# INTERAGENCY WORKSHOP ON RESEARCH AT THE INTERFACE OF THE LIFE SCIENCES AND PHYSICAL SCIENCES

**Richard Swaja (NIBIB), Bruce Hamilton (NSF), Wendy Liffers (NIDCR), Roderic Pettigrew (NIBIB), Lawrence Tabak (NIDCR), and Jeremy Berg (NIGMS)**

**June 30, 2004**

## Executive Summary

An "Interagency Workshop on Research at the Interface of the Life Sciences and the Physical Sciences" was held on May 10, 2004, in Room 6C6 of Building 31 on the National Institutes of Health (NIH) Main Campus in Bethesda, Maryland. The workshop was coordinated by the NIH and the National Science Foundation (NSF) in response to language in the House of Representatives reports accompanying the FY2004 Appropriations Bill which suggested that the NIH and NSF convene an interagency conference to discuss how agencies can effectively facilitate research at the interface of the life and physical sciences. To address this mandate, the following objectives were developed for the workshop:

1. Demonstrate that there are or have been (a) agency activities aimed at identifying issues associated with interagency and interdisciplinary collaborations and recommending courses of action to address the issues and (b) successful collaborative interagency efforts at the interface of the life and physical sciences;

2. Identify barriers to and opportunities for interagency collaborations involving the life and physical sciences; and

3. Recommend courses of action to validate the barriers and opportunities and to address those identified during the workshop.

Ten Federal agencies with interests in the life and/or physical sciences were represented including the Department of Defense (DOD), Department of Energy (DOE), Environmental Protection Agency (EPA), Food and Drug Administration (FDA),

National Aeronautics and Space Administration (NASA), National Institutes of Health, National Institute of Standard and Technology (NIST), National Oceanic and Atmospheric Administration (NOAA), National Science Foundation, and United States Department of Agriculture (USDA). A total of about 60 people attended the workshop including two primary discussants from each of the ten agencies, other staff from the represented Federal agencies, and staff from other agencies.

To reflect the existing high level of concern for this topic, information was presented on challenges and recommendations concerning interagency and interdisciplinary collaborations from (1) previous conferences coordinated by Federal and other agencies and (2) current agency efforts. Information was also presented on several successful interagency collaborations to demonstrate that agencies recognize the value of cooperative efforts and that many such programs have been and are being conducted.

Issues and challenges identified for interagency and interdisciplinary collaborations were classified into five areas – communication, culture, mechanisms, program selection, and shared resources. Critical issues associated with each of these areas include:

- *Communication* – Specific issues that need to be addressed include:
    - The need for structures that encourage the genuine engagement of scientists from different disciplines.
    - The establishment of dedicated forums that encourage communication and exchange of information within and across agencies.

- *Culture* – The following items are associated with culture-related challenges:
    - Differences between (1) traditional education and work environments among disciplines in the physical and life sciences, (2) cultures and missions among Federal agencies, and (3) intramural scientific resources and externally-funded scientists.
    - Abilities to maintain guaranteed long-term commitments.
    - Consideration of timing, review process, budget, and project sustainability issues in interagency program development.
    - *A priori* agreement on common endpoints and evaluation measures.

- *Mechanisms* – Specific items associated with this topic include:
    - Abilities and options to ensure continuity of funding commitments across agencies.
    - New methods of collaboration in view of potentially severely constrained budgets.
    - Support of collaborations through other than financial resources such as facilities, laboratories, tools, and staff.

- *Program selection* – In view of potential future budget constraints and the magnitude of effort necessary to develop and implement major interagency and interdisciplinary collaborations, it is important to select programs that are

appropriate for and will benefit from cooperative approaches. Issues that need to be considered in the program selection process include:

- Prioritization relative to agency missions and national needs,
- Development of criteria and guidelines for program selection, and
- Consideration of the relative levels of support needed between the physical and life sciences and how to obtain that support.

- *Shared resources* – Specific considerations associated with this topic include:
  - Development and support of research-enabling user facilities including consideration of possible collaborative stewardship of resources between agencies, and
  - Consideration of human and physical resources (intramural and extramural) in the development of collaborations.

Consensus recommendations resulting from this workshop include:

- Conduct a conference of physical and life scientists to (1) identify "grand challenges" or specific topics that could be addressed by research at the scientific interface and are relevant to national priorities and (2) suggest actions to strengthen research at the interface of the life and physical sciences.

- Convene an "Interagency Committee" for (1) planning the conference of physical and life scientists and (2) planning and coordinating response to the Workshop recommendations.

- Implement an interagency personnel exchange program to provide experience for personnel in cultures, missions, programs, and contacts at other agencies with interests in the physical and life sciences.

- Develop a summer institute program for faculty and Federal program directors to focus on specific problems for potential collaborative programs.

