have limited skills and abilities in advising.

The question then is what expectations might a student reasonably have of "an adviser" and what differentiates an adviser from "a mentor. "

I believe that the responsibilities of an adviser go beyond making a student aware of requirements for successful completion of a degree or course of study. They can and should include clear articulation of objectives, priorities, and safety considerations in a given program of research. Institutions can put processes in place to ensure that the "nuts and bolts" of the advising function are executed in a fashion that largely meets a student's short-term needs and expectations. However, the adviser's role in providing perspective on research directions and career aspirations, assisting in the identification of employment options, and networking are not as easy to define. Nevertheless, these are roles that experienced research advisers in the academic chemical research enterprise are known to take on.

When I discussed advising expectations with my current research students, they noted the importance of support in their transition from a passive to an active role in the learning process and of being given an independent hand in developing and executing their research projects. They further noted that both clear segmentation of research assignments within the group and the articulation of an unambiguous timeline for their completion of degree requirements and graduation were important to them. They saw these things as being considerate of the time limits in their lives.

After more than 20 years of on-the-job training in industrial research management and a half-dozen years in academia, I can only hope that at worst I have done no harm and at best I have met expectations and been a positive influence in the lives of my protégés.

Mentoring is broader and deeper than advising. Mentoring, in its essence, is about relationships, life perspectives, values, and being a role model. Therefore, actions and behavior that result in effective mentoring are less predictable. The unspoken aspect of mentorship lies in both the opportunity and the choice to positively impact a person's career or life direction, in essence taking on a role similar in many ways to the level of relationship between a parent and a child. It is to be hoped that each of us can look back and identify persons we consider to be or to have been our mentors. And, quite possibly, the mentor will have been our teacher or research adviser. The key is choosing to place yourself in circumstances in which it is possible to develop a relationship that has the hallmarks of mentorship. ■

Dr. Thomas Smith is Professor of Chemistry & Microsystems Engineering, Rochester Institute of Technology. He is also a member of the ACS Graduate Education Advisory Board and of the ACS Society Committee on Education.

The Art of Mentoring Scientists

Cynthia Larive,
University of California, Riverside


Cynthia Larive

Several years ago, I was asked to give a lecture on effective mentoring. In putting together that talk, I assembled the list below. My students were curious about what I was doing, so I shared my slides with them. Afterwards, I was surprised to see my list taped above several students' desks. Now when new students join my group, I give them a copy of the list. I also try to review the list periodically so that I don't lose sight of my own goals as a mentor.

Lessons I Want My Students To Learn

- It is a privilege to do science.
- Work hard and consistently.
- Persistence pays off.
- Think creatively.
- Read the literature.
- A failed experiment can be an opportunity.
- Adhere to ethical practices in science and life.
- Being a faculty member is a great job.
- Live a balanced life.
- When all is said and done—people are the most important consideration.

For chemists, the research group is an integral component of student training. It is where the lessons in my list are learned. Within the research group, mentoring takes place both on an individual basis through the one-on-one relationship between the mentor and the student and through group interactions. Both types of exchange are important in the development of productive and happy members of the scientific community. Within the research group, students often form lifelong friendships. They look to each other for support during the difficult periods of graduate study and share in each other's successes. The group provides students with the chance to become intellectual and social leaders among their peers and lets senior students gain experience as mentors by assisting in the supervision of undergraduate researchers or beginning graduate students.

The first contact between the faculty

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member and the student lays the groundwork for the nature of their future interactions. Often this initial meeting occurs during a campus visit, and it can be an important aspect of a student's choice of where to attend graduate school.

When it comes to choosing an adviser, the student has more to consider than finding a research project that interests him or her. Another component of the adviser selection decision consists of choosing an adviser whose mentoring style seems compatible with what the student wants and needs. By and large this system of mentor selection works very well, and often a strong bond forms between the faculty member and the student. Occasionally, the student's initial choice of research adviser turns out to be unsuitable. In this case, ideally the department's policies and culture allow the student to move to a different group in a seamless fashion and without any negative consequences.

