PROJECT SUMMARY

Support is requested for an undergraduate research summit in chemistry to be held in the summer of 2003. The purpose of this summit is to examine the issues involved in undertaking and sustaining chemistry research at predominantly undergraduate institutions (PUIs) and to publish a report that provides recommendations on how to enhance the number, quality, productivity, and visibility of chemistry research programs at PUIs. A summit meeting is particularly timely because of the changing landscape of higher education and the research community over the past few decades.

Issues to be addressed at the summit include how faculty members at PUIs continue to generate cutting-edge ideas for research, how undergraduate research is defined, what the outcomes of undergraduate research ought to be for student participants, how PUIs respond to the changing student and faculty demographics, how the growth and development of faculty members at PUIs are promoted over the entire career, how faculty members at PUIs foster collaborations so that they can contribute to the complex scientific topics under investigation today, how curricula that support undergraduate research throughout are developed, what is the appropriate infrastructure for support of research at PUIs, and how should undergraduate research be assessed, including who should do the assessment.

The summit will be developed by a Steering Committee working in close contact with the Chemistry Division of the Council on Undergraduate Research (CUR). Two symposia on "New Models" and "Best Practices" of undergraduate research are already planned for the spring 2003 meeting of the American Chemistry Society. The Steering Committee will hold a meeting in conjunction with these symposia to plan the summit. The summit will be attended by a range of stakeholders including people representing a variety of types of PUIs, government agencies and laboratories, industry, and professional organizations.

The Chemistry Division of CUR will take the lead in disseminating the report and in working to see that recommendations in the report are implemented. It is anticipated that new and proven models and paradigms for conducting research at PUIs will be contained within the recommendations in the report.

INTRODUCTION

A number of undergraduate institutions have long and distinguished records of faculty-student collaborative research in chemistry. In 1979, when the Council on Undergraduate Research (CUR) was first started by Brian Andreen of Research Corporation and a group of nine chemists, the initial undertaking of the organization was to publish a directory of research in chemistry at primarily undergraduate institutions. This directory served to document the record of success that faculty members at selected private, liberal arts institutions had in conducting research. It was understood that the benefits of this research included the importance of the scholarly contributions to the discipline and the valuable educational opportunity it provided to students who worked in collaboration with faculty members. Quality research was not happening only at private, liberal arts institutions, and by the time the Third Edition of the CUR Directory was published, it documented research at predominantly undergraduate public institutions as well.

Today, involvement of undergraduate students in research has gained national significance. Reports such as *Shaping the Future* by the National Science Foundation (1996), *Reinventing Undergraduate Education* by the Boyer Commission of the Carnegie Foundation for the Advancement of Teaching (1998), and *Science Teaching Reconsidered* by the National Research Council (1997) helped in bringing the value of undergraduate research to national prominence by underscoring themes such as the following:

> "every student should be presented an opportunity … to be involved in some way in scientific inquiry" (*Shaping the Future*)
>
> "undergraduates need to become an active part of the audience for research" (*Reinventing Undergraduate Education*)
>
> "cooperative activities, active learning, and connections with practicing researchers and research activities improve the learning environment for all students" (*Science Teaching Reconsidered*)

Throughout these documents, the importance of discovery and inquiry in promoting student learning is emphasized. Summer opportunities exist for undergraduates to participate in research at colleges, universities (NSF-REU as one primary example), national laboratories, and industrial facilities through internships. Among the tangible results of such research opportunities are the success of conferences such as the National Conference on Undergraduate Research, with as many as 2000 student presenters each year, and the poster sessions at the National Meetings of the American Chemical Society, which at the recent meeting in Orlando involved over 750 posters representing work done by undergraduates. The positive outcomes of research for the student are slowly translating into curricular reform, with many educators advocating the involvement of all undergraduates in a research experience during their course of study. Indeed, recent descriptions of the guidelines for degree certification published by the Committee on

Professional Training of the American Chemical Society (ACS) stress the importance of a research experience during undergraduate studies.