- Work with the Office of Science and Technology Policy (OSTP) to identify and develop approaches to address critical issues associated with interagency and interdisciplinary collaborations. Examples of critical issues discussed at the Workshop include "best practices" from successful collaborations, funding needs and mechanisms, eligibility of Federal researchers for agency extramural funding, and methods for identifying national priorities and relevant programs.

The NIH and NSF Workshop coordinators currently plan to convene an interagency committee to initiate response to the workshop recommendations. Other plans are to distribute this report to workshop participants and to post this report on the NIBIB and NSF Web sites. Complete information about the workshop including PowerPoint files of agency perspective and case study presentations is available on the Internet at http://www.nibib1.nih.gov/events/interagency/index.htm .

# Workshop Proceedings and Results

## Background

The application of principles and methods from the physical sciences to address problems in the life sciences has produced remarkable advances during the last century. Recent emphasis on interdisciplinary approaches to biomedical research and training by Federal agencies has provided unprecedented opportunities for collaborations among life scientists (clinicians, biologists, etc.) and physical scientists (physicists, chemists, mathematicians, computer scientists, engineers, etc.). As experience and training of investigators associated with this modern paradigm continue to develop and progress, research at the interface of the life and physical sciences will be strengthened and result in new advances underpinned by breakthroughs in both areas. Several Federal agencies have substantial interests and responsibilities associated with the physical and life sciences and are in positions to catalyze and support research at the interface.

In recognition of the potential advances that can result from multi-disciplinary scientific collaborations, language in the House of Representatives reports accompanying the FY2004 Appropriations Bill suggested that the National Institutes of Health (NIH) and the National Science Foundation (NSF) convene an interagency conference to discuss how Federal agencies can effectively facilitate research at the interface of the life and physical sciences. The specific language appeared in House Report 108-188 of the Labor/HHS Appropriations Subcommittee; House Report 108-235 of the VA/HUD/Independent Agencies Appropriations Subcommittee; and House Report 108-401 on appropriations for the USDA, FDA, and Related Agencies. Excerpts of these reports that refer to research at the interface of the life and physical sciences and the interagency conference are included in Appendix A of this report.

In response to the House language, an "Interagency Workshop on Research at the Interface of the Life Sciences and the Physical Sciences" was held on May 10, 2004, in Room 6C6 of Building 31 on the NIH Main Campus in Bethesda, Maryland. The conference was coordinated by the NIH (National Institute of Biomedical Imaging and Bioengineering [NIBIB], National Institute of Dental and Craniofacial Research [NIDCR], and the National Institute of General Medical Sciences [NIGMS]) and the NSF. The meeting was chaired by Drs. Roderic Pettigrew (NIBIB), Lawrence Tabak (NIDCR), and Jeremy Berg (NIGMS). NSF coordinators and representatives included Drs. Denise Caldwell and Bruce Hamilton.

## Objectives

In response to the Appropriations Bill language, the following three objectives were developed for this workshop:

4. Demonstrate that there are or have been (a) agency activities aimed at identifying issues associated with interagency and multi-disciplinary collaborations and recommending courses of action to address the issues and (b) successful collaborative interagency efforts at the interface of the life and physical sciences;
5. Identify barriers to and opportunities for interagency collaborations involving the life and physical sciences; and
6. Recommend courses of action to validate the barriers and opportunities and to address those identified during the workshop.

## Program

The workshop agenda is attached as Appendix B to this report. The one-day meeting consisted of plenary presentations and interactive discussions aimed at addressing the workshop objectives. The morning sessions were designed to set the stage for the meeting and afternoon interactive discussions. During the session on "Agency Perspectives", each agency provided a five-minute summary of its mission; interests in the physical and/or life sciences; and perspectives on opportunities, the primary issue/challenge, and the primary recommendation for a course of action. In support of objective 1(b) above, five case studies of successful interagency collaborations involving research and training in the physical and life sciences were presented during the "Case Studies" session. The presentations emphasized challenges that had to be addressed and lessons learned from the collaborations. Case studies ranged from small (two agencies) to complex (eight agencies) and from narrow-scope with narrow-impact to broad-scope with broad-impact. In addition to the case studies, two presentations were made in support of objectives 1(a) and 1(b) on current activities that focus on collaborative research business models and team science needs. PowerPoint files of the individual agency perspective and case study presentations are available on the Internet at http://www.nibib1.nih.gov/events/interagency/index.htm .

The afternoon sessions were interactive, plenary discussions aimed at addressing objectives 2 and 3 by developing lists of (1) issues, challenges, and opportunities for interagency collaborations and (2) courses of action to address the issues and challenges. The bases of discussions in these sessions were the individual agency perspectives communicated during the morning sessions.