On the surface, the relationship between student and mentor appears akin to that of master and apprentice. According to this model, the apprentice gains technical skills at the foot of the master until it is clear that the student can assume her or his own role in the scientific community. However, developing technical competence is just one mentoring outcome, and indeed, it may be the easiest of all the goals to assess and achieve. Mentors face the additional challenge of evaluating students' strengths and weaknesses so that over the course of five years, students learn to build on what they do well and correct the areas where they need to improve. The mentor must discover what motivates each individual and how to offer effective counsel. The goal is a constant—to help the student develop as an independent, creative, and productive scientist, knowing that every decision and interaction along the way will be shaped by individual considerations. In that sense, mentoring young scientists is very much an art. Although mentoring can be challenging at times, it is also profoundly gratifying to have a hand in the development of productive future members of the scientific community. ■

Dr. Cynthia Larive is Professor of Analytical Chemistry, University of California Riverside, and winner of the ACS 2007 J. Calvin Giddings Award for Excellence in Education. She is a member of the ACS Committee on Professional Training and of the ACS GEAB.

Mentoring in the University

Alvin Kwiram, University of Washington

The importance, and the rewards, of high-quality mentoring of graduate students, postdoctoral scholars, and younger faculty colleagues cannot be overemphasized. Some faculty do a superb job; others may not be as effective. As for all professional roles, effective mentoring involves a learning curve that includes thoughtful study and deliberate practice to achieve a certain skill level. Unfortunately, in our present system of graduate education there is no formal training program where one learns mentoring skills. Our own learning curve may have started with our experience being mentored in graduate school. If that was a positive experience, then we are already part way up the curve. If it was a somewhat dysfunctional relationship, then we may have some things to unlearn first.

Serving as a mentor is a high calling and deserves our serious attention. Students basically entrust their lives into our hands for a significant period of time, and to some extent we shape their future. They are often ill prepared to understand the forces that will impact their development. They are often uncertain of their own potential and where they fall in the distribution of talent. They may not be sure of what career choices will be appropriate for them. These are just a few of the areas in which they can grow and develop more effectively if they are mentored by someone who understands this important stage in their development and can guide them skillfully. But to do this may well take as much as or more than the amount of thought and effort used in choosing the dissertation topic. Faculty advisers who do not take their role in this arena seriously are doing a serious disservice to the student and to the discipline.

Alvin Kwiram

Although the statistics for attrition in the ranks of doctoral students in the sciences are much better than the overall figures (roughly 50% of students who start the Ph.D. never finish), there is room for improvement. We claim that we need to attract more students to go into the sciences. Helping qualified students who are already in doctoral programs to succeed may be the easiest way to improve the output from the pipeline. But helping all our students to achieve their maximum potential and to go on to successful careers must be a high priority.

Most mentors would agree that one of the most gratifying factors in their professorial life is to encourage the flowering of young minds, to witness the growing intellectual maturity of the students, and to follow their successes and contributions to society. We can take almost as much satisfaction and pride in their progress as we do in the successes of our own biological children. Unfortunately, most of us received little training for this responsibility either. But that just makes it all the more imperative that we give these matters more serious and systematic attention. The art of teaching is a noble calling, and mentoring our young colleagues individually and personally is near the top of the privilege pyramid. Let's make the most of it. ■

Dr. Alvin Kwiram is Professor Emeritus, Department of Chemistry, and former Provost at the University of Washington, Seattle. He is also the Chair of the ACS Graduate Education Advisory Board.

Careers in Industry Roundtable for Graduate Students

Meet industry leaders
Discuss career paths in industry

Sunday, August 17, 2008, 2:00 - 4:00 p.m.
Hall D, Pennsylvania Convention Center
Philadelphia, PA

Sponsored by ACS Committee on Corporation Associates and ACS Younger Chemists Committee

ACS CORPORATION ASSOCIATES

AskGradEd

Dear GradEd:
Several students from our department applied to the PfLAGS session in Cincinnati last May [2007], but none of us was able to get in. So we were considering hosting a session on our campus. Could you tell us what would be involved and any additional information about the program?