It is interesting that CUR was first started because of concern that an inadequate number and variety of funding sources existed to support research at undergraduate institutions. Today, such a claim no longer can be made. With the availability of NSF programs such as the RUI, REU, MRI and CCLI, and other programs such as those supported by NIH (Academic Research Enhancement Award), Research Corporation, The Petroleum Research Fund, and the Camille and Henry Dreyfus Foundation, ample opportunities exist for chemistry faculty members at undergraduate institutions to secure external support for their research. Also, the increased recognition of the value of undergraduate research has led many institutions to develop internal means of supporting the activity either through endowment funds or out of their yearly operating budget, although this has raised the question of whether fewer faculty members then seek external support for their work. Many faculty members at undergraduate institutions are enormously successful at undertaking significant research in collaboration with undergraduates. For example, *Academic Excellence*, a recent comprehensive study of faculty scholarship in the sciences at a spectrum of undergraduate institutions, reports over the decade of the 90s that science faculty members at PUIs in the study averaged one peer-reviewed publication every two years.

It is apparent, though, that there is now a different set of concerns facing faculty members at PUIs who wish to remain active and productive in research. These concerns relate to dramatic changes in the landscape of undergraduate research (and in fact all research) that have occurred in the 25 years since CUR was first started. There is concern about PUIs, which remain an important contributor to the knowledge base and human-resource base in the sciences, being poised to respond to these changes in ways that will enable faculty members not only to maintain vibrant research programs but also take their research to new levels. Also, *Academic Excellence* documented some findings that are potential cause for concern. Despite a 21 percent increase in the size of the science faculties at PUIs over the period of the study, proposal submission to external granting organizations remained level. In addition, only about a quarter of the publications by science faculty at PUIs had student co-authors.

CHANGING LANDSCAPE

Research at PUIs tends to use the single investigator model, which has been very successful for many years throughout the larger community of academic chemists. There has been increasing recognition, though, that many problems in chemistry do not fall neatly within subdisciplinary areas, such that the single-investigator model is often no longer the only meaningful way to conduct research in chemistry. Instead, research today frequently involves multidisciplinary teams in which different scientists contribute different areas of expertise. The complexity of many scientific problems under examination necessitates the formation of such collaborations. Furthermore, the knowledge base in chemistry is expanding so rapidly that faculty members at PUIs may have difficulty keeping abreast of the changes. PUIs are not able to offer the variety and breadth of seminars given at research universities. This makes it harder for faculty at PUIs to keep up with developments in new fields, such as combinatorial chemistry,

proteomics, and nanotechnology. Furthermore, since the faculties at PUIs are fairly small, new hires in emerging fields are rare. In addition, even though chemistry departments at PUIs have unparalleled opportunities to secure funding for instrumentation, there are instruments necessary for some fields of investigation (e.g., 600 MHz NMR spectrometers for investigations in structural biochemistry) that are beyond the reach of most undergraduate institutions. Such equipment may be more essential today to remain a valued contributor to our knowledge base than was the case in the past. It follows that maintaining a productive research program at an undergraduate institution will increasingly necessitate collaborations with investigators from resource-rich institutions, such as research universities, national laboratories, and industry.

The demographics of our communities are changing, as highlighted in reports such as *Shaping the Future* and *Reinventing Undergraduate Education*. Students have different backgrounds and expectations than they did 25 years ago. Increasing numbers of students from traditionally underrepresented populations will make up the student population, and the student population can be expected to exhibit a wider array of learning styles than formerly observed at many PUIs. Schools must be positioned to accommodate higher percentages of students from populations that have been less extensively served in the past, which may require a change in the research culture at many institutions. Science courses and research laboratories must be welcoming, relevant, and accessible to students who are from historically underrepresented groups.

The makeup of the faculty, especially at undergraduate institutions, is changing as well. *Academic Excellence* reports that in the 1990s, 40 percent of new tenure-track faculty members in the sciences were women, compared to only 21 percent in the 1980s. Growth in the representation of minority faculty members is not nearly as dramatic, but considering demographic trends, can be expected to increase in the future. Moreover, hiring and career development issues are increasingly affected by "dual career" families and increasingly both parents fully participate in child-rearing. Personal responsibilities must be balanced against the considerable amount of "after hours" time that is needed to be an active and productive teacher-scholar.

There is increasing interest among scientists to integrate research throughout the curriculum. Science courses ought to provide students with the opportunity to conduct actual investigations. Students prosper when courses are more "research-like" in their structure. Students benefit when they are involved in research activities earlier in their undergraduate studies. Recent initiatives like the NSF Distinguished Teacher-Scholar Program and the NSF Award for the Integration of Research and Education recognize the importance of having faculty members integrate their teaching and research into one seamless activity.