## Participants

Ten Federal agencies with interests in the life and/or physical sciences were represented including the Department of Defense (DOD), Department of Energy (DOE), Environmental Protection Agency (EPA), Food and Drug Administration (FDA), National Aeronautics and Space Administration (NASA), National Institutes of Health (NIH), National Institute of Standard and Technology (NIST), National Oceanic and Atmospheric Administration (NOAA), National Science Foundation (NSF), and United

States Department of Agriculture (USDA). Each agency had two primary discussants who are listed in Appendix C of this report. A total of about 60 people attended this workshop including the primary discussants from the ten agencies, other staff from the represented Federal agencies, and staff from other agencies.

## Pre-Meeting Information

To provide background information and examples of related current and prior agency activities, a summary of issues and recommendations concerning interagency and multi-disciplinary collaborations from previous conferences and workshops conducted by Federal and other agencies from 1996 to the present was prepared and distributed to attendees prior to the meeting. This information supports objective 1(a) by demonstrating the existence and results of agency activities aimed at identifying issues associated with scientific collaborations and recommending courses of action to address the issues. The summary is attached as Appendix D to this report.

## Issues and Challenges for Interagency Collaborations

The list of primary issues or challenges contributed by the participating agencies (attached as Appendix E) was used as a starting point for interactive discussion in the first afternoon session. The contributed items and others offered during the discussion were classified into five categories – communication, culture, mechanisms, program selection, and shared resources. Critical issues and challenges associated with each of these areas (response to part of objective 2) include:

- *Communication* – Communication of information and engagement of scientists within and across agencies is vital for effective and sustained interagency collaborations. Specific issues that need to be addressed include:
    - The need for structures that encourage the genuine engagement of scientists from different disciplines. Ways to effectively communicate interdisciplinary issues and funding opportunities to the scientific community are essential.
    - The establishment of dedicated forums that encourage communication and exchange of information within and across agencies. Interagency efforts are needed to form coherent visions, facilitate joint planning, and offer flexible implementation mechanisms. Also, effective resources for sharing scientific data and information across agencies need to be developed.

- *Culture* – Basic differences in missions and traditional work environments create some barriers to interagency and interdisciplinary collaborations. In particular, the following items are associated with culture-related challenges:
    - Differences between (1) traditional education and work environments among disciplines in the physical and life sciences, (2) cultures and

missions among Federal agencies, and (3) intramural scientific resources and externally-funded scientists.
    - Abilities to maintain guaranteed long-term commitments.
    - Consideration of timing, review process, budget, and project sustainability issues in interagency program development.
    - *A priori* agreement on common endpoints and evaluation measures.

- *Mechanisms* – The development and implementation of mechanisms that effectively support interagency collaborations requires consideration of continued funding commitments, possible severe budget constraints, and support through other resources in addition to finances. Specific items associated with this topic include:
    - Abilities and options to ensure continuity of funding commitments across agencies.
    - New methods of collaboration in view of potentially severely constrained budgets. This issue can be partly addressed by (1) ensuring high-level support and involvement during program development and implementation and (2) setting aside portions of budgets for new collaborations.
    - Support of collaborations through other than financial resources such as facilities, laboratories, tools, and staff. Several agencies offer significant "in kind" support in the physical and life sciences that can effectively leverage resources for program implementation.

- *Program selection* – In view of potential future budget constraints and the magnitude of effort necessary to develop and implement major interagency and interdisciplinary collaborations, it is important to select programs that are appropriate for and will benefit from cooperative approaches. Issues that need to be considered in the program selection process include:
    - Prioritization relative to agency missions and national needs,
    - Development of criteria and guidelines for program selection, and
    - Consideration of the relative levels of support needed between the physical and life sciences and how to obtain the support.

- *Shared resources* – Leveraging resources among research organizations can facilitate program efficiency and effective use of Federal facilities. Specific considerations associated with this topic include:
    - Development and support of research-enabling user facilities including consideration of possible collaborative stewardship of resources between agencies, and
    - Consideration of human and physical resources (intramural and extramural) in the development of collaborations.

## Opportunities

The primary opportunities for interagency and interdisciplinary collaborations communicated by the participating agencies during the "Agency Perspectives" session were summarized and briefly discussed in support of part of objective 2 during the workshop. The following text provides the unedited list of primary opportunities contributed by the agencies. No revised list of opportunities was developed due to time constraints and the broad scope of suggestions.

- DOD – Biomimetics –Infusing biological processes into engineered solutions.
- DOE – Systems biology research – Impacts in energy, environment, agriculture, and medicine.
- DOE – Addressing challenges in biology, computation, and physical sciences.
- EPA – Sustainable development as a better organizing principle for the next generation of environmental protection tools.
- FDA – Delivery of new healthcare products.
- NASA – Office of Biological and Physical Research is evolving programs in human health, radiation support, and human life support technologies.
- NIH – In a position to catalyze interagency interactions aimed at transferring technologies to biology and medicine.
- NIST – Quantitative biology – Converging technologies (nano, bio, IT).
- NOAA – Integrating earth science and environmental observations to develop prediction and forecast information for improved societal response.
- NSF – Systems biology, sensors, and cyberinfrastructure.
- USDA – Nanobiotechnology, foods for health, biomass conversion for energy.

