

# **U.S. National Science Foundation Division of Chemistry Strategic Directions 2008-2012**



Advancing American Competitiveness

Communicating the Value of Chemistry and  
Chemical Research to the Public

Increasing Global Engagement

Increasing Grand Challenge Research through  
Centers

Broadening Participation

Addressing Funding Needs of Investigators  
Across Career Stages

Assessing the Impact of the Broader Impacts  
Review Criterion

Updating the Division of Chemistry Structure

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## CHE 2012: Strategic Directions

### Introduction

**“Today you can email movies and sound recordings and books. In about 20 years, you will be able to email three-dimensional products; they will be “printed” in 3-D using tabletop nanotechnology assembly devices, which will rearrange molecules from inexpensive input material into complex products. So you will be able to email a blouse, for instance, or a computer, or a toaster – or the toast.”**

**Ray Kurzweil “Future of the American Idea” November 2007 Atlantic Monthly**

The field of chemistry is at an exciting crossroads as it shifts from a focus on atoms and molecules to greater levels of complexity such as self-assembling chemical systems that accomplish complicated functions. Recent investments in nanoscience, computational approaches, and tools with single molecule sensitivity and time- and spatial-resolution on the scale of molecules are enabling many new discoveries such as biomimetics and use of molecules as tiny electronic devices. Chemistry has often been called the “central science” because of its many interfaces with other physical, life, geological and mathematical sciences as well as engineering.

The National Science Foundation (NSF) Division of Chemistry is the only U.S. federal unit charged with fundamental research in chemistry. The integration of science and engineering research and education is also part of the NSF mission. Basic research in chemistry and workforce development fuel the \$972B chemical industry in the U.S. With a focus on continuous improvement and producing world class science and accompanying workforce, the Division has identified strategic directions for its programs and other activities for 2008-2012. This includes articulating the philosophy of the Division, identifying and defining its values, and communicating this internally and to the community we support. We will hone the Division’s process for conducting its activities and for evaluating the success of those activities. We will learn to clearly state the results of CHE investments and better articulate the case for chemistry within the NSF, the Administration, Congress, and the scientific enterprise. This document will be updated annually. It is complementary to the NSF Strategic Plan and the NSF goals of Discovery, Learning, Research Infrastructure and Stewardship<sup>1</sup> as well as the document “2020 Vision for the National Science Foundation” published by the National Science Board.<sup>2</sup> This work is also consistent with direction from our parent organization, the Directorate for Mathematical and Physical Sciences (MPS). We are informed by recent strategic plans developed by two other major federal agencies that sponsor chemical research in the U.S.: the Department of Energy (DOE) Office of Science<sup>3</sup> and the National Institute for General Medical Sciences (NIGMS) of the National Institutes of Health (NIH).<sup>4</sup> In drafting this document, the Division also studied the President’s American Competitiveness Initiative<sup>5</sup> and the America

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<sup>1</sup> [http://www.nsf.gov/publications/pub\\_summ.jsp?ods\\_key=nsf0648](http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf0648)

<sup>2</sup> <http://www.nsf.gov/nsb/documents/2005/nsb05142/nsb05142.pdf>

<sup>3</sup> [http://www.er.doe.gov/Sub/Mission/Mission\\_Strategic.htm](http://www.er.doe.gov/Sub/Mission/Mission_Strategic.htm)

<sup>4</sup> <http://www.nigms.nih.gov/About/StrategicPlan/>

<sup>5</sup> <http://www.whitehouse.gov/stateoftheunion/2006/aci/>

COMPETES Act<sup>6</sup> as well as the National Academy of Sciences' "Rising Above the Gathering Storm,"<sup>7</sup> the National Research Council's "The Future of U.S. Chemistry Research: Benchmarks and Challenges"<sup>8</sup> and the National Science Board's "Research and Development: Essential Foundations for U.S. Competitiveness in a Global Economy."<sup>9</sup>

In February 2007, a Committee of Visitors (COV) (a subcommittee of the MPS Advisory Committee (AC)) reviewed the Division of Chemistry (CHE) and recommended that the Division produce a document to elucidate its strategic directions. Luis Echegoyen, Division Director, oversaw the formation of a facilitating group consisting of eight CHE staff (see Appendix II), Cynthia Burrows (University of Utah and member of the MPS-AC), and Susan Hamm (MPS Staff Associate for Budget and Planning). The Division received community input from the COV report, a Town Hall forum at the National Meeting of the American Chemical Society in Boston in August 2007 and a website established for community input November-December 2007. The Division merged this data to form a SWOT analysis (Strengths, Weaknesses, Opportunities and Threats/Barriers) (see Appendix I) and from it identified eight critical issues. The critical issues were the focus of the CHE Retreat in October 2007, which was facilitated by Michelle Buchanan (Associate Laboratory Director for Physical Sciences, Oak Ridge National Laboratory, ORNL). CHE then prepared a draft of this document that was discussed with the chemistry representatives of the MPS-AC in November 2007. A revised draft was posted on the web for public comment in early 2008 and it will be presented at a Town Hall forum at the National Meeting of the American Chemical Society in New Orleans April 7, 2008. Acknowledgements are found in Appendix II.

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<sup>6</sup> [http://science.house.gov/legislation/leg\\_highlights\\_detail.aspx?NewsID=1938](http://science.house.gov/legislation/leg_highlights_detail.aspx?NewsID=1938)

<sup>7</sup> [http://www.nap.edu/catalog.php?record\\_id=11463](http://www.nap.edu/catalog.php?record_id=11463)

<sup>8</sup> [http://books.nap.edu/catalog.php?record\\_id=11866](http://books.nap.edu/catalog.php?record_id=11866)

<sup>9</sup> <http://www.nsf.gov/statistics/nsb0803/nsb0803.pdf>

## Executive Summary

The **mission** of the NSF Division of Chemistry (CHE) is to support innovative research in chemical sciences, integrated with education, through strategic investment in developing a globally engaged U.S. chemistry workforce reflecting the diversity of America.

We **envision** NSF CHE as:

1. A global leader in transforming chemical discovery and innovation, while advancing chemistry education, literacy and America's competitive edge.
2. Encouraging chemists to lead multi-disciplinary efforts that expand humanity's knowledge and address short- and long-term societal problems.
3. A major voice in the communication of the value of chemistry to the public.
4. Comprised of outstanding staff dedicated to the vitality of the field of chemistry.

Reflecting our **values** we believe in:

1. The importance of fundamental scientific research for the benefit of society.
2. Empowering future generations in science and engineering.
3. Maintaining the highest standards of integrity and ethical behavior.
4. Fairness, openness and clear communication.
5. Diversity of the scientific workforce and broadening participation in all CHE activities at all levels.

This report identifies eight "Critical Issues" for the Division of Chemistry. These issues were developed from extensive community input.<sup>10</sup> For each critical issue, we have identified goals, objectives and examples of tactics that we can undertake. The issues are ranked in priority order.

- 1. Advancing American Competitiveness:** Our goal is to sustain and enhance our traditional strengths in fundamental research while furthering innovation and the intellectual exchange between U.S. academia and industry. One objective is to provide leadership to the community in identifying and promulgating industry/university collaboration mechanisms that work. We will partner with educators to spur curricular innovation that better prepares students to become innovators, entrepreneurs, and/or industrial chemists.
- 2. Communication:**
  - (i) Communicating the Value of Chemistry to the Public:** Our goal is to get the public excited about chemistry as a means to attract the best and brightest students and to garner public support for the discipline. We will partner with the NSF Office of Legislative and Public Affairs (OLPA), scientific professional societies and other groups to find pathways to engage major media to promote the value of chemistry

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<sup>10</sup> An analysis based on external and internal feedback of the Strengths, Weaknesses, Opportunities and Threats (Barriers) of the Division of Chemistry with respect to the NSF's four strategic goals – Discovery, Learning, Research Infrastructure and Stewardship - is provided in Appendix I.