Finally, there are increasing pressures to assess whether educational activities, including research, actually improve student learning. Educators must demonstrate that curricular changes and research activities have the intended effect of improving learning. Most of the current evidence for the value of undergraduate research is anecdotal, which does not mean that it ought to be dismissed or that these stories do not have considerable significance. However, there is an increasing demand for demonstrated measures that unequivocally show the value of undergraduate research.

CHALLENGES AND OPPORTUNITIES

The changes that have occurred in the past 25 years have raised the question of whether and how faculty members at PUIs are keeping pace and positioning themselves not only to continue their productive role in contributing knowledge to the discipline and educating students through research, but to enhance the quality of their research programs. Some of this concern is a reflection of scale. Most chemistry departments at PUIs, and especially those with some of the longest and richest track records of research, are relatively small. There might often be only one chemist in a particular subdiscipline of chemistry at a PUI, and it is often difficult for colleagues to form small scholarly communities with a focus such as natural product synthesis or laser spectroscopy. Small faculty size also makes it difficult to establish multidisciplinary teams of investigators in rapidly emerging areas such as chemical biology and materials science. Additionally, a chemistry faculty member might be the only one in the department at a particular career or personal life stage. There are also fewer staff available to perform the day-to-day administrative duties needed to run a chemistry department. From the point of view of student mentoring, many PUIs may not be well equipped to meet the needs of students with different backgrounds and different learning styles. PUIs usually make up for this through close faculty-student mentoring. The small class sizes and expectation that faculty members participate directly in student advising at PUIs facilitate faculty-student interaction and mentoring. However, there are stresses brought on by the increasing demands of staying active and productive as a teacher-scholar in today's climate.

The issues described above are not unique to chemists and exist to some degree in all fields of higher education. It will important to investigate ways in which the small size of PUIs can be advantageous, perhaps by facilitating the development of unique programs to address critical issues that might not be as easily solved at a larger, more bureaucratic institution. For example, given the higher proportion of women faculty members in chemistry and the sciences at undergraduate compared to graduate institutions, PUIs could serve as models for how to create policies and practices that appropriately address the demographic changes taking place in the academic workforce.

There are success stories at PUIs that can serve as models for others to examine and from which knowledge can be gained. The findings in *Academic Excellence* that faculty members in the sciences at PUIs average about one paper every two years shows that the faculty are productive scholars and want to stay active in research. However, the observation that only a quarter of the publications have student co-authors raises the question of whether science faculty are conducting more research on their own or with post-doctoral associates, technicians, or as visitors to other facilities than with students. There are faculty members at PUIs who have developed beneficial collaborations within their own college, and with colleagues at other institutions, national laboratories, or industrial laboratories, but it is important to identify ways to expand the role of undergraduates in these collaborations. To this end, it is useful to consider development projects at PUIs that integrate research more thoroughly throughout the curriculum, and incorporate emerging areas into science curricula.

Progress is being made in easing the tension between career and family issues with some institutions implementing proactive policies on family leave and the scheduling of tenure decisions. The success, energy, and enthusiasm that exists within

the PUI community must be used to examine the enterprise of research at PUIs with the goal of developing ways for research-rich institutions to stay that way and for institutions trying to develop an active culture to achieve the potential that is possible. It is clear that the old models will not work in many situations and people must think in new ways given today's realities. It is the purpose of this proposal to outline a mechanism for the renewal of models for undergraduate research.

PROJECT PLAN

An examination of the issues facing faculty members in chemistry departments at PUIs was begun at the Orlando ACS meeting with a two-day symposium titled "Undergraduate Research: Where Have We Been? Where Are We? Where Are We Going?" This session, while quite successful, generated few concrete proposals or recommendations about how to maintain and enhance the vibrancy of research programs at PUIs. Instead, many of the talks identified aspects of the issues outlined earlier in this proposal and presented individual success stories. It is important to continue the discussion started at the Orlando meeting. Toward that end, two half-day symposia will be held within the Chemical Education Division at the Spring 2003 ACS meeting in New Orleans (see Appendix I for complete text of the abstracts of these two symposia). These symposia will be more focussed on future trends in undergraduate research and models for how research is better accomplished at PUIs in today's environment.

One of the symposia is titled "New Models for Conducting Research at Undergraduate Institutions" and will frame more thoroughly the issues already outlined and present specific examples of how some individuals, departments, and institutions have successfully addressed them. The other symposium is titled "Best Practices in Undergraduate Research" and will highlight a range of successful NSF-REU site programs at PUIs. A virtue of the Chemistry REU program is that it has encouraged a broad range of research paradigms. Also, many of these programs have involved significant numbers of students from underrepresented groups. Successful REU programs are important models for how to conduct undergraduate research in today's environment.

The sessions in New Orleans will be a useful step in the process, but will not permit the in-depth analysis and discussion that is needed to examine research in chemistry at PUIs and make meaningful recommendations for not only keeping the enterprise viable but to take research to new levels. For that reason, we request support for subsequent activities that will culminate in a summit meeting on undergraduate research. The outcome of the summit will be a published report describing recommendations for the development of more vibrant research programs at PUIs. The summit meeting will be co-convened by Thomas Wenzel, Charles A. Dana Professor of Chemistry at Bates College, and Robert Lichter, outgoing Executive Director of The Camille and Henry Dreyfus Foundation. A Steering Committee comprised of the co-conveners and the following individuals will oversee all phases of the development and implementation of the summit, as well as the publication of the final report. This committee will work in close contact with the Chemistry Division of CUR, which is well represented on the Steering Committee (six of the twelve members are CUR Councilors, including the current Chair of the Division and the Editor-in-Chief of the *CUR*

Quarterly). Further information about the backgrounds of Steering Committee members is contained within the accompanying biographical sketches.

Julio de Paula, Haverford College
Tim Elgren, Hamilton College
Carlos Gutierrez, California State University, Los Angeles
Diane Husic, East Stroudsburg University
Kerry Karukstis, Harvey Mudd College
Moses Lee, Furman University
Sean Seymore, Rowan University
Joanne Stewart, Hope College
Jodi Wesemann, Saint Mary's College of California
Marc Zimmer, Connecticut College

At the recent business meeting of CUR, the Chemistry Council unanimously endorsed the concept of the summit and unanimously agreed to help in developing the summit and to take the lead in efforts designed to disseminate and implement the recommendations in the final report.

The first stage of the project will take place in summer and fall 2002 as the Steering Committee identifies suitable speakers for the symposia in New Orleans. Once the content of each symposium is established, members of the Steering Committee will continue work throughout the year on the development of topics.

A daylong meeting, attended by the Steering Committee, symposium speakers, and other invited participants, will be held in conjunction with the spring 2003 ACS meeting in New Orleans. The main purpose will be to plan the structure and format of the summit that will occur in the summer of 2003. A short-list of potential participants for the summit will be generated. Particular issues will be identified and divided among members of the Steering Committee who will then be responsible for developing a background/position paper. A draft of each background/position report will be completed in time for the annual meeting of the CUR Chemistry Division in June of 2003, which will be held at Ursinus College. Members of the Steering Committee who are not CUR Councilors will be invited to this session either in person or via video conferencing. Input from the CUR Chemistry Division will be gathered, and the background papers finalized soon thereafter. The final background/position papers will be provided to participants of the summit prior to the meeting. The goal is to lay as much groundwork as possible before the summit so that participants arrive having thought about the questions and ready to begin the discussion of recommendations for how to address them.

The summit in 2003 will involve about 50 participants representing a range of stakeholders. People from academe (public, private, commuter, and residential institutions), government agencies and laboratories, industries, and professional organizations will be involved. Faculty members from research-rich and developing institutions will participate. The full set of participants will spend two and a half days discussing the information in the background/position papers and preparing a set of recommendations. The last session(s) will be devoted to reaching consensus on a set of recommendations for the final report. The Steering Committee will then divide up the topics and spend a half-day preparing a first draft of the report.

The following are examples of questions that participants will address at the summit.

How do we ensure that faculty members at PUIs generate cutting-edge ideas for research?

Generating good ideas is probably the most critical component of being active in research and being able to secure financial support for the work. Members of the PUI community have often focussed on issues of time, efficiency, and infrastructure that are important when trying to conduct research rather than how to best generate new ideas for research. Developing new ideas can be difficult given the small scale and relative isolation of departments at many PUIs. It is also difficult given the rapid expansion of our knowledge base. We are in an electronic, information-based world, and PUIs may have a more difficult time keeping pace with these advances.

How do we define undergraduate research?

There is a surprising amount of debate within the PUI community about this topic. Some argue that the only criteria ought to be the extent and value of the student experience. Others argue that the purpose of undergraduate research should be the same as that of research carried out at all levels: to generate new knowledge, with publications and conference presentations representing the intended outcome of research. In defining undergraduate research, the PUI community must also examine the risk if undergraduate research is defined differently than what other communities view as the meaning of research.

What are the anticipated outcomes for undergraduate students who participate in research?

A description of what activities ought to be included in an undergraduate research experience (e.g., literature searching, writing, oral communication, etc.) and what skills are then developed ought to be articulated since there are different views and models.

What are the implications of and how do we respond to the changing demographics of students and faculty?

Response to this question may well require a change in the culture that characterizes many departments and institutions. There are incredible opportunities for those who respond to the changing demographics in a proactive manner. For example, PUIs have been and still are an important source for generating students who go on to obtain doctoral degrees in science and engineering. PUIs are an important source of future secondary school science teachers as well. It follows that proactive participation of PUIs in the education of undergraduates through research is likely to have a significant impact on science in the US. To capitalize on demographic changes, the PUI community must consider the level of responsibility and engagement on the part of faculty members and administrators and the extent to which undergraduate students are treated as scientific colleagues during the research experience. The PUI community must also examine its relationship to two-year institutions and look to provide more research opportunities to students from these institutions.

How do we promote continuing growth and development over the entire career of faculty members?

Faculty members must be research-active over their entire careers if departments want to build a thriving culture of undergraduate research. Data obtained in the study *Academic Excellence* indicate a drop in some measures of research productivity for faculty members at the Associate Professor rank. This may reflect an increased level of administrative responsibilities of faculty members at this rank, but it may also be that mid- and late-career faculty members at PUIs have an especially difficult time being aware of and responding to changes taking place within the research community. It is also reasonable to examine whether a focus on funding and award opportunities for new faculty members discourages or jeopardizes the research efforts of more advanced faculty.

How can faculty members at PUIs contribute new knowledge to the complex scientific topics under investigation today while maintaining active research programs on their own campuses and without losing sight of the undergraduate contribution?

Many projects under investigation today are complex and require collaborative efforts. Faculty members at PUIs will increasingly need to develop collaborations with investigators at their own institution, at other PUI and research institutions, in industry, and at other research facilities. Furthermore, these collaborations must involve an equitable partnership between the faculty member from the PUI and other investigators, so that all participants have ownership of the project. In the desire to contribute to the scientific community, PUI faculty must maintain their identity and continue to involve undergraduates from their own campus in their research projects.

How do chemistry departments at PUIs develop a curriculum that supports research throughout, and in which research is a natural outcome of the program?

Research, which involves the creation of new knowledge, is different in some ways than other activities in a traditional undergraduate chemistry curriculum, which are mostly focussed on learning accepted knowledge. Discovery-based laboratory courses and library-based investigations cannot substitute for a student-faculty collaborative research project, yet there is an increasing awareness that the development of courses and a curriculum that are more "research-like" throughout has benefits to students and can further enhance the research experience. One of the main strengths of PUIs is their low student-teacher ratio and the involvement of faculty members in laboratory teaching. These features ought to facilitate the development of novel investigative curricular offerings.

How do we define and then improve the appropriate infrastructure to support vibrant research programs at PUIs?

Obvious topics within this question relate to the facilities, infrastructure, and support staff that ought to characterize research-active chemistry departments at PUIs. There is also the question of whether the increased summer opportunities for undergraduates to conduct research at Ph.D.-granting institutions has hindered the ability of PUI faculty to maintain the quality of their research programs. Another issue involves the structure of research groups at PUIs. Does the nature of investigations today increase

the need for post-doctoral associates at PUIs? If so, are research-only or teaching-research positions more effective at PUIs? Furthermore, is it best in a department to foster larger, individual research groups with post-doctoral associates or smaller groups who share a common area of research? For many chemistry departments at PUIs, either set of circumstances represents a new paradigm for conducting research with possible impacts on the curriculum. Since building a thriving research infrastructure requires financial resources, how do we create a culture of grant writing among chemistry professors at PUIs?

Do current efforts to assess the value of undergraduate research focus on the most important issues? Who is best qualified to conduct an assessment of undergraduate research?

There is an increasing demand for definitive measures that show the benefits of educational methods, including undergraduate research, for students. It is also important to assess the value that participation in research has for faculty members at PUIs, and to assess the contribution that faculty-student research at PUIs makes to the discipline (publications, conference presentations, etc.) Faculty members at PUIs may not themselves have the time and knowledge to adequately assess the various outcomes of undergraduate research.

How do we raise the visibility of and respect for the research contributions of PUIs within the broader chemical community?

Development of a series of recommendations that, if implemented, would address the issues outlined in these questions will lead to new models and paradigms for conducting research with undergraduates at PUIs. The goal of the summit is to identify proven models and generate new ideas for ways of conducting research so that student and faculty participants at PUIs realize even greater benefits from their participation in research.

The agenda for the summit is ambitious, as these are topics that have not been broadly considered by the PUI community. We are confident that bringing together a diverse, yet carefully selected group in a workshop format for which substantial advance planning has occurred will enable thorough discussions and the development of meaningful recommendations. Furthermore, we anticipate that many of the recommendations will generally apply to research in all disciplines at PUIs, even though the process will involve members of the chemistry community.

DISEMMINATION AND IMPLEMENTATION

It is important that steps be taken after the workshop to disseminate and implement the recommendations in the report. The CUR Chemistry Division unanimously agreed to take the lead in this effort. CUR's mailing list and bulletin board can be used to widely distribute the report to faculty members and administrators at PUIs. Programming at CUR conferences, and regional and national ACS meetings will be organized around recommendations in the report. The *CUR Quarterly* will be used to

publish articles that highlight the recommendations and demonstrate ways in which individuals, departments, and institutions are successfully addressing issues in the report. Members of the CUR Chemistry Division will work with representatives of funding agencies in an effort to implement recommendations that either pertain to or can be addressed by changes in funding opportunities.

A number of other activities to inform the community about the report and the nature of the recommendations are planned as well. One member of the Steering Committee has recently started a position within the ACS Division of Educational and International Activities and will help identify people within ACS who would be interested in the report and can help in efforts to disseminate and implement the recommendations. Another member of the Steering Committee is a member of the ACS Committee on Professional Training, and we will work with that organization to promote the findings in the report. The Steering Committee will work to get articles on the report in the *Journal of Chemical Education* (the CUR Chemistry Division already has a regular Association Report that is published several times a year and at least one of these would be on the outcomes of the summit*), Chemical and Engineering News*, *Science*, the *Chronicle of Higher Education*, regional ACS newsletters, and newsletters of organizations such as the American Association of Higher Education. The report will be brought to the attention of key science policy makers and Congressional leaders. There is considerable interest in trying to establish a Gordon Conference on undergraduate research after publication of the report. This would enable members of the community with an interest in undergraduate research to meet on a regular basis to continue a dialogue not only about material in the report, but also about how the PUI community continues to adapt to future changes that occur.

APPENDIX – Symposia Abstracts for the Spring 2003 ACS Meeting

NEW MODELS FOR CONDUCTING RESEARCH AT UNDERGRADUATE INSTITUTIONS

The recent symposium at the Orlando meeting (Undergraduate Research: Where Have We Been? Where Are We? Where Are We Going?) generated considerable discussion about undergraduate research. One outcome of the symposium was the message that the landscape for undergraduate research is changing, and further discussion is needed to examine how faculty members at undergraduate institutions adjust to these changes to maintain vibrant research programs. For example, the single-investigator model that commonly characterizes research at undergraduate institutions is often not able to address the complexity of problems investigated today. Furthermore, the demographics of our communities are changing. Students have different backgrounds and different expectations than twenty years ago. The makeup of the faculty is changing with higher proportions of women and minorities. There are increasing desires for scientists to integrate research throughout the curriculum, and pressures at institutions to enhance their connection to the community. This half-day symposium will examine the challenges and opportunities involved in conducting research at undergraduate institutions, and present successful examples for addressing these issues.

BEST PRACTICES IN UNDERGRADUATE RESEARCH

The National Science Foundation-Research Experiences for Undergraduates Program (NSF-REU) supports programs at undergraduate institutions that provide undergraduate research opportunities in meaningful and innovative ways. A strength of the Chemistry-REU program is that it encourages a broad range of research paradigms. Some programs focus on industrial connections. Others recruit student participants from a limited geographical area to link faculty members and students around a common research topic. There are programs that include high school teachers, and others that link with nearby two-year colleges as a way of encouraging students to complete a four-year degree. Several programs have an international focus whereby students build their research skills in the U.S. before conducting research abroad. A hallmark of many REU programs has been the substantial involvement of underrepresented groups. The scope of most REU awards also creates a critical mass of faculty members at the undergraduate institution who are engaged in research. Successful REU programs are models for how to conduct undergraduate research in today's environment, and will be highlighted in this session.