## Recommendations

The second afternoon interactive session of the workshop focused on objective 3 - to recommend courses of action to validate the barriers and opportunities and to address the issues and challenges identified during the meeting. The starting point for discussion was the list of primary recommendations for courses of action communicated by the agencies (attached as Appendix F) during the "Agency Perspectives" session. Consensus recommendations resulting from this meeting include:

- Conduct a conference of physical and life scientists to (1) identify "grand challenges" or specific topics that could be addressed by research at the

scientific interface and are relevant to national priorities and (2) suggest actions to strengthen research at the interface of the life and physical sciences. Possible grand challenges suggested at the Workshop include molecular physics in complex environments and systems biology. These items represent suggestions offered at the meeting and are not intended to limit the scope of the conference.

- Convene an "Interagency Committee" for (1) planning the conference of physical and life scientists and (2) planning and coordinating response to the Workshop recommendations.

- Implement an interagency personnel exchange program to provide experience for personnel in cultures, missions, programs, and contacts at other agencies with interests in the physical and life sciences.

- Develop a summer institute program for faculty and Federal program directors to focus on specific problems for potential collaborative programs.

- Work with the Office of Science and Technology Policy (OSTP) to identify and develop approaches to address critical issues associated with interagency and interdisciplinary collaborations. Examples of critical issues discussed at the Workshop include "best practices" from successful collaborations, recognition of all collaborators, agency funding needs and mechanisms, eligibility of Federal researchers for agency extramural funding, and methods for identifying national priorities and relevant programs.

## Summary

The Interagency Workshop represents an initial step in establishing collaborations among relevant Federal agencies with regard to research at the interface of the life and physical sciences. Information presented on challenges and recommendations concerning interagency and interdisciplinary collaborations from (1) previous conferences coordinated by Federal and other agencies and (2) current agency efforts reflects the existing high level of concern for this topic. Information presented on a subset of successful interagency collaborations demonstrates that agencies recognize the value of cooperative efforts and that many such programs have been and are being conducted. The NIH and NSF Workshop coordinators currently plan to convene an interagency committee to initiate response to the workshop recommendations. Current plans are also to distribute this report to agency representatives and other meeting attendees, and to post it on the NIBIB and NSF Web sites.

## Acknowledgements

The authors gratefully acknowledge the contributions of Colleen Guay-Broder, Cheryl Fee, Mary Beth Kester, and Pat Sokolove of the NIBIB in developing the agenda,

preparing materials, and handling meeting logistics. The invaluable efforts of Mariaileen Sourwine and Stacy Wallick of the NIBIB in coordinating data management and program execution at the workshop are also gratefully acknowledged. Special recognition is given to Stacy Wallick for preparing a comprehensive and cohesive pre-meeting information package based on results of previous conferences. Sincere thanks is extended to Sohi Rastegar of the NSF who did a great job co-moderating the interactive sessions and once again demonstrated his proficiency at keeping a group focused on meeting objectives and obtaining valuable output from a large amount of information.

# APPENDIX A

# EXCERPTS FROM THE FY2004 HOUSE APPROPRIATIONS REPORT THAT REFER TO AN INTERAGENCY MEETING

*(Language specific to the interagency meeting is italicized in the following text.)*

## 1. House Labor/HHS Appropriations Subcommittee – Report 108-188 (p. 94)

NIH: OFFICE OF THE DIRECTOR
**Physical sciences** – The Committee recognizes that breakthroughs in the physical sciences underpin many of the remarkable advances in the life sciences that have been achieved during the past century. Biomedical research now involves not only molecular biologists but also chemists, bioengineers, bio-imaging experts, physicists, mathematicians, computer scientists, and other professionals. Increasingly, the boundaries between the life sciences and physical sciences are being blurred, as capacities and talents bridging the disciplines are essential for modern experimentation and discovery. Accordingly, the Committee believes that a major effort must be undertaken to promote the advancement of research at the interface between the life sciences and the physical sciences. This interface occurs in many agencies including NIH, NSF, Office of Science, Department of Energy, DARPA, NASA, NOAA, and others. *The Committee suggests that the NIH work with all such agencies to convene a conference to discuss what needs to be done to encourage progress in the physical sciences that will provide support and underpinning in the future for advances in the life sciences.*

## 2. House VA/HUD/Independent Agencies Appropriations Subcommittee – Report 108-235 (p. 143)

NSF: RESEARCH AND RELATED ACTIVITIES
While the National Institutes of Health has principal responsibility for research involving human health and disease, NSF has historically played a critical role in funding long range basic research and technology development which have been critical to NIH's more focused mission. NSF's work on the basic chemical processes which made possible the mapping of the human genome is perhaps the best known example of this extraordinarily important collaboration. The Committee believes that the future of scientific advancement in both the physical sciences and the life sciences will increasingly rely on such collaborations and urges the NSF to work aggressively with NIH to determine how this research can be strengthened. The Committee has recently asked the NIH to convene a conference of all the stakeholder agencies within the Federal government whose missions involve the conduct or support of research at the scientific interface between the life sciences and the physical sciences. *NSF is encouraged to play a leading role in this*