—*Grad*

Dear Grad:
The ACS Office of Graduate Education and Department of Career Management and Development would be pleased to bring the Preparing for Life After Graduate School (PfLAGS) workshop to graduate students and postdocs at your university. This two-day workshop is usually hosted by chemistry departments, though as you noted we can also hold it at events such as the Regional Meetings. If you are interested in bringing PfLAGS to your campus, you will first want to find a faculty sponsor and obtain your university department's approval. The ACS would then work with a university contact to oversee the logistics and administration of the program. As the workshop works best with around 25–35 participants, spreading the word to recruit fellow students and postdocs would be a vital component to organizing the workshop.

To date, the PfLAGS workshop has been held on more than 12 university campuses in addition to being presented at the ACS Central Regional Meeting in Cincinnati. These programs have received very positive evaluations from graduate students and postdocs. Participants have particularly noted how the presenters have given them a very clear understanding of the opportunities—as well as challenges—in the job market and how they feel much more prepared to enter into their own job searches after going through the workshop.

As you may already know, the key components of the workshop include defining the variety of career options for the graduating chemist; learning the skills—beyond the lab techniques used in research—that are needed for success; understanding the different career advancement paths; and finding the appropriate job. Because the lead PfLAGS presenters have extensive experience in the chemical industry, approximately two thirds of the material focuses on industry, with about a third concentrating on academic careers. Another optional inclusion is a third day devoted to mock interviews and resume reviews, which provides a great opportunity for one-on-one interaction as well as practice toward conquering the job interview. While the key contents of PfLAGS have remained largely the same since the first workshop held at the University of Wisconsin–Madison in 2005, the material has also been constantly updated to ensure its utmost relevance to today's job market.

For further details, or to set up a session on your campus, please contact the OGE at 202-872-4588 or e-mail GradEd@acs.org. You may also find more information at the ACS PfLAGS Web site, which includes references to published articles on PfLAGS, at http://portal.acs.org/portal/acs/corg/content?_nfpb=true&_pageLabel=PP_SUPERARTICLE&node_id=2019&use_sec=false&sec_url_var=region1.

—*GradEd*

We welcome your questions for the AskGradEd column at GradEd@acs.org. Please indicate whether you would like us to use your name or keep you anonymous.

The Graduate Junction

The Graduate Junction is a brand new Web site designed to help research students contact others who share similar research interests, regardless of the department, institution, or country in which they work. Two postgraduate students at the University of Durham developed The Graduate Junction. Since its launch in May 2008, The Graduate Junction has proved very popular with research students and academics alike. Within the first month, more than 3,000 students registered and the news spread to more than 40 countries.

Researchers currently have access to two main sources of information: published literature and academic conferences. Although they are essential, literature reviews can only reveal completed work. Relevant academic conferences provide a forum where students with similar research interests can interact, but such gatherings occur infrequently. It is very easy for researchers to become isolated and overly focused on the specifics of their own work, consequently losing a sense of what other related work is being done.

The creators of The Graduate Junction hope to prevent that isolation and allow students to start forming research-related networks that can stay with them throughout their careers. Other intentions behind The Graduate Junction are to provide an atmosphere similar to that of academic events and to use the Internet to establish a worldwide graduate research community.