- (including existing shows such as CBS's CSI, PBS's NOVA and Discovery Channel's Mythbusters). We will better engage our awardees by showcasing and publicizing the results of their NSF-funded work through various venues such as the NSF website and press releases.
- (ii) **Articulating the Impact and Importance of Chemical Research:** Our goal is to increase support for chemical research by articulating various opportunities and national needs. We will raise awareness of the benefits that accrue from CHE funding, especially research results that have an obvious and direct impact on important societal problems and economic opportunities.
- (iii) **Improving our Interface with the Chemistry Community:** Our goal is to deliver information about CHE programs and activities to our community in the most thorough, efficient and effective manner possible. We will improve the use of both electronic and in-person formats through websites, newsletters, town halls and "cyber-visits" to chemistry departments.
3. **Increasing Global Engagement:** CHE has the opportunity to enable U.S. academe and international partners to work more closely where appropriate to benefit the U.S. and the vitality of the chemistry discipline. The competition for leadership in chemistry is increasing due to large investments by other countries. CHE will work to increase the global engagement of the U.S. chemistry community, especially encouraging U.S. students to go abroad for part of their study, and ensure that the U.S. is the most attractive destination for chemists. We will partner with the NSF Office of International Science and Engineering (OISE), professional societies and other federal agencies to promote international collaborations through workshops, interactions with international centers and organizations, and increasing the reach and size of CHE's International Collaboration in Chemistry program. We will provide strong support for U.S.-based fellowships, facilities and instrumentation (especially remotely accessible instrumentation) and advocate international use as a means of attracting students to the U.S.
4. **Increasing Grand Challenge Research through Centers:** CHE's new Centers for Chemical Innovation Program (CCI) represent a new mode of funding to support transformative basic chemical research on "grand challenges." CHE will support the strongest chemistry projects and provide the opportunity for chemists to form centers. The CCI program will hold centers to an accountable, responsible, rigorous assessment of progress to ensure that the whole is greater than the sum of the parts. The Division is sensitive to the community's concern about preserving the single investigator "core." We will study grant size, duration and number of grants for the CHE portfolio in general and optimize the mix to make the best possible investments to enable transformations in the field of chemistry.
5. **Broadening Participation (gender, race, ethnicity, disability status):** Our goal is to be a leader in increasing the pool of under-represented groups among the chemistry faculty and, thereby, the pool of potential NSF Principle Investigators. We will develop fellowship programs, broadening participation plan requirements for centers and Departmental proposals, leadership awards and outreach. We will continue to work to

make the review process equitable by monitoring aggregate demographic data and training Program Officers in diversity. We will partner with the NSF Directorate for Education and Human Resources (EHR) programs and professional societies to clearly communicate broadening participation guidance and best practices through a website and presentations.

- 6. Addressing Funding Needs of Investigators Across Career Stages:** The community raised a concern about possible under-representation of Mid-Career Faculty (10-25 years post-PhD) proportionate to the pool. While funding the best science, we will pay attention to the inclusion of Principal Investigators (PIs) across all career stages from beginning to mid-career to well-established. We will accomplish this by ensuring that the CHE awardee population is not biased towards any particular stages of career, and by investing in potentially transformative research (PTR). We believe that mid-career faculty are especially well-positioned to advance such research. We will also provide opportunities for PIs who are unfunded to re-establish chemical research efforts.
- 7. Broader Impacts -- Assessing the Impact of this Review Criterion:** We will better assess broader impacts activities in our awards, including broadening participation. We will develop an assessment plan for the broader impacts of CHE-supported activities, focusing first on a limited set of questions.
- 8. Updating the Division of Chemistry Structure:** Our goal is to structure CHE to best anticipate and respond to scientific needs and to achieve transformative research in chemistry. The initial objective is to map the disciplinary structure within CHE with tools such as keyword frequency as a guide for consideration of a new CHE structure. We will also streamline co-review within CHE and across Divisions and Directorates for proposals falling at the intersection between programs. Major changes proposed to the Division's structure will be thoroughly vetted.

## Critical Issues Discussion

**1. Advancing American Competitiveness:** How can CHE work to close the gap between academe and industry so as to further innovation and increase the effectiveness of our investments in basic research?

The Council for Chemical Research report “Measure for Measure: Chemical R&D Powers the U.S. Innovation Engine”<sup>11</sup> spells out the case for investing in basic research in chemistry, yielding multiple benefits for the country including a higher standard of living, higher Gross Domestic Product, more jobs and increased tax receipts. “By maintaining strength in a variety of basic research fields,” states a 1993 National Science Board (NSB) report,<sup>12</sup> “we will be positioned to benefit from the breakthroughs made by investigators in other parts of the world.” Recent trends include exportation of industrial chemistry research, manufacturing, and funds to other countries. In addition, an NSB report in 2008 states, “The stagnation in industry support for its own basic research in this century, together with the current decrease in support of academic R&D and basic research by the Federal Government could over time have severe implications for U.S. competitiveness in international markets and for highly skilled and manufacturing jobs at home.”<sup>9</sup> This report also notes that the net economic effects on the Nation and on industry of the offshoring are not yet well understood.

At the 2006 Workshop on Enhancing Competitiveness<sup>13</sup> sponsored by NSF, NIH, the National Institute of Standards Technology (NIST), and led by Dr. Mark Wrighton, in response to ACI, it became clear that there is a major obstacle in the cooperation of industry and U.S. academic institutions: the difficulty in reaching agreements on intellectual property (IP). This is born out by the low proposal submission rate to the NSF Grant Opportunities for Academic Liaison with Industry (GOALI) program, which requires an IP agreement. The 2008 NSB report notes, “Academic researchers, primarily supported by Federal funds, are now likely to have less available funding and to be considerably less aware than previously of the major research challenges that face U.S. industry and industrial competitiveness. Further, with fewer industry researchers focusing on basic research, a company may be unable to readily tap into the expertise and facilities of the university community.”<sup>9</sup> These are lost opportunities for advancing innovation and for the education of U.S. students. CHE has the opportunity to enable academe and industry to work more closely where appropriate to benefit U.S. taxpayers.

Under the America COMPETES Act, it is the intention of Congress to double the NSF budget over the next 7 years. The proposed doubling of NSF funding explicitly acknowledges the critical investment represented by fundamental research in the physical sciences.

**Goal:** Sustain and enhance our traditional strengths in fundamental research while furthering innovation and the intellectual exchange between U.S. academia and industry.

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<sup>11</sup> <http://www.ccrhq.org/search/index.html>

<sup>12</sup> <http://nsf.gov/nsb/documents/1993/nsb93127/nsb93127.htm>

<sup>13</sup> <http://enhancinginnovation.wustl.edu/>



Objective 1: Provide leadership to the community in identifying and promulgating successful industry/university collaboration mechanisms.

Tactic 1: Convene "summit conferences" to identify points of contention and routes to productive resolution of IP issues in the chemical and pharmaceutical communities.

The GOALI program provides opportunities to integrate research in a manner consistent with the modern reality that most chemistry students are heading toward industrial rather than academic careers.

Tactic 2: Enhance the community's knowledge about and participation in GOALI collaborations. Triple the number of GOALI proposals in CHE within the 5-year planning period, with a concomitant increase in supported awards (consistent with proposal merit) beyond the current average of three awards per year.

One of the challenges advanced by our COV was better utilization of industrial scientists as reviewers and advisors. This can be difficult, because industrial scientists are sometimes actively discouraged due to potential conflicts derived from access to intrinsically "proprietary" information. In its 2008 report, the NSB recommends that "industry researchers should also be encouraged to participate as authors and reviewers..."<sup>9</sup>

Tactic 3: Consistently explain to the community as a whole the mutual benefits of involvement of industrial colleagues in research prioritization processes, and actively recruit reviewers and rotators from industry.

Tactic 4: Enhance participation by industrial chemists in technical workshops as a means of fostering collaborations and other interactions.

Tactic 5: Explore new mechanisms of interaction between academia and industry.

The majority of chemistry majors have little exposure to the industrial environment and culture. Earlier exposure to industrial careers and acknowledging the value and excitement of these careers are needed to provide industry with the top-notch job candidates they need to compete.

Objective 2: Encourage curricular innovations that better prepare students to become innovators, entrepreneurs, and/or industrial chemists.

Tactic 1: Encourage industrial partnerships in Undergraduate Research Collaboratives (URCs), Research Experiences for Teachers, and Research Experiences for Undergraduates (REU).

Tactic 2: In collaboration with educators and the Directorate for Education and Human Resources (EHR), work for chemistry curricular innovation that introduces students to industrial and entrepreneurial culture. This effort could begin with a joint workshop.

There are good models of innovation mechanisms that CHE can publicize. Our colleagues in the Engineering Directorate actively stimulate industry/university partnerships through the

Industry/University Cooperative Research Centers program. In addition, there are the three-way industry/university/government partnerships through the cross-directorate program Partnerships for Innovation.

Tactic 3: Encourage the inclusion of industrial partners (organizations and individuals) in Centers for Chemical Innovation, collaborative proposals and other programs, with concomitant benefits of enhanced innovation and commercialization opportunities, educational perspectives through bidirectional visits, and leveraged industrial funding.

## 2. Communication

### (i) Communicating the Value of Chemistry to the Public

The discipline of chemistry is central to many sciences, technology and our quality of life; however, it also suffers an image problem world-wide. The public generally thinks of “chemicals” as pollutants or toxins rather than the matter that comprises the world and life. CHE can communicate better that chemistry is not only the central science, but is the essential science for addressing important questions and challenges related to new products, technology, energy and the environment. Science literacy and a better public image of chemistry would help attract the best and brightest students including those from under-represented groups. This would also help the field attract better support through public funds.

**Goal:** Increase public knowledge and appreciation of chemistry as a means to attract the best and brightest students and to garner public support for the discipline.

**Objective 1:** Improve the human face of chemistry: find pathways to engage major media to promote the value of chemistry.

Tactic 1: Work with the Directorate for Education and Human Resources (EHR), the NSF OLPA and professional societies to engage film, web, radio and television producers to raise awareness of chemistry. Consult with the Division of Research and Learning to better understand the process, precedents, and pitfalls in working with the PBS NOVA series and possible participation by CHE. PBS and NOVA are very effective at emphasizing the “human face” of chemical research, which is consistent with NSF’s strategic plan.

Tactic 2: Partner with entities that have access to many students (for example, the Educational Testing Service) to advertise chemistry careers to students. While we need the general public to value chemistry’s role in their lives, it is also true that we need to attract the best and brightest into the field, including those from under-represented groups. It would also be valuable to present chemistry as a viable discipline of study to launch other careers such as in medicine, law and science policy.

**Objective 2:** Improve the effectiveness of CHE awardees’ public education activities, including better publicizing the results of their NSF-funded work.

One benefit of increasing the number of centers in our portfolio is that each will have a clear charge to engage the public. OLPA can provide valuable guidance in these public education

activities, helping us to work with awardees' Public Information Officers to identify newsworthy stories.

Tactic 1: Enlist OLPA's assistance in reviewing awardees' public education activities, especially in regards to center-based activities.

Tactic 2: Encourage awardees to employ web media-savvy students to document and publicize interesting research and education activities. This is a potentially very inexpensive but large impact activity that could take advantage of social computing (e.g., YouTube.com). CHE should consider providing supplements for these projects. PIs should be encouraged to improve the chemistry content on wikis aimed at the public.

The CHE Discovery Corps Fellowship Program (DCF) began in 2004 to promote the integration of research and professional service. The community has interpreted "service" in a variety of helpful ways resulting in a broad spectrum of activities.

Tactic 3: Given the importance of public education, CHE should consider changing the scope of the DCF program to one that specifically integrates research and public chemistry education.

## **(ii) Articulating the Impact and Importance of Chemical Research**

Chemistry is vital to the U.S. economy: the Council for Chemical Research (CCR) "Measure to Measure" report<sup>11</sup> states that chemical technology is core or important in all 15 classes of industry (Automotive, Biotechnology, Chemicals, Computers and Semiconductors, Electrical and Electronics, Energy, Engineering, Food, Forest, Health Care, Instruments and Optical, Materials, Metals and Mechanical, Pharmaceuticals and Telecommunications). No other technology comes close. In the last 15 years, despite only inflationary annual increases<sup>14</sup> to CHE's budget, tremendous success has occurred in chemical research. During that time, the field of chemistry has given birth to major discoveries ranging from buckyballs, single molecule conductance and nanotechnology, to an array of new drug chemistries. The field has moved from a focus on investigations of atoms and molecules to the study of self-assembly of chemical systems that can produce larger-scale emergent effects. During this 15 year period, the number of CHE proposals has increased 52%. Meanwhile, the average funding rate has fallen from 40% to 26%, as the Division's budget has been significantly outpaced by rising research costs. Key infrastructure for chemical research on campuses, including laboratories, instrumentation, computers and technical support staff, is often aging or lacking.

In order to realize the future promise of chemistry to master energy from the sun, solve global climate issues, surpass Moore's Law for information storage, increase green manufacturing, and understand biological and environmental processes, strong investments in the fundamental research supported by CHE must continue.

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<sup>14</sup> Since 1980, the CHE budget has grown with the Pharmaceutical Manufacturing Price Index, which is somewhat higher than the Biomedical Research Price Index.

Under the America COMPETES Act, it is the intention of Congress to double the NSF budget over the next 7 years. How can we better articulate the high value of the current research (including that with a long-term horizon) that is being done and involve the community more?

**Goal:** Make the case for an increase in support for chemical research by articulating various opportunities and needs.

**Objective 1:** Raise awareness of the successes of our funding, especially research results which have an obvious and direct impact on important societal problems and opportunities.

Tactic 1: Fund a series of high level workshops to consider the role of the discipline of chemistry in finding solutions to important societal problems. An excellent focus is global climate change, which is occurring because of complex chemical processes in the atmosphere and ocean. More important than the cause of global climate change, though, is the fact that any viable solution to this problem will, by necessity, require the expertise of chemists. The publication of the resulting workshop reports would help to raise the profile of chemistry as a discipline and make a strong case for increased basic research in the area.

Tactic 2: Replace CHE's current annual divisional report, which has very limited circulation, with a professionally-produced brochure. This brochure would summarize our annual accomplishments and spotlight important research results through articles written at the *Scientific American* level. These brochures would be distributed widely to the chemistry community as well as to various agencies and societies with overlapping interests. We would ask OLPA to partner with us as we begin planning this brochure.

Tactic 3: With OLPA, organize a high-profile event for the National Mall or Capitol Hill briefings that would draw attention to the accomplishments of the chemistry discipline and the importance of chemistry in daily life. Several recent events, including one on solar energy and other green technologies, show that this type of event generates press attention that reaches the general public.