*conference, which will hopefully occur during 2003. The Director should be prepared to testify to the Committee at NSF's appropriations hearings on the 2005 budget on the results of this conference as they relate to NSF and on any changes in resource allocations or management systems within NSF which would strengthen this critical area of research.*

**3. House Appropriations for Agriculture, Rural Development, Food and Drug Administration, and Related Agencies – Report 108-401 (p. 776)**

NIH: OFFICE OF THE DIRECTOR
The conferees recognize that breakthroughs in the physical sciences underpin many of the remarkable advances in the life sciences that have been achieved during the last century. Increasingly, the boundaries between the life sciences and the physical sciences are being blurred, as capacities and talents bridging the disciplines are essential for modern experimentation and discovery. Accordingly, the conferees believe that a major effort must be undertaken to promote the advancement of research at the interface between the life sciences and the physical sciences. This interface occurs in many agencies including NIH, NSF, Office of Science, Department of Energy, DARPA, NASA, NOAA, and others. *The conferees commend NIH for its plans to evaluate, as part of the NIH Roadmap process, what steps need to be taken to encourage progress in the physical sciences that will provide support and underpinning for future advances in the life sciences and to convene a conference to discuss the issue with other Federal agencies.*

END

# APPENDIX B

# AGENDA FOR THE INTERAGENCY WORKSHOP ON RESEARCH AT THE INTERFACE OF THE LIFE SCIENCES AND THE PHYSICAL SCIENCES

**May 10, 2004**
**Room 6C6 – Building 31C**
**NIH Main Campus – Bethesda, Maryland**

8:30 AM – Welcome – *Lawrence Tabak (NIH/NIDCR) and Denise Caldwell (NSF)*

8:35 AM - Orientation – *Roderic Pettigrew (NIH/NIBIB) and Jeremy Berg (NIH/NIGMS)*

8:45 AM – Agency Perspectives
*Moderators: Bruce Hamilton (NSF) and Walter Stevens (DOE)*

9:45 AM – Break

10:15 AM – Case Studies of Interagency Collaborations
*Moderators: Kevin Teichman (EPA) and Angela Hight-Walker (NIST)*

Lessons from the Human Genome Project - *Ari Patrinos (DOE)*
NIH Interagency Collaborations - *John Whitmarsh (NIH/NIGMS)*
Metabolic Engineering - *Fred Heineken (NSF)*
The Multi-agency Biomass Program - *John Ferrell (DOE)*
Bioengineering and Bioinformatics Summer Institutes Program - *Sohi Rastegar (NSF*)
Interagency Collaborations for Research Business Models –
*Connie Atwell (NIH/NINDS)*
Catalyzing Team Science: Interagency Aspects - *Dan Sullivan (NIH/NCI – BECON)*

11:45 AM – Plan for Afternoon Sessions – *Roderic Pettigrew (NIH/NIBIB)*

Noon – Lunch

1:00 PM – Issues, Challenges, and Opportunities for Interagency Collaborations
*Moderators: Sohi Rastegar (NSF) and Richard Swaja (NIH/NIBIB)*

2:30 PM – Break

3:00 PM – Courses of Action
*Moderators: Richard Swaja (NIH/NIBIB) and Sohi Rastegar (NSF)*

4:30 PM – Summary - *Roderic Pettigrew (NIH/NIBIB) and Jeremy Berg (NIH/NIGMS)*

4:45 PM – Acknowledgements and Adjourn – *Lawrence Tabak (NIH/NIDCR)*

End

# APPENDIX C

## AGENCY REPRESENTATIVES AT THE INTERAGENCY CONFERENCE ON RESEARCH AT THE INTERFACE OF THE LIFE SCIENCES AND THE PHYSICAL SCIENCES

The following representatives were primary discussants for the ten Federal agencies represented at the May 10, 2004, interagency workshop:

**Department of Defense (DOD)**

| | | |
|---|---|---|
| William Berry | william.berry@osd.mil | 703-696-0363 |
| Harold Guard | guardh@onr.navy.mil | 703-696-4501 |

**Department of Energy (DOE)**

| | | |
|---|---|---|
| Walter Stevens | walter.stevens@science.doe.gov | 301-903-2046 |
| David Thomassen | david.thomassen@science.doe.gov | 301-903-9817 |

**Environmental Protection Agency (EPA)**

| | | |
|---|---|---|
| Kevin Teichman | teichman.kevin@epa.gov | 202-564-6705 |
| Edward Washburn | washburn.edward@epa.gov | 202-564-1134 |