The Graduate Junction should prove to be useful at any stage of the research process for all master's and doctoral degree students, as well as for postdoctoral fellows. It will allow researchers to stay informed about current developments in their fields. With the addition of conference and postgraduate job listings imminent, The Graduate Junction ought to be one of the most useful resources available for all research students. http://www.graduatejunction.com

Mentoring Resources

The following is a limited bibliography of resource articles about mentoring. Please see also page 5 of the *Newsletter* article by Chris Golde for a short list of mentoring resources for graduate students. There is also an interesting resource list and bibliography in the National Academy publication on mentoring, *Adviser, Teacher, Role Model, Friend* (item 1 in the Golde article's sidebar, "Mentoring Resources for Graduate Students"). Please see **www.nap.edu/readingroom/books/mentor/7.html.**

The Howard Hughes Medical Institute (HHMI) and the Burroughs Wellcome Foundation have two publications of interest, *Making the Right Moves: A Practical Guide to Scientific Management for Postdocs and New Faculty, 2nd Edition, 2006;* and *Training Scientists To Make the Right Moves: A Practical Guide to Developing Programs in Scientific Management, 2006.* Both publications are available online at **www.hhmi.org/labmanagement.** They serve as a resource for universities, professional societies, and other organizations interested in helping early-career scientists become successful managers of research programs.

The ACS Academic Professional Guidelines outline professional standards that chemistry scientists, faculty, postdocs, and students are expected to meet. It is online at: **http://portal.acs.org/portal/PublicWebSite/careers/ethics/CTP_004008** This item complements the broader *ACS Professional Employment Guidelines*, which may be found online at **www.onlineethics.org/CMS/profpractice/ethcodes/13411/ACSEmploy.aspx.**

Planning for Graduate Work in Chemistry, 7th Edition, 2006, is a user-friendly online handbook prepared by the *ACS Committee on Professional Training* for students looking ahead to graduate school, **http://portal.acs.org:80/portal/fileFetch/C/CTP_005936/pdf/CTP_005936.pdf.**

Another ACS publication, *And Gladly Teach,* is a resource for chemists preparing for an academic career: **http://portal.acs.org:80/portal/fileFetch/C/CTP_005004/pdf/CTP_005004.pdf.** There are also Web-linked references from Preparing Future Faculty (a partnership initiative of The Council of Graduate Schools and the Association of American Colleges and Universities) at **www.preparing-faculty.org/PFFweb.Resources.htm#mentor.**

Several universities offer guidelines for mentoring on their Web sites. The University of Washington–Seattle has a good presentation about mentoring for faculty and another for students. Please see *Mentoring: How To Mentor Graduate Students–A Faculty Guide*, at www.grad.washington.edu/mentoring/gradfacultymentor.pdf and *Mentoring: How To Obtain the Mentoring You Need*, at **www.grad.washington.edu/mentoring/GradStudentMentor.pdf.**

Mentoring Awards. For an example of an awards program for faculty mentors that is run by graduate students, please see the Web site of the Washington University in St. Louis at **http://artsci.wustl.edu/~gss/mentor_awards/Intro2006.html.** The program's structure and the award criteria could be helpful to other organizations thinking about launching a similar awards program.

The Council of Graduate Schools has an ongoing Ph.D. Completion Project. There is abundant information on the Web site, although not all of it is relevant to chemistry. The section on mentoring and advising is available at: **www.phdcompletion.org/promising/mentoring.asp.**

Sigma Xi undertook a comprehensive survey of the postdoc experience. A summary of the results is available at **http://postdoc.sigmaxi.org.**

Science Careers from the journal *Science* often has informative articles regarding career preparation, including mentoring. For example, please see the report, *To Choose an Adviser, Be an "Armchair Anthropologist,"* by Siri Carpenter: **http://sciencecareers.sciencemag.org/career_development/previous_issues/articles/2007_07_20/caredit_a0700102.** Another report, *Making Mentoring Mandatory,* by Beryl Lieff Benderly, refers to a recent federal law known as the America COMPETES Act. This legislation has stimulated steps taken by NSF and NIH to require PI's whose proposals request support for the training, mentoring, or both of postdocs to document the same. Please see **http://sciencecareers.sciencemag.org/career_development/previous_issues/articles/2007_10_05/caredit_a0700140.**

Please see also, *Choosing the Right Research Adviser*, by Richard M. Reis, *Chronicle of Higher Education,* **http://chronicle.com/jobs/news/2000/01/2000010702c.htm.**

Prepared by the ACS Office of Graduate Education