

Generating New Research Ideas

Julio de Paula, Department of Chemistry, Haverford College, Haverford PA 19041

John Stevens, Department of Chemistry, University of North Carolina at Asheville, Asheville NC 28804

For research to be successful, three elements of the enterprise must be considered carefully: the motivation and qualifications of the people, the institutional infrastructure (including research facilities and equipment), and the continual generation of ideas. Much attention is given by administrators and funding agencies to the first two elements, but making progress in the third also requires a significant amount of effort. Research ideas must be the product of a complex intellectual process that tests a scientist's knowledge, creativity, and ability—particularly in this information age—to gather and sort information in rapidly changing fields of study. Unlike the novelist who often engages in solitary battles with a blank sheet of paper, modern scientists often rely on collaborations to develop ideas that are likely to result in significant contributions to knowledge. Although the preceding are challenges that any scientist must face, faculty members at primarily undergraduate institutions (PUIs) work in unique environments that present unique obstacles and opportunities for achievement in research. Because PUI faculty are required to devote so much of their time to teaching undergraduates in traditional classroom and instructional laboratory settings, it is difficult to stay productive in current research areas, to enter a new research area, and to be competitive in a rapidly changing research environment where principal investigators at research institutions have the edge on productivity. Yet the PUI environment is less rigid and allows for rapid movement into new areas and new collaborations. Fink¹ argues that professional development has become so important that it should be added to the three traditional areas of faculty activity: teaching, research/creative activity, and service. We advance the notion that meaningful faculty development programs are also important for strategic positioning of institutions of higher education in their struggle to compete for the best students and instructors. It follows that a new focus is needed on enhancing opportunities for scholarly progress at PUIs, and fostering the development of new ideas is key. This document explores issues that can inhibit and foster development of scholarly activity at PUIs. We also make explicit recommendations for initiatives that can facilitate the generation of new research ideas at PUIs.

We begin by considering traditional and new ways in which ideas are generated and developed by scientists at all institutions, while highlighting some of the special problems and opportunities experienced at PUIs. Following the scientific literature continues to be a very important mechanism for staying current in one's own field. Most publishers make the daunting task of screening the ever increasing number of scientific periodicals a bit easier by delivering tables of contents directly to the reader by electronic mail. Online databases have also become rather sophisticated. However, whereas some are free (e.g., PubMed), others are so expensive (e.g., SciFinder) as to be prohibitive for resource-limited institutions.

Writing proposals—though a time-consuming and stressful activity—has the often underestimated benefit of promoting review of the current literature and assessment of an existing research program—including the opportunity to revisit old ideas that were never

¹ Fink, L.D. *Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses*, Wiley ISBN 0-7879-6055-1, 2003.

implemented. However, a lower percentage of the faculty at PUIs has been writing proposals, according to a study of the role of research in the natural sciences at undergraduate institutions sponsored by The Camille and Henry Dreyfus Foundation, The Robert Welch Foundation, W. M. Keck Foundation, M. J. Murdick Charitable Trust, and Research Corporation.² An examination of the culture that is leading to this decline in proposal pressure is in order. Some institutions and organizations have developed initiatives to deal with the problem. For example, the Council on Undergraduate Research (CUR) and the ACS Petroleum Research Fund run periodic workshops on proposal writing, gatherings in which experienced writers pass on their knowledge to other faculty members and institutional officers who wish to develop skills in the preparation of successful proposals. Faculty at California State University at Fullerton have established a Writing Club, in which groups meet regularly to discuss and review proposals before submission.

Attendance at conferences is also a very important activity, as it is a very efficient means of gathering large amounts of information in a relatively short period of time. It is also at conferences that personal contacts are established and collaborations are often initiated (and nurtured). Because of heavy teaching schedules, faculty at PUIs have fewer opportunities to travel during the academic year, and most institutions do not have the means to support significant travel, especially in the light of increasing conference registration fees, travel, and lodging. Fortunately, some organizations, such as the Gordon Research Conferences, do offer a limited number of travel grants to faculty at PUIs.

Sabbaticals are touted by most as perhaps the most efficient of all mechanisms for the generation of new research ideas. The opportunity to become a member—even if only temporarily—of a new research community and to become immersed in a new field can lead to significant changes in research direction. There are many programs that promote sabbatical leaves both in the United States (e.g., programs at the NSF, such as the Nanotechnology in Undergraduate Education,³ and the ACS Petroleum Research Fund Undergraduate Faculty Sabbatical Program⁴) and abroad (e.g., the Fulbright Fellowship Program⁵). Going abroad is made all the more attractive by tax exemptions on salaries through the Foreign Earned Income Exclusion clause of the tax code. Also, some foreign institutions, such as the Max Planck Institutes, run their own sabbatical programs, with significant financial support for salary. In spite of all these attractive features, going abroad—and sometimes even moving temporarily to a different state within the US—can be very problematic for two-career families. It follows that some attention should be given to the support of in-house sabbaticals, currently discouraged by most funding agencies, and other models allowing a split time between the home institution and research site.

One of the least expensive ways for individuals and institutions to maximize contact with leaders in established and emerging fields of study is to host seminar visits at the home institution. In many cases, research institutions send speakers at no cost to PUIs. But capitalizing on existing expertise at the home institution can also be important, as long-lasting collaborations—including

² *Academic Excellence: The Sourcebook*, Research Corporation, ISBN 0-9633504-6-3, 2001

³ NSF Nanotechnology Undergraduate Education Program. 12 June 2003
<<http://www.nanofab.psu.edu/education/nsf-nue-program.htm>>.

⁴ PRF Programs. 12 June 2003 <<http://www.chemistry.org/portal/a/c/s/1/acdisplay.html?DOC=prf\prfgrant.html>>.

⁵ The Fulbright Program. 12 June 2003 <http://www.cies.org/about_fulb.htm>.

interdisciplinary efforts—between faculty at a PUI can be initiated by the mere experience of hearing a colleague speak about a new research project. There is a tendency at PUIs to optimize the seminar experience for the undergraduates, and it is important to remind oneself that seminar programs are important aspects of professional development of faculty.

The idea that seminars are important has been expanded by chemists at Colgate University, who established a Speakers Bureau mirroring those run by research institutions. By giving seminars, faculty at PUIs not only interact with like-minded scientists at the host institutions, but they also further the cause of undergraduate research, making it clear that quality work can be done at PUIs.

Research collaborations are becoming the norm in modern science, and chemists often play a pivotal role in interdisciplinary efforts. Collaborations can also have a significant impact on diversity at institutions, allowing students and faculty to interact with a broader cultural, ethnic, and gender base of scientists. The effect can be particularly important at an institution with a small faculty. There are many examples in the PUI community of successful and long-term scholarly interactions with scientists at research institutions, national laboratories, the private sector, and other PUIs.⁶ Funding agencies are sponsoring many programs that are designed to foster collaboration and communication among scientists. Examples include the Collaborative Research at Undergraduate Institutions (CRUI),⁷ Research Sites for Educators in Chemistry (RSC),⁸ and Research Coordination Networks (RCN)⁹ programs at the NSF.

Whereas collaborations will only become more important, faculty at PUIs must be fully aware of the challenges and rewards of all types of interactions. In the next two paragraphs, we attempt to summarize the main issues.

When collaborating with a research university or a national laboratory, faculty at PUIs can take advantage of a more complex infrastructure often designed to promote productivity in research. Interactions with leaders in research often ease transitions into new areas, including such emerging interdisciplinary fields as nanoscience, bioinformatics, and homeland defense. There is also significant anecdotal evidence that interactions with younger scientists—graduate students and post-doctoral fellows—can be a revitalizing experience for faculty from a PUI. However, in the eyes of the scientific community, it can be difficult for a faculty member at a PUI to establish full independence from a more famous researcher who is a collaborator. Also, because of discrepancies in infrastructure, it can be challenging for technology to be transferred completely—or even partially—from a research institution to a PUI. For example, the PUI may not be able to afford maintenance of a 500 MHz NMR spectrometer even if the instrument is donated by a wealthier institution.

⁶ For a successful example of a collaborative project between PUIs, see <http://faculty.juniata.edu/reingold/TIM.html>, the web site for the Theoretically Interesting Molecules (TIM) Consortium.

⁷ Collaborative Research at Undergraduate Institutions. 12 June 2003
<<http://www.nsf.gov/pubs/2003/nsf03514/nsf03514.htm>>.

⁸ Research Sites for Educators in Chemistry. 12 June 2003 <http://www.nsf.gov/pubs/2001/nsf0110/nsf0110.htm>>.

⁹ Research Coordination Networks in Biological Sciences. 12 June 2003
<<http://www.nsf.gov/pubs/2000/nsf0056/nsf0056.htm>>.

More and more faculty at PUIs are finding collaborators among their own colleagues. An example is Haverford College's Nanoscience Program, funded by the David and Lucile Packard Foundation and featuring a collaboration between seven faculty members from Chemistry, Biology, Physics, and Mathematics.¹⁰ Intra-institutional collaborations can enrich the local research culture, having a positive effect on all faculty and students. Also, much of the technology and expertise is developed and remains at the PUI when reliance on other institutions is minimized. However, without carefully planned hiring, it is difficult to find a large enough nucleus of scholars at PUIs who share common research interests. Internal collaborations must also have mechanisms in place to maximize the infusion of ideas from the outside, especially if the work is in an emerging field. Also, demanding teaching schedules lead to dramatic loss of productivity during the academic year, whereas productivity is maintained at a reasonable level when the collaborator is at a research institution.

A recent trend worthy of note is the increase in the number of post-doctoral fellows and laboratory technicians being hired by faculty at PUIs. The notion of populating research laboratories at PUIs with post-doctoral fellows has been controversial. On the one hand, opponents of the idea are wary of shifting the focus away from the education of undergraduates in research methods. On the other hand endorers of the idea point to positive impact on research productivity, continuity of the research program, training of new faculty, and enhanced opportunities for generating new ideas via interactions with young professionals who are knowledgeable in cutting-edge concepts and techniques. There is a growing sense among both private and federal agencies, including the Camille & Henry Dreyfus Foundation, the NSF, and the Howard Hughes Medical Institutes, that the advantages outweigh the disadvantages, and it is likely that we will see more opportunities for post-doctoral fellows to conduct research and, in some cases, do a bit of teaching at PUIs.

The preceding paragraphs have summarized some of the unique challenges that faculty at PUIs must face to generate new ideas in a rapidly changing research environment. We have also discussed some of the unique opportunities that only PUIs are poised to explore, such as programs targeted at funding sabbaticals, conference attendance, and the hiring of postdoctoral fellows by faculty at PUIs. However, more needs to be done to overcome the barriers that can lead to underachievement by researchers at PUIs.

The NSF is contemplating the creation of undergraduate research centers, which, in principle, could provide a wide platform for exchange of information and resources between institutions of various types. Because this synergy is likely to be a significant factor in enhancement of research productivity, we endorse NSF's proposal to establish undergraduate research centers in which faculty at PUIs play an important role .

Issues that impact resource-limited institutions require significant attention. As pointed out earlier in the document, access to online databases makes it possible for researchers to navigate the immense sea of scientific information. Yet, some vendors have pricing schemes that cannot be accommodated by too many PUIs. Whereas many of the same vendors do provide deep discounts for consortia of institutions, it is important to keep in mind that many institutions cannot, for one reason or another, take advantage of the strategy and, in some cases, even

¹⁰ For details, see http://www.haverford.edu/biology/Nanoscience_Program/nanoscience.htm.

participation in a consortium does not drive the cost below budgetary thresholds. We recommend that a group of influential scientists from academic institutions and the private sector, perhaps with support from the American Chemical Society, be formed to address this issue directly with database vendors.

Also of importance to resource-limited institutions is the availability of sabbaticals, another element identified in this document as key to professional development of faculty at PUIs. Many institutions have inadequate sabbatical leave policies because of lack of proper financial backing. For example, it is commonplace for a PUI to offer a handful of sabbatical leaves per year for the entire faculty, who then must compete for an award. More ideal would be a policy that allows for automatic leaves with a salary guarantee every few years. Of course, for many institutions this generous a policy would not be possible. However, funding agencies can help by establishing programs that cover much of a faculty member's leave salary, thereby providing significant budget relief to the PUI. Also, to respond appropriately to the rise in numbers of two-career families that cannot relocate temporarily, funding agencies should reconsider the notion that in-house sabbaticals are not sufficiently useful to merit funding.

Finally, there are several initiatives that can be implemented by grass-roots organizations, such as the Council on Undergraduate Research. For example, online conferences could be convened that emphasize current research at PUIs in emerging areas, such as nanoscience and bioinformatics. In this way, and without leaving the comfort of the home institution, faculty at PUIs seeking to gather strength in new research areas can develop a better sense of which strategies work at similar institutions. The conferences could also lead to many collaborations.

The teaching load norm at most PUIs varies from about 7 to 12 hours per week and seldom takes into account the hours required to supervise research. We recommend that the teaching load be defined so as to allow about 20-25% of contact hours to be devoted to supervision of undergraduates in research. A successful accounting strategy, implemented at many PUIs, consists of giving each faculty member a research course with its own number and catalog entry, with the faculty member receiving teaching credit for the activity. This recommendation is directed towards all those involved in the support of the PUI community.

In conclusion, PUIs continue to strengthen their research programs, but there are unique obstacles to productivity that can be overcome with proper attention to issues that fall under the general umbrella of faculty development. We hope that this document can stimulate further discussion of ways to facilitate the generation of new and exciting research programs at PUIs.