

Collaboration: An Opportunity to Become Productive in Research at Predominantly Undergraduate Institutions

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Undergraduate research is widely recognized as an effective and complete teaching strategy that both refines skills learned in the classroom and develops entirely new ones (1,2,3). Despite the relatively small size of their science programs, predominantly undergraduate institutions (PUIs), excel at attracting good students to chemistry and encouraging them to enter graduate programs (1). This is due largely to small class sizes, nurturing faculty, and a selective admission process. This educational experience is enhanced when the faculty members are also dedicated to involving students in pursuing publishable research activities. According to the recent publication *Academic Excellence* however, there are disturbing indications that undergraduate research programs at PUIs are not as healthy as they once were. Despite a substantial infusion of funding from private and governmental agencies to support undergraduate research, key indicators suggest that neither the number of scholarly publications by faculty at PUIs, nor the number of proposal submissions and funded grants have increased (4).

Conducting and maintaining a productive research program at a PUI is extremely challenging, given the numerous constraints on faculty time, money, equipment, specialized methodologies, personnel, and research space (2,3,5). These challenges are often cited by faculty at PUIs as reasons for preventing them from keeping current through the literature (3) and from generating new research ideas, particularly ones that are interdisciplinary in nature (2,3,5). A closely related problem is the need for a PUI to cover the breadth of a discipline with a small faculty. This means that it can be difficult to find a colleague who is able to participate in detailed discussions concerning recent advances in a particular research area.

Collaborations within and between institutions provide faculty members with an opportunity to interact with a wide range of scientists with complementary interests, and colleagues with which to discuss their fields of research. Such interactions would naturally lead to the development of new and stimulating research ideas. However, while research in doctoral/research institutions (DIs) is becoming far more collaborative and multidisciplinary, the number of PUIs involving two or more faculty members has not increased (1,4).

In addition to addressing the current health of research at PUIs at the undergraduate research summit, there is a need to develop new ideas for encouraging faculty and predominantly undergraduate institutions to develop and pursue publishable research activities that involves undergraduate student coworkers. In addition, undergraduates who do not pursue graduate degrees may only have the opportunity to experience research at their undergraduate institution so encouraging these programs is important. Even though numerous challenges exist in developing research programs at PUIs, this white paper will suggest that collaborations can help to overcome some of them. The idea of forming partnerships or collaborations among scientists is not new, even when directed to faculty at PUIs. In an article by Scalzi and Kovacic, the authors voiced the firm conviction that with the deepening educational, social, and financial problems facing the educational establishment in the early 1970s, DIs and PUIs should communicate in order to co-operatively address their mutual difficulties in science education (6). Recognizing this need to co-operate, the Undergraduate-Graduate Research Collaboration Program (UGRCP) was conceived in 1966, and a pilot project, funded by the NSF, was conducted at the University of Wisconsin-Milwaukee (6).

The opportunity for faculty at PUIs to collaborate with in-house colleagues or scientists at other locations has continued to be recognized as an important solution to many of the challenges mentioned above (1,2,3,5). However, successful collaborations arise only from projects that are of deep scientific interest to all parties and generate resources that address the needs of everyone concerned. Collaborations must not

be viewed as service from DIs or other laboratories to PUIs, but as mechanisms for reaching goals of mutual interests. Further, each party must make a unique and significant contribution to the collaboration. The benefits of a fruitful collaboration include the following:

- Collaborations promote the generation of new ideas, especially for multidisciplinary projects, such as biochemistry and chemical biology, nanoscience, material science, environmental science, and others.
- Collaborations raise the level of research productivity, as measured by the number of scholarly publications and professional presentations. This serves as a highly successful technique for combating faculty disenfranchisement from mainstream research (6).
- Collaborations permit access to state-of-the art instrumentation, such as very high field NMR spectrometers, X-ray diffractometers, various electron and scanning probe microscopes, lasers, and many others.
- Collaborations permit access to specialized methodology, glassware, and equipment. Examples include cell culturing and sorting equipment, high vacuum lines, molecular modeling, metal vapor deposition, and others.
- Collaborations encourage interactions with a broader range of highly trained personnel, with more diverse backgrounds and interests. It provides the opportunity for PUI faculty and students to work with graduate students, postdoctoral fellows, resident scientists, technicians, and others.

Opportunities for faculty at PUIs to develop collaborations are vast and diverse. In addition to collaboration with DIs, some PUI faculty members have forged collaborations with government laboratories, as well as industrial research laboratories. Many government facilities have active programs for supporting faculty and their students during the summer as well as sabbatical leave opportunities for faculty. Similar programs also exist in the laboratories of some of the major chemical, pharmaceutical and biotechnology companies. Regional companies may also be interested in supporting summer projects for faculty and faculty/student teams, either in company facilities or at the PUI.

There are numerous reasons why these laboratories are interested in collaborating with the faculty at PUIs. While the most obvious is for the recruitment of talented students into graduate programs or company workforces, this may not be the only, or even the most important reason. PUI faculty possesses valuable technical skills that may not be readily available at collaborating institutions. They are often willing to investigate significant research topics that are of interest to a company, but not crucial to a core mission and thus the company may be unwilling to devote its own personnel to the problem. Furthermore, PUIs may have certain instrumentation that the collaborating laboratory is unwilling to purchase or support, but does occasionally require. In essence, PUI faculty and students are able to make genuine scientific contributions to real-world research problems. Finally, some of these laboratories are interested in collaborating with faculty at PUIs to enhance their visibility in the community and to provide outreach activities for targeted students and institutions.

There are several mechanisms that faculty at PUIs can use to seek support in establishing collaborations. These include the NSF collaborative-RUI programs, the RSEC (research sites for educators in chemistry) programs, and the Merck/AAAS undergraduate science program. The latter program specifically targets collaboration between chemists and biologists within an institution. A new program by the PRF (the UFS program) provides sabbatical leave support for undergraduate faculty interested in establishing new research collaborations. In addition, there are instances of collaboration by faculty at PUIs with

international researchers. Many of these collaborations are built on common interests in specific research problems and funding mechanisms exist within NSF and other organizations to help establish them.

Even though there are enormous benefits in developing research programs at PUIs through collaboration, it is important to realize that there are potential pitfalls.

- Many programs encourage PUI faculty members to conduct research in their collaborator's laboratory. While this is a quick and effective way to *begin* a collaboration, such an arrangement will not enhance an individual's independent scholarship in the long run. In addition, this arrangement lessens the impact on PUI's students and the home institution infrastructure. Faculty at PUIs should strive to establish their own productive and independent research programs at their home institutions. While there will certainly be situations where PUI faculty will wish to spend time in their collaborators' laboratories to learn new techniques or to access specialized equipment, it is healthier to the long-term interaction if the PUI brings a unique contribution to the collaboration
- It is imperative that the collaboration eventually results in refereed publications. This is of particular concern in industrial collaborations, where publication in the open literature is rarely a priority. A publication record is an important factor for securing future research funding and lacking it will compromise the long-term success of the faculty member, the institution and even participating student coworkers.
- It is not a "collaboration" if students are simply shipped from a PUI to a DI or another institution. There must be an activity in which *both* sides benefit intellectually and scientifically.

In summary, collaboration among scientists at all levels and types of institutions can provide enormous benefits. Faculty members at PUIs will find that nearly any research program will be enhanced through active collaboration.

References:

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