Tactic 4: Encourage professional societies and other groups to talk with the chemistry community about opportunities and needs in supporting chemical research - perhaps at meetings or outreach visits. An important aspect is to find opportunities to talk directly to graduate and undergraduate students about the source of their NSF support. One way to reach students would be to request a separate meeting with them during site visits or outreach visits.

Tactic 5: Hold PI workshops in the Washington DC area to improve networking among PIs, especially junior investigators. Devote part of these workshops to the education of the PIs on the importance of highlights and press releases about their research. Staff from OLPA would be invited to participate and to help train PIs on the effective conversion of technical research results into compelling stories of discovery. OLPA staff can accompany a PI to Capitol Hill to meet with Congressional staff and Members from the PI's state and district. The purpose of such visits is to share news about the PIs' discoveries and to educate the legislators about scientific research in their jurisdictions.

**(iii) Improving our Interface with the Chemistry Community:**

In recent years the Division has utilized electronic means to enhance communication with the U.S. academic chemistry community. The Division of Chemistry website<sup>15</sup> is updated with program announcements, Dear Colleague Letters, workshop reports and other reports. There are links to pages dedicated to topics the Division is attempting to promote, such as Small Grants for Exploratory Research, Cyber-Enabled Chemistry, National Laboratories and User Facilities, International Activities, and Merit Review/Broader Impacts. Electronic mail is also sent directly to the chemistry community by the Division. The “CHE-COMM” email list includes all PIs who have submitted proposals in the past 7 years, roughly 9000 in number, plus anyone who requests to be included. This email list is used sparingly but effectively, with 2 newsletters per year (before each National American Chemical Society Meeting), Dear Colleague Letters and several “Funding Opportunities” notices as new NSF program solicitations of interest to the community are released. The Division has held semiannual open Town Halls at the National Meetings of the American Chemical Society for the past several years. These are advertised through the website, email and full-page advertisements in C&E News. The Division is initiating “cyber-visits” with chemistry departments across the country, allowing formal and informal interactions among faculty and the CHE staff. Even with these recent improvements in outreach to the community, the job of communication remains a challenge.

**Goal:** Deliver information about CHE programs, processes, issues and activities to the community in the most thorough, efficient and effective manner possible.

Objective 1: Use electronic formats more effectively to improve communication.

Tactic 1: Improve the Division Newsletter and the format in which it is conveyed. Improving the format with color photos and including scientific news of NSF-supported work will make the Newsletter of more interest and utility to the community.

Tactic 2: Include PowerPoint and video presentations on the website to more effectively inform the community of issues and trends in funding, as well as the research results and broader impacts of CHE investments.

Objective 2: Use in-person formats more effectively to improve communication.

Tactic 1: Increase the profile of the CHE Town Halls, and combine with symposia formats for more in-depth discussion of issues of concern to the community.

Tactic 2: Increase the use of “cyber visits” to departments and meetings to supplement Program Officer travel by several per year.

**3. Increasing Global Engagement**

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<sup>15</sup> <http://www.nsf.gov/div/index.jsp?div=CHE>

The National Science Board report “International Science and Engineering Partnerships: A Priority for U.S. Foreign Policy and Our Nation’s Innovation Enterprise”<sup>16</sup> recommends coinvesting in basic research across borders. The report states, “Advances in science and engineering that improve the human condition will increasingly depend on the ability to draw upon the best minds regardless of national borders.” CHE has the opportunity to enable U.S. academe and international partners to work more closely where appropriate, to benefit the U.S. and the vitality of the chemistry discipline through the flourishing of the best ideas and the free flow of information.

At the NSF, the OISE is an interface for NSF’s directorates, offices, divisions, and programs with multi-national organizations, international science organizations, and national funding agencies and ministries in other countries. The three overseas Offices in Paris, Tokyo, and Beijing foster closer linkages with national agencies in the Europe and Eurasia and the East Asia- Pacific regions. OISE is an invaluable partner as CHE forms its international strategy. Challenging issues beyond CHE but manageable with the help of OISE include: intellectual property protection, export controls, common research integrity values and foreign bureaucratic overhead.

As pointed out in the NRC report “The Future of U.S. Chemistry Research: Benchmarks and Challenges,”<sup>17</sup> there is a decreasing U.S. share of Science and Engineering (and Chemistry) journal articles, and the competition for leadership in chemistry is increasing due to large investments by China, India, Japan and other countries. Some policies implemented after the September 11<sup>th</sup> attacks have provided obstacles or perceptions of obstacles for attracting the best students and postdoctoral fellows to the U.S. to study chemistry. Other developed countries are attracting researchers from abroad through handsome startup packages and fellowships. The Benchmarking report states, “...more foreign students who obtain a U.S. Ph.D. are likely to return to careers in their native country or to other opportunities abroad.” While NSF grants provide support for foreign students and postdoctoral fellows at U.S. institutions, the NSF has limited funding for other foreign collaborators. CHE should be proactive about global engagement so as to maximize the benefits of international cooperation for the chemistry community and ensure that the U.S. is the most attractive and competitive destination for chemists.

Among existing NSF programs targeting international collaboration, the recent CHE program “International Collaboration in Chemistry” (ICC) has successfully coupled U.S. researchers with researchers in Germany, the United Kingdom and China. There is a coordinated review of a joint proposal, and upon joint recommendation, the partner funding agency funds the foreign side, and CHE funds the U.S. side. This program can address important CHE goals, while providing opportunities to integrate research and education in a manner consistent with the modern reality that most chemistry students are heading toward global careers.

**Goal:** Increase global engagement of the U.S. chemistry community, especially U.S. students going abroad, and ensure that the U.S. is the most attractive destination for chemists.

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<sup>16</sup> [http://www.nsf.gov/nsb/publications/2007/draft\\_isep\\_nsb0710.pdf](http://www.nsf.gov/nsb/publications/2007/draft_isep_nsb0710.pdf)

<sup>17</sup> [http://www.nap.edu/catalog.php?record\\_id=11866](http://www.nap.edu/catalog.php?record_id=11866)

Objective 1: Provide leadership to the community in identifying and promulgating successful international collaboration mechanisms.

Tactic 1: Make a world map showing current CHE activity (research collaborations, conferences, joint awards, etc.) and publicize it.

Tactic 2: Partner with OISE, other agencies and professional societies to support workshops to provide leadership in establishing ties with strategically chosen countries, perhaps in strategic scientific areas.

Tactic 3: Enhance participation in international collaborations by creating a chemical research world network of partnering agencies who share the CHE vision of a joint proposal-joint review-joint funding recommendation-parallel funding model. CHE will aim to expand the ICC Program to foreign agencies in countries at the forefront of chemical research like Japan, France, Spain, India, Brazil, Russia, Chile, and Argentina. CHE will also partner with other foreign agencies who express interest in joining the ICC network. CHE envisions doubling the number of ICC proposals within the 5-year planning period, with a concomitant increase in supported awards (consistent with proposal merit) beyond the 2007 level of 20 awards. CHE will also encourage CHE PIs to form relationships with international centers, such as the new Japanese World Premier International Centers, by providing supplementary funds to existing awards.

Tactic 4: Intensify efforts to develop contacts with chemistry colleagues worldwide. Employ rotators and Program Officers that have significant international experience and contacts. Continue to partner with international chemistry organizations such as the International Union of Pure and Applied Chemistry (IUPAC) and Chairmen of the European Research Councils' Chemistry Committees (CERC3); also the International Committees of professional societies such as the American Chemical Society.

Objective 2: Attract and retain the best and brightest chemistry students to the U.S. by providing the best graduate and postdoctoral experiences.

Tactic 1: Provide strong inducement for excellence in graduate and postdoctoral research associated with CHE grants by fully funding research fellowships within unsolicited proposals.

Tactic 2: Provide strong support for facilities and instrumentation (especially remotely accessible instrumentation) and advocate international use.

#### **4. Increasing Grand Challenge Research through Centers**

Since its first annual budget in 1952, the Division of Chemistry has funded largely single investigator grants. Many NSF Divisions and indeed, other sister agencies offer center programs. The proportion of funds devoted to centers varies by disciplinary culture and agency mission. Within the Mathematical and Physical Sciences Directorate, the Division of Mathematical Sciences expends 9% of its funds on Institutes. In the Division of Materials

Research, the Materials Research Science and Engineering Centers (MRSECs) form 25% of the budget. The Division of Physics invests 10% in centers. Centers function well for the mission agencies and many divisions of DOE, NIH and the Department of Defense offer them. Recent successes such as those funded by the Nanoscience and Technology Initiative and other NSF Initiatives have proved that the center mode of funding has great potential in chemistry.

Centers can tackle complex scientific problems that require interdisciplinary approaches. They are excellent environments to cross-train students – employers need students who are team players, do-ers and problem solvers. Centers also provide a highly visible focus that can promote chemistry in general. CHE's new Centers for Chemical Innovation Program (CCI) represent a new model and mode of funding to support transformative basic chemical research on "grand challenges." The CCI Program was initiated as a pilot in 2004 (under the name Chemical Bonding Centers) with several ambitious goals: to support high risk, transformative science; to energize the chemistry research community to tackle grand challenges; and to creatively engage the public. The name change to Centers for Chemical Innovation reflects the addition and emphasis of innovation as a key feature of the scientific outcomes expected from these centers.

The Division is sensitive to the community's concern about preserving the single investigator "core" but believes that increasing the number and nature of centers is important, both to provide strong scientific synergism and to increase the Division's ability to increase its funding level. Increasing the number of chemistry centers will only be considered in the context of budget growth.

**Goal:** Support the strongest chemistry projects, and provide the opportunity for chemists to form centers.

**Objective 1:** Ensure that CHE can support the strongest projects, regardless of modality (research project or center). Hold all awards to high expectations of performance and accountability.

Tactic 1: Study closely the balance of funding modalities. It will be ultimately determined by proposal pressure, quality and success, and thus by the chemistry community.

Tactic 2: Include assessment of the CCI Program from the beginning, possibly hiring an external expert. Identify key markers or characteristics of highly synergistic projects and include these indicators in program assessment.

The 2007 NSF report entitled "The Impact of Proposal and Award Management Mechanisms"<sup>18</sup> states, "NSF should require that each of the directorates and research offices develop an overarching framework that accounts for and balances all of their research-related activities to help guide strategic planning when determining the appropriate balance between funding rates and award size for particular solicitations or more broadly across the unit. The framework should incorporate flexible management approaches that enable the

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<sup>18</sup> [http://www.nsf.gov/news/newsmedia/IPAMM\\_Report\\_Final.pdf](http://www.nsf.gov/news/newsmedia/IPAMM_Report_Final.pdf)



directorates/offices to track and respond to developments that are most relevant to their communities, including the growth of collaborative interdisciplinary research activity.”

Objective 2: Make the best possible investments to enable transformations in the field of chemistry.

Tactic 1: Consider funding a study by experts on the tradeoffs between grant size, duration and number of grants, including factors such as risk and potential high impact. Optimize the mix to make the best possible investments to enable transformations in the field of chemistry.

Tactic 2: Remain open to creative new funding modalities.

## 5. Broadening Participation (gender, race, ethnicity, disability status)

CHE notes a steady increase of female PIs and coPIs from 1993 to present, from 10% of awardees to 18%, with 18% being approximately representative of all U.S. chemistry faculty at present.<sup>19</sup> This rate of increase, however, predicts parity (51%) in 50 years, an undesirably slow rate of change. For under-represented racial and ethnic minorities (URM), the representation in the chemistry faculty is 7.1%; the proportion of CHE awards is below this figure and the increases have been dishearteningly small, from 4% of awardees in 1993 to 5.3% of awardees at present. The challenge for CHE is to help increase the pool of under-represented groups engaged in chemistry research and submitting proposals to NSF. The Division has been very committed to this endeavor already, having written a “Plan for Broadening Participation in Chemistry” in 2006,<sup>20</sup> in which we state aspirations for broadening participation among CHE panelists, reviewers, workshop participants, Program Officers, and Committees of Visitors. The Division (with NIH-National Institute of General Medical Sciences and DOE-Basic Energy Sciences) also supported two major workshops on equity in chemistry departments -- one on gender in 2006<sup>21</sup> and one on racial and ethnic minorities in 2007.<sup>22</sup> CHE is planning a Workshop on Scientists with Disabilities in 2008. We have already adopted some of the recommendations from the Gender Equity Workshop: as part of the orientation for panelists, CHE Program Officers discuss the issue of implicit bias in peer review; and the CHE CRIF multi-user program now requires a departmental Broadening Participation plan. An NSF-wide Working Group on Broadening Participation has been formed, and we have adapted some of their early recommendations here.

**Goal:** CHE will be a leader in increasing the pool of under-represented groups in chemistry (including female, racial and ethnic minorities, and persons with disabilities).

**Objective 1:** Broaden participation of under-represented faculty members in chemistry departments, especially under-represented racial and ethnic minorities, given the current wide shortfall from parity.

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<sup>19</sup> <http://www.nsf.gov/statistics/doctoratework/>

<sup>20</sup> <http://www.nsf.gov/pubs/2007/nsf07021/nsf07021.pdf>

<sup>21</sup> <http://www.chem.harvard.edu/groups/friend/GenderEquityWorkshop/>

<sup>22</sup> <http://chemchairs.uoregon.edu/>

Tactic 1: Develop a fellowship program for encouraging chemists to proceed from the BS to PhD to postdoc to faculty, with a goal of broadening participation.

Tactic 2: Require a plan for broadening participation in departmental and center proposals and consider supplements to fund the activities. Provide workshops and other outreach to assist departments in developing these plans.

Tactic 3: Engage in outreach activities, encourage mentoring, and support periodic workshops and other endeavors to encourage students to pursue academic careers in chemistry and to encourage PIs from under-represented groups to submit competitive proposals.

Tactic 4: Consider a “leadership” award (similar to the previous ADVANCE Leadership Award)<sup>23</sup> for individual PIs who have performed outstanding work in service of this goal.

Objective 2: Continue efforts to make the review process equitable.

Tactic 1: Continue to educate the community about the research on implicit bias.

There are many laws regulating the obtaining, storing and reporting of demographic data. The lack of demographic data in agencies hinders the analysis of workforce and equity issues.

Tactic 1: To the extent possible, annually monitor and publicly report on aggregate demographic data concerning CHE proposals and awards, as well as panelists, reviewers and Program Officers.

Tactic 2: Continue to recruit new reviewers, especially from under-represented groups so as to not overtax the proportionately few that are already providing reviews. The website for recruiting reviewers<sup>24</sup> should be advertised through websites and print media and the community should be educated about the importance of self-reporting their demographic data.

Tactic 3: Provide training for CHE staff about diversity issues in general, as well as NSF policies and priorities. Incorporate broadening participation efforts as a performance indicator in program staff and management performance plans. Update and report data on the Division’s Plan for Broadening Participation annually.

Objective 3: Clearly communicate broadening participation guidance and best practices.

Tactic 1: Establish a website for the CHE community dedicated to broadening participation in chemistry. Partner with the professional societies and the NSF EHR programs such as such as ADVANCE, Research in Disabilities Education, Tribal Colleges and Universities Program, Historically Black Colleges and Universities Undergraduate Program and Research on Gender in Science and Engineering to share

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<sup>23</sup> The program was NSF 01-107 (website no longer available).

<sup>24</sup> [http://www.nsf.gov/mps/che/reviewer/reviewer\\_info.jsp](http://www.nsf.gov/mps/che/reviewer/reviewer_info.jsp)

best practices, and showcase broadening participation highlights resulting from funded work.

Tactic 2: Include broadening participation issues in presentations at professional society meetings and outreach visits, newsletters, etc.

## 6. Addressing Funding Needs of Investigators Across Career Stages

Concerns about Mid-Career Faculty (MCF, 10-25 years post-PhD) arose many times from our survey of the chemistry community. CHE has one of the highest levels of participation in the CAREER program, which is aimed at pre-tenure faculty. Some in the community are concerned that there is an overemphasis on bringing people into the funding pool but not sustaining them. Many mid-career scientists have well-equipped laboratories, honed mentoring skills, and are positioned to take risks after tenure. However, these opportunities may not have been capitalized on, discouraging not only the PIs but their junior colleagues and students from continuing or pursuing academic careers. Support for scientists across career stages is a nexus for proper balance and distribution of CHE's funds. Retraining opportunities, Creativity Extensions (CREX's), Small Grants for Exploratory Research (SGERs), international opportunities, liaisons with industry, use of national facilities, and participation in collaboratories or centers are all exciting possibilities for scientists at all levels, but may be of particular utility for MCFs.

According to the NSF Science and Engineering Indicators (2006)<sup>25</sup>, in 1973, approximately 25-30% of science and engineering faculty were within ten years of their doctoral degree. By 2003, the number of pre-tenure faculty in science and engineering decreased to approximately 10%, and a number of funding agencies had initiated programs to encourage beginning faculty in their research and teaching careers. In 1994, the NSF CAREER Program was designed to encourage pre-tenure faculty by providing prestigious awards with the aim of integrating research and education. With current start-up packages at many universities approaching \$500,000 per faculty member in chemistry, some in the community question the increasing CHE funding for the CAREER Program.

**Goal:** Effectively engage Principal Investigators (PIs) across all career stages from beginning to mid-career to well-established.

**Objective 1:** Study the CHE portfolio with the goal of better understanding the representation of faculty at various stages of careers.

Tactic 1: Evaluate the CAREER Program as it is carried out in CHE to determine its impact in developing Assistant Professors into tenured, Associate and/or Full Professors with sustained research and educational programs. The CAREER Program investment by CHE will be evaluated in terms of faculty need and assessed in terms of its impact on beginning faculty. The current NSF-wide study of the CAREER Program will be particularly helpful in this regard.<sup>26</sup>

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<sup>25</sup> <http://www.nsf.gov/statistics/seind06/>

<sup>26</sup> In progress.

Tactic 2: Evaluate the CHE portfolio considering the pool of potential PIs that are available nationally, not just those that apply. Are there patterns at various career levels that are of concern?

Tactic 3: Engage other funding agencies in discussions regarding new or changing programs impacting faculty at various stages of their careers. Program Directors from other agencies with a stake in the CHE community will be invited to share and discuss information on new and continuing initiatives.

The “America COMPETES Act”<sup>6</sup> directs federal agencies funding research in science and technology to dedicate an appropriate percentage of their research and development budgets toward frontier research. The NSF has recently revised the Proposal Merit Review criterion for Intellectual Merit to include the phrase, “To what extent does the proposed activity suggest and explore creative, original, or potentially transformative concepts?”<sup>27</sup>

Unlike beginning faculty who must publish an extremely high pace in order to achieve tenure, mid-career faculty often have the opportunity to engage in potentially transformative research. The success of the America COMPETES Act (HR 2272) in making the United States more internationally competitive in innovative science and engineering depends on our ability to guide and engage these experienced researchers in frontier research integrated with education.

Objective 2: Effectively invest in potentially transformative research, drawing especially on the MCF pool who are ideally situated for this type of research.

Tactic 1: Engage MCF in a “Transformative Research” Workshop and other activities demonstrating previous successes and promoting entrepreneurial behavior.

Tactic 2: Utilize available programs focused on PTR (e.g. SGERs and CREX’s) and encourage transformative research in unsolicited proposals.

It can be difficult for anyone who has taken even a short leave from academic research (administrators, industrial chemists, family caregivers, etc.) to re-enter the profession due to the accelerated pace of methods and instrument development, the exponential growth of chemical literature, and the constant evolution of new and interdisciplinary fields (e.g., nanoscience, sustainability and complexity). In order to obtain the broadest participation from the chemistry community and to capitalize on training investments already made, unfunded faculty must have opportunities to restart their research efforts.

Objective 3: Provide opportunities to PIs who are unfunded to re-establish chemical research efforts.

Tactic 1: Increase the number of CHE-supported awards to MCF who are “re-establishing” chemical research efforts by 1-2 investigators per program per year from 2008 to 2012 (considering that each year approximately 50 new awards are made in each program, this

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<sup>27</sup> <http://www.nsf.gov/pubs/2007/in130/in130.jsp>

represents a 2-4% effort.) This funding would be specifically directed towards unfunded faculty who wish to enter a new area of research. Program Officers should be empowered to make these choices in the context of their regular programs in the interest of program vitality. This type of proposal could be strengthened by strong Departmental / University support and could provide any or all of the following: sabbatical support, retraining support, instrument replacement / refurbishment, postdoctoral fellows with new expertise, resources to establish a collaboration with a national laboratory, and an extended (4-5 year) grant period.

Tactic 2: Provide incentives to PIs who lead centers to include mid-career faculty (not otherwise funded) in their research and/or teaching programs. This might be modeled after Research Opportunity Award (ROA) supplements.

## 7. Broader Impacts – Assessing the Impact of this Review Criterion

The review criteria used for all NSF proposals were revised by the National Science Board in 1997 to include Broader Impacts in addition to Intellectual Merit.<sup>28</sup> Since then, NSF has tried to clearly describe “what Broader Impacts are” and to convey a sense of how this review criterion is used in funding decisions. Some of the CHE efforts include a 2002 Dear Colleague Letter,<sup>29</sup> a Broader Impacts Poster Session at the 2005 ACS Meeting, and the inclusion of a number of examples of possible broader impact activities in presentations to the community. We perceive that there are some measurable positive outcomes from the Broader Impacts criterion, such as the increasing number of women with active CHE awards. However, we do not have a formal assessment. With an external expert, we are conducting a preliminary assessment of the recently instituted broadening participation plan requirement in the Chemical Research Instrumentation and Facilities (CRIF) Program. This will provide an assessment of one aspect of Broader Impacts.

The conversation about Broader Impacts is changing from “what are they” to “how do we track and assess them?” Both our PI community and Congress are now asking us to not only *describe* Broader Impacts, but also to *evaluate* and *assess* them (see for example, Sec. 7022 of HR 2272, the America COMPETES Act).<sup>6</sup>

**Goal:** Assess the Broader Impacts activities in our awards, including broadening participation.

**Objective 1:** Deepen our understanding of Broader Impacts (both descriptive and evaluative), focus on CHE’s objectives, and convey the key points of our thinking to PIs and reviewers.

Tactic 1: Continue CHE efforts to effectively *describe* Broader Impact activities to our PI community. Share national goals, best practices and exemplary outcomes. Clarify the Division’s priorities among the various Broader Impact activities.

Tactic 2. Develop metrics and tools for *evaluating* Broader Impacts: in proposal reviews, in funding decisions, and in post-award oversight. Clearly communicate expectations for reporting and reviewing Broader Impact outcomes in renewal proposals. Develop internal

<sup>28</sup> <http://www.nsf.gov/pubs/1997/iin121/start.htm>

<sup>29</sup> <http://www.nsf.gov/pubs/2002/nsf02161/nsf02161.htm>

NSF codes to identify and track families of Broader Impact activities and understand the Broader Impact portfolio of our programs.

Tactic 3. Modify expectations for annual and final project reports to include a substantive discussion of Broader Impact activities. Encourage submission of Highlights that demonstrate effective Broader Impact activities.

Objective 2: Study the effectiveness of the activities in achieving the stated goals of the Broader Impacts criterion, including broadening participation activities.

Tactic 1: Develop a plan to assess the success of Broader Impact activities supported by CHE. It is important to focus first on a few questions – not all possible Broader Impacts. External expertise such as from the Directorate for Education and Human Resources (EHR) or an outside expert may be required. We can also learn from the formal assessments already complete or underway in other NSF programs.

**8. Updating the Division of Chemistry Structure:** How best do we structure the NSF Division of Chemistry (CHE) to respond to scientific needs and achieve NSF goals in chemistry?

Both the 2004 and 2007 Committee of Visitors reports<sup>30</sup> spurred discussions of whether the programmatic structure of CHE (organic, physical, inorganic, analytical and surface, and integrated activities) is outmoded and limiting the field. Might a different structure better serve PIs whose work “falls in the cracks” between programs within CHE, or between our programs and those in other Divisions? A useful exercise may be to consider the question of how we would structure CHE if we were starting from scratch.

CHE should continually be alert to potential obstacles that impede particular classes of innovative proposals and should work to eliminate these obstacles. CHE should be structured so that it quickly identifies new, promising areas of research and encourages and supports their growth.

**Goal:** Structure CHE to guarantee that the very best projects in research, education, training and infrastructure development are supported and anticipate and respond to new developments in chemistry.

One key challenge is that we lack contemporary labels with which to describe the content in our programs. Moreover, while individual programs have their own taxonomies, CHE is lacking a global taxonomy. We need a clearer picture of where overlap takes place and a simple map of what CHE supports. This will enable us to work better with those interested in applying for funds, with partner agencies and with other chemical science funders (including international partners).

Objective 1: Develop a new structure with which to classify the work that we support. Such a taxonomy will help with placing proposals into Programs and recruiting Program Officers with

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<sup>30</sup> <http://www.nsf.gov/mps/advisory/cov.jsp>

appropriate expertise. It will provide a yardstick with which to measure the natural evolution of the chemistry discipline.

Tactic 1: Study current practices -- journals, reviewer databases, Physics and Astronomy Classification Scheme (PACS), etc. -- and adapt and adopt these to define a limited list of keywords that span the work supported by CHE. Construct a map of the Division's Programs using these keywords. Adjust the programs to consolidate strengths and eliminate redundancies.

Tactic 2: Require PIs to categorize the science contained in their proposals by choosing an appropriate, limited number of keywords. This will help with the assignment of reviewers and will facilitate on-going assessment of the evolution of the discipline and the structure of the Division.

A second major focus addresses interdisciplinary work, either by individuals or by small collaborative teams. We need to guarantee that interdisciplinary proposals are not inherently at a disadvantage compared with proposals that sit comfortably within a single program. Our efforts will be informed by the ongoing activities of internal NSF groups, namely the Working Group on Facilitating Transformative & Interdisciplinary Research (FacTIR).

Objective 2: Develop a mechanism to streamline/facilitate co-review within CHE and across Divisions and Directorates.

Tactic 1: Develop incentives for co-review/co-funding -- these do not necessarily have to be in the form of program dollars.

Tactic 2: Institute working groups of Program Officers for topical areas at the various interfaces. Such groups should facilitate review of interdisciplinary proposals, and help identify new scientific directions at the earliest stages, which may, for example, inform decisions to fund topical workshops.

Tactic 3: Appoint several Program Officers to positions shared between NSF Divisions. Institute yearly inter-divisional panels with our largest partners, patterned on the annual MPS/Molecular and Cellular Biology (MCB) CAREER panel. These panels should help bring a critical mass to the co-reviewing effort, enabling a larger slate of proposals to be considered for co-review. "Orphan" proposals will find better homes and be fairly reviewed.

The question of collaborative proposals has special connotations. The current approach utilizing the Collaborative Research in Chemistry (CRC) program is viewed by some in the community as artificially engineering collaborations. The alternative of integrating these proposals with related individual proposals in the "core" programs compounds the usual challenges of interdisciplinary review with competitive budgetary disadvantages; when large collaborative projects compete head-to-head with smaller, individual investigator projects, Program Officers and reviewers have a natural inclination to favor a number of smaller, individual investigator projects over a larger, more expensive project from a team of researchers.

Objective 3: Determine if the collaborative proposals should be incorporated into the individual investigator programs. The goal is to have the inherent quality of both collaborative proposals and individual investigator proposals be the only factor considered in making award decisions.

Tactic 1: Investigate various ways of allocating program funds for collaborative proposals, and implement the best plan to eliminate bias against these proposals.

Tactic 2: Implement processes for co-review and/or co-funding of collaborative awards across programs.

**Final comments:**

CHE is developing a business plan to ensure it has the right internal structure and systems to accomplish the goals in this document. These five-year goals and objectives will be implemented with priority determined by the community and the Division. This document will be updated annually, and a report on progress will be posted on the MPS website for Committee of Visitor Reports.<sup>29</sup>



**APPENDIX 1****Strengths, Weaknesses, Opportunities, Threats (Barriers) (SWOT Analysis)  
Division of Chemistry (CHE)  
October 2007**

Based on NSF Strategic Goals: Discovery, Learning, Research Infrastructure and Organizational Stewardship

**TOP DISCOVERY ISSUES****DISCOVERY STRENGTHS**

1. Outcomes are focused on high quality fundamental research (often viewed as cutting edge and innovative by the community).
2. CHE is agile in being able to move rapidly to support new areas.
3. Management of the CHE review process, including the rotator program and reviewer selection is viewed favorably.
4. The community feels that CHE manages funds to foster and implement the best ideas of the community.
5. The diversity in the nature of the CHE programs (individual and center grants), and participants (small and large institutions, minorities and women, domestic and international, early career and established investigators) as well as use of SGERs and CREXes, is widely appreciated and recognized.

**DISCOVERY WEAKNESSES**

1. Peer review is being compromised by the low funding rates. Low funding rates are driving a conservatism in ideas proposed and funding decisions being made.
2. Some in our community perceive that curiosity-driven, fundamental research with a long-term horizon is being reduced in favor of research that addresses national priorities (a more applied flavor).
3. New ideas at the interface of chemistry with other disciplines and between the traditional sub-disciplines of chemistry are difficult to review. The traditional CHE structure may be inhibiting the development of the field.
4. Our community perceives that CHE funds could be better distributed - among centers, groups and individuals - among elements of the community such as new, midcareer, various types of institutions - in order to maximize chemical discovery.
5. NSF initiatives are conducted in good scientific areas and then, due to budgetary restraints, are dropped for the "next big thing" with negative consequences.

### **DISCOVERY OPPORTUNITIES**

1. CHE can work to encourage/identify more transformative proposals by re-evaluating its current proposal process, and perhaps making more use of the Small Grants for Exploratory Research (SGER) option.
2. CHE can communicate better that chemistry is not only the central science, but is the essential science for addressing important questions and challenges related to new products, technology, recycling and the environment.
3. CHE has an opportunity to nurture discovery by maintaining and communicating diverse modes of support (individual, collaborative, center), and a diverse portfolio of viewpoints (early and mid career, established, female, under-represented minorities, etc.).
4. By working more closely with other funding agencies as well as other NSF units, CHE can promote more interdisciplinary research activities.
5. By working more closely with its foreign government counterparts, NSF/CHE has an opportunity to further discovery by taking advantage of new perspectives and international facilities.

### **DISCOVERY-BARRIERS**

1. Very low success rates lead to “protective” research proposals and conservative reviewers, with short-term payoffs being unduly emphasized.
2. CHE needs a better consensus on the balance between the size of the awards and the number of investigators that can be funded.
3. Difficulties in resolving Intellectual Property (IP) issues between the academy and the industry are adversely affecting the Grant Opportunities for Academic Liaison with Industry (GOALI) program.
4. Communication and cooperation need to be improved both with other divisions/directorates within the NSF and with other funding agencies.
5. The scientific community needs more open explanations about funding opportunities from the NSF, particularly if they are offered irregularly.

### **TOP LEARNING ISSUES**

#### **LEARNING STRENGTHS**

1. The Research Experience for Undergraduates (REU) and CAREER programs, both integrating research and education, are excellent investments.

2. The Research at Undergraduate Institutions program is important to encourage undergraduate research.
3. Graduate student and postdoctoral training are strengths of the research efforts.
4. CHE is a leader in broader impacts especially in terms of broadening participation.
5. Other efforts receiving praise (though perhaps not entirely CHE based) include K-12 research efforts, CAREER outreach, teaching enhancement, Undergraduate Research Collaborative (URC) program, and faculty development.
6. Recent Town Hall meetings and electronic newsletters were viewed as a positive mechanism for learning about NSF CHE opportunities in learning.

### **LEARNING WEAKNESSES**

1. Some feel there is too much funding for education at R1 institutions, especially in the REU program.
2. NSF could opt to fund more smaller proposals from midcareer PIs, particularly as these PIs are effective at training graduate and undergraduate students.
3. The boundary between CHE and the Division of Undergraduate Education (DUE) (and other groups) is unclear to the community.
4. Some in the community feel that REU Programs are wasteful, preferring individual research grants that fund undergraduate participation.
5. Perceived issues about salary and long hours associated with chemistry careers make the field less attractive to students than business and other majors, working against CHE's efforts.
6. CHE staff have little time for effective program metrics and assessment, especially when it comes to broadening participation. PIs need better definitions of expectations and deliverables.
7. The community would like to see new programs for mid-career faculty.
8. The community has identified a need for more effective outreach to all citizens.
9. CHE should define priorities for the REU program. Are the goals to broaden participation, sustain research at primarily undergraduate institutions, recruit graduate students, reach community colleges, emphasize research ethics, or emphasize interdisciplinarity?

## LEARNING OPPORTUNITIES

1. Effectively engage Principal Investigators at small schools and schools in states with limited NSF support. Ensure that the CHE portfolio has an appropriate representation of faculty at these schools.
2. CHE should encourage minority participation by conducting workshops at Minority-Serving Institutions (MSIs) about NSF programs and writing effective proposals. CHE should increase support at these institutions. Increased participation at professional societies such as the National Organization for Advancing Black Chemists and Chemical Engineers (NOBCCHE), the Society for Advancing Chicanos and Native Americans in Science (SACNAS) and the Association for Women in Science (AWIS) would also help, and CHE could create an honorary award at each meeting.
3. CHE could grant a greater number of smaller budget awards to seed efforts at the local level.
4. CHE could launch new initiatives in many directions: graduate and postdoctoral fellowships, transition from postdoctoral fellow to faculty (with training workshops), support for international travel/research, new research programs for teachers and 9<sup>th</sup> -12<sup>th</sup> grade students, new experiential models, innovations for non-science students, scientific literacy, new faculty at small schools, mid-career faculty, middle and secondary education, community college faculty, matching program for sabbaticals and retraining for better use of national facilities.
5. The URC program should be reexamined and another competition should be run.
6. A postdoctoral fellowship program should be started with a focus on the goal to broaden participation by under-represented groups.

## LEARNING BARRIERS

1. Politics and culture are limiting factors. Some perceive that the community is content with the status quo and resistant to change.
2. U.S. chemical education at the K-12 and undergraduate level is not adequate.
3. Evaluation of broader impacts and broader participation is difficult.
4. Communication within or about NSF programs relevant to learning must improve.
5. Chemistry curricula deter international experience.
6. There are a limited number of proposals from MSI and smaller colleges.

7. REU and CAREERs are NSF-wide programs – may need strong leadership on Working Groups to effect change.

### **TOP RESEARCH INFRASTRUCTURE ISSUES**

#### **RESEARCH INFRASTRUCTURE STRENGTHS**

1. The Chemical Research Instrumentation and Facilities (CRIF) program generally works well.
2. The CRIF program funds instrumentation for research but leverages education at the same time.
3. CRIF funding is especially helpful for predominantly undergraduate institutions.

#### **RESEARCH INFRASTRUCTURE WEAKNESSES**

1. The CRIF program is underfunded, a reiterated weakness.
2. Some in the community applying to CRIF lack information about how to write proposals and form partnerships with industry and small schools.
3. No tracking of funded equipment poses a weakness.
4. Key infrastructure for chemical research on campuses is aging or lacking.

#### **RESEARCH INFRASTRUCTURE OPPORTUNITIES**

1. CRIF should explore opportunities to work with industry and other government agencies.
2. CHE should inform and educate institutions about the proposal writing process, possibly utilizing cyber-infrastructure.
3. Matching funds for CRIF should be explored.
4. There is an opportunity to involve predominantly undergraduate institutions (PUIs), community colleges, and high schools in CRIF projects.
5. Shared instrumentation opportunities can be further explored.

#### **RESEARCH INFRASTRUCTURE BARRIERS**

1. A resounding complaint is the lack of funds for infrastructure.

2. Challenges exist for smaller institutions.
3. Upkeep, upgrades and autonomy of use are instrumentation-related barriers.

### **TOP STEWARDSHIP ISSUES**

### **STEWARDSHIP STRENGTHS**

1. The quality of CHE staff is high. The Program Officers are knowledgeable, accessible and supportive.
2. The review process is rigorous and thoughtful.
3. Special programs for beginning investigators (CAREER) are well received.
4. CHE promotes close links among research, education and outreach.

### **STEWARDSHIP WEAKNESSES**

1. There is little in the way of evaluating the educational components of awards. The way research grants are administered seems to foster rushing graduate students into doing PI-specific research without a good grounding in other areas of chemistry.
2. The review process does not evaluate the cost effectiveness of doing the research. This is both in terms of the actual cost of the research and in whether the cost is justified for the value of the knowledge gained.
3. Grant sizes are too small to adequately fund personnel, supplies and equipment needed to accomplish significant research.
4. More continuity for CHE technical staff is needed for effective stewardship.

### **STEWARDSHIP OPPORTUNITIES**

1. Availability of new information technologies makes it possible for CHE to seek more public visibility about its goals and the importance of chemical research and education to society.
2. Because of increased awareness in the Congress, an opportunity has emerged for CHE to build new bridges to industry to improve its positions in American competitiveness funding requests.

3. CHE should conduct periodic “Chair Forums” and meetings with RUI, GOALI, CAREER beginning investigators, etc., by videoconference to enhance communication.
4. Longer term stays for both rotating and permanent POs need to be made more attractive, including opportunities for potential scientific collaborations with local universities, government research facilities and industry.

### **STEWARDSHIP BARRIERS**

1. The lack of funding for CHE Programs is a critical barrier to the national effort in fundamental chemistry. It diminishes resources for creativity in chemical research, and impacts all facets of the chemistry community.
2. The number of Program Officers is too low. Increase the number of POs, or enhance the POs resources to efficiently direct their efforts.

## APPENDIX II

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