**Food and Drug Administration (FDA)**

| | | |
|---|---|---|
| Norris Alderson | nalderson@oc.fda.gov | 301-827-3340 |
| Donald Marlowe | dmarlowe@oc.fda.gov | 301-827-3340 |

**National Aeronautics and Space Administration (NASA)**

| | | |
|---|---|---|
| John Emond | john.l.emond@nasa.gov | 202-358-1686 |
| Mark Lee | mark.c.lee@nasa.gov | 202-358-0816 |

**National Institutes of Health (NIH)**

| | | |
|---|---|---|
| Belinda Seto | setob@mail.nih.gov | 301-451-4772 |
| John Whitmarsh | whitmarj@mail.nih.gov | 301-451-6446 |

**National Institute of Standards and Technology (NIST)**

| | | |
|---|---|---|
| Michael Casassa | michael.casassa@nist.gov | 301-975-2371 |
| Angela Hight Walker | angela.hightwalker@nist.gov | 301-975-2155 |

**National Oceanic and Atmospheric Administration (NOAA)**

| | | |
|---|---|---|
| Quay Dortch | quay.dortch@noaa.gov | 301-427-2089 |
| Juli Trtanj | juli.trtanj@noaa.gov | 301-427-2089 |

**National Science Foundation (NSF)**

| | | |
|---|---|---|
| Denise Caldwell | dcaldwel@nsf.gov | 703-292-7371 |
| Bruce Hamilton | bhamilto@nsf.gov | 703-292-8301 |

**United States Department of Agriculture (USDA)**

| | | |
|---|---|---|
| Hongda Chen | hchen@csrees.usda.gov | 202-401-6497 |
| Michael Jawson | mdj@ars.usda.gov | 301-504-5281 |


End

# APPENDIX D

# SUMMARY OF RECOMMENDATIONS FROM PRIOR CONFERENCES ON INTER-DISCIPLINARY AND INTERAGENCY COLLABORATIONS

The following summary of issues and recommendations concerning interagency and multi-disciplinary collaborations from previous conferences and symposia conducted by Federal and other agencies from 1996 to the present was distributed to attendees prior to the May 10 workshop. This information was prepared to provide pre-meeting information and to demonstrate the existence and results of agency activities aimed at identifying issues associated with scientific collaborations and recommending courses of action to address the issues.

The following meetings provided the information contained in the summary:

NIH BIOENGINEERING CONSORTIUM (BECON)

1. BIOENGINEERING: BUILDING THE FUTURE OF BIOLOGY AND MEDICINE - FEBRUARY 27 - 28, 1998
2. BIOMEDICAL IMAGING - JUNE 25-26, 1999
3. NANOSCIENCE AND NANOTECHNOLOGY - JUNE 25-26, 2000
4. REPARATIVE MEDICINE: GROWING TISSUES AND ORGANS - JUNE 25-26, 2001
5. SENSORS FOR BIOLOGICAL RESEARCH AND MEDICINE - JUNE 24-25, 2002
6. NIH BECON: CATALYZING TEAM SCIENCE - JUNE 23-24, 2003

OTHER MEETINGS

7. MODELING OF BIOLOGICAL SYSTEMS: A WORKSHOP AT THE NATIONAL SCIENCE FOUNDATION - MARCH 14 -15, 1996

8. EUROPEAN UNION OF PHYSICS RESEARCH ORGANISATIONS (EUPRO): PHYSICS AND BIOLOGY WORKSHOP - OCTOBER 28, 1999

9. ASSESSING BIOENGINEERING AND BIOINFORMATICS RESEARCH TRAINING, EDUCATION AND CAREER DEVELOPMENT: OPPORTUNITIES FOR NIH AND NSF COLLABORATION- JUNE 13-14, 2001

10. FUTURE DIRECTIONS OF BIOCHEMICAL ENGINEERING WORKSHOP: VISION AND PRIORITIES: NOVEMBER 29 - 30, 2001 (NSF)

11. ACCELERATING MATHEMATICAL-BIOLOGICAL LINKAGES: REPORT OF A JOINT NSF-NIH WORKSHOP - FEBRUARY, 2003

| NIH BECON: BIOENGINEERING: BUILDING THE FUTURE OF BIOLOGY AND MEDICINE<br>February 27-28,1998 | |
|---|---|
| **Issues** | **Recommendations** |
| **Through a systems approach, elucidate biological principles.**<br>- research using a systems integrated approach, including the quantitative aspects of physical-biological interactions in space and time<br>- gain a full understanding of the rules of how living systems operate and respond.<br>- elucidate new fundamental knowledge of biological principles in terms of multiple mechanisms across length and complexity scales | **Establish collaborative initiatives.**<br>- grant programs supported by multipleInstitutes and Centers, combining bioengineering, bioscience, and clinical science approaches to create innovative and effective approaches<br>- foster academic-industry partnerships. |
| **Facilitate translation from promise to performance.**<br>- fruition in clinical practice of health technologies depends on effective translational research and dissemination into general use.<br>- use bioengineering capacity for design and research in basic research, population studies, clinical trials, databases, regulatory science, products and services that will facilitate new prevention and therapeutic strategies to meet patient needs. | **Reimagine the bioengineering academic structure.**<br>- create an intellectual infrastructure spanning all of the educational stages (kindergarten-career)<br>- establish pedagogical paradigms to encourage innovative teaching methods and materials<br>- teach engineering within the context of biology. |
| **Catalyze multidisciplinary teams.**<br>- required for capitalizing on the bioengineering approach to synthesize and integrate information from diverse fields into focused basic and application-oriented solutions. | **Increase emphasis on joining engineering and biology.**<br>- emphasize joining of engineering and biology in fundamental research and training |
| | **Communicate principles.**<br>- communicate successes by on- |

| | |
|---|---|
| | going dialogue between academia, industry, government (NIH, FDA, as well as local, state, and federal legislatures), and the public<br>- facilitate the communication by creating accessible, user-friendly databases of molecular, physico-chemical, and physiologic knowledge and integrative principles |

| NIH BECON: BIOMEDICAL IMAGING<br>June 25-26, 1999 | |
|---|---|
| **Issues** | **Recommendations** |
| - clinical studies, with careful attention to integration of informatics, are needed to assess biomedical imaging technologies and to advance biomedical imaging research.<br>- greater cooperation among NIH, FDA, HCFA, and industry (both large and small businesses) would improve the speed with which new imaging technologies, probes, and contrast agents can be transferred into clinical practice. | |

| NIH BECON: NANOSCIENCE AND NANOTECHNOLOGY<br>June 25-26, 2000 | |
|---|---|
| **Issues** | **Recommendations** |
| - encourage genuine collaboration among industry, academia, and government scientists. | - a new generation of students should be trained, combining a rigorous disciplinary depth with the ability to reach out to other disciplines. |
| - build interdisciplinary teams of researchers.<br>- particular attention needs to be paid to ways to enhance communication among all the disciplines, ranging from physical sciences to medicine. Pursue bold, new, innovative education and training programs now, to promote this cross-talk among today's researchers<br>- and develop a new generation of researchers to whom this interaction is second nature. | - technology-specific peer-review panels should be implemented. Reexamine peer-review mechanisms broadly within NIH with the goal of encouraging support for technology-driven and high-risk nano-science and -technology exploratory research.<br>- develop co-funding strategies involving different funding agencies with complementary missions.<br>- encourage genuine collaboration among industry, academia, and government scientists. |

| | |
|---|---|
| | - develop incentives that encourage team research as well as individual efforts. Academic and industrial reward, promotion, and tenure systems should recognize individuals who make substantial contributions to research projects that cross traditional boundaries. |

| NIH BECON: REPARATIVE MEDICINE: GROWING TISSUES AND ORGANS<br>June 25-26, 2001 | |
|---|---|
| **Issues** | **Recommendations** |
| | - establish Centers that are both research centers and resource centers<br>- fund projects directed toward development of core, enabling technologies<br>- develop collaborative funding opportunities among multiple agencies with complementary missions.<br>- program initiatives including training, cross-training, and retraining programs |
| **NIH BECON: SENSORS FOR BIOLOGICAL ESEARCH AND MEDICINE<br>June 24-25, 2002** | |
| **Issues** | **Recommendations** |
| - break down barriers to funding non-hypothesis driven research, as well as practical device development research that in itself would not be considered innovative, but which would have impact on treatment of disease; | - tailor initiatives for a specific clinical goal, technology and research community, and avoid general announcements for applications<br>- physical sciences students and biomedical students should be encouraged to 'swap places' during training (spend time in the hard sciences lab, spend time in the clinic); |
| - seek to develop technology (sensors) in the context in which it will be used (e.g., disease state, biomedical research applications, etc.);<br>- find ways to support movement of technology down the developmental pipeline and into the clinical setting. | - define the clinical problems that are most pressing, and advertise the needs of the biomedical community to appropriate groups of physical scientists<br>- effectively communicate specific disease information to physical scientists to better engage them in the desired biomedical research |

| | |
|---|---|
| - For those cases where there is little financial motivation for a company to develop a needed product (e.g., third world diseases), the NIH should consider support for a large fraction of the research and development effort. | enterprise. Common language should be developed. Information can include sharing large datasets, specific biomarkers of interest, clinical findings of note, etc.;<br>- communicate to the biomedical community the range of technologies available that may provide solutions to research needs |

| NIH BECON: CATALYZING TEAM SCIENCE<br>June 23-24, 2003 | |
|---|---|
| **Issues** | **Recommendations** |
| **Team science would be enhanced if NIH:**<br>- allowed more than one Principal Investigator (PI) on individual grants<br>- allowed multiple performance sites to receive appropriate indirect cost recovery;<br>- developed improved funding mechanisms for team science; gave more attention to the special review needs of team science;<br>**Academic institutions:**<br>- developed measures of team contributor value other than PI status and authorship<br>- created career paths for those who provide the infrastructure for the team;<br>- streamlined the administration of team science;<br>**Journals:**<br>- specified co-authors' contributions.<br>- identified guarantors of article content;<br>- established data and materials sharing policies. | |

| MODELING OF BIOLOGICAL SYSTEMS:<br>A WORKSHOP AT THE NATIONAL SCIENCE FOUNDATION<br>March 14-15, 1996 | |
|---|---|
| **Issues** | **Recommendations** |
| **Integrating data and developing models of complex systems across multiple spatial and temporal scales.**<br>- scale relations and coupling<br>- temporal complexity and coding<br>- parameter estimation and treatment | ▪ graduate training grant programs that involve faculty engaged in both computational and experimental approaches<br>▪ postdoctoral fellowships to encourage mathematicians and |

| | |
|---|---|
| of uncertainty<br>- statistical analysis and data mining<br>- simulation modeling and prediction. | computational scientists to pursue research training in biology, and to enable biologists to acquire computational and modeling skills<br>▪ summer workshops and short courses to help practicing biologists, mathematicians, and computational scientists to begin to bridge the gap between these rather diverse disciplines. |
| **Structure-function relationships**<br>- large and small nucleic acids proteins<br>- membrane systems<br>- general macromolecular assemblies<br>- cellular, tissue, organ systems<br>- ecological and evolutionary systems. | Greater emphasis on mathematics and computational studies in K-12 and undergraduate curricula will likely have far-reaching benefits for biology education. |
| **Image analysis and visualization**<br>- image interpretation and data fusion<br>- inverse problems<br>- 2, 3, and higher-dimensional visualization and virtual reality | |
| **Basic mathematical issues**<br>- formalisms for spatial and temporal encoding<br>- complex geometry<br>- relationships between network architecture and dynamics<br>- combinatorial complexity<br>- theory for systems that combine stochastic and nonlinear effects, often in partially distributed systems. | |
| **Data management**<br>- data modeling and data structure design<br>- query algorithms, especially across heterogeneous data types<br>- data server communication, especially peer-to-peer replication<br>- distributed memory management | |

| | |
|---|---|
| and process management | |
| **EUROPEAN UNION OF PHYSICS RESEARCH ORGANISATIONS (EUPRO): PHYSICS AND BIOLOGY WORKSHOP<br>October 28, 1999** | |
| **Issues** | **Recommendations** |
| - Cooperation with chemistry, engineering, medicine and pharmacy required for successful research at the interface of biology and physics. | - Raise the interest of biologists and their level of awareness of the importance of physics<br>- Convince bright young people that research at this interface is intellectually challenging. (i.e. graduate schools in biophysics) |
| - Involve "main stream“ physicists in the mechanism of setting priorities and selecting successful applications. | - Work together in the same laboratory for extended periods of time to achieve better understanding of physicists and biologist. |
| | - Develop specific interdisciplinary programmes at the interface of physics and biology (i.e. UK Life Sciences Program of the Engineering and Physical Sciences Research Council) |
| | - Create new structures to help overcome "cultural barriers.“ Successful programmes often have structural components (like the creation of new chairs) and involve the universities sharing responsibility with the funding agency. |
| **ASSESSING BIOENGINEERING AND BIOINFORMATICS RESEARCH TRAINING, EDUCATION AND CAREER DEVELOPMENT: OPPORTUNITIES FOR NIH AND NSF COLLABORATION<br>June 13-14, 2001** | |
| **Issues** | **Recommendations** |
| | ▪ Provide a clear and continuous path of education and career |

| | |
|---|---|
| | development opportunities from the undergraduate through senior career levels<br>▪ Develop specific mechanisms to support cross-disciplinary training for junior and mid-career faculty and administration of inter-disciplinary research and training programs.<br>▪ Support additional opportunities for cross-disciplinary training beyond that offered through institutional training grants<br>▪ Support training programs that increase interactions with industry<br>▪ Increase opportunities for infrastructure support such as databases, hardware, software, systems, and personnel<br>▪ Strengthen the review process for multi-disciplinary research and training grant applications to ensure that the importance of cross-disciplinary, non-hypothesis-driven (needs-driven) research |
| | **Increase the number of individual fellowships and institutional training grants at all career levels in bioengineering and bioinformatics that:**<br><br>- include quantitative biology, computational biology, and integrative systems modeling.<br>- are cross-disciplinary<br>- include funds to support faculty with complementary expertise<br>- support the development and testing of curricula and new training approaches. |

| FUTURE DIRECTIONS OF BIOCHEMICAL ENGINEERING WORKSHOP: VISION AND PRIORITIES<br>November 29-30, 2001 (NSF) | |
|---|---|
| **Issues** | **Recommendations** |
| - Fundamental aspects of bioprocess research<br>- In situ process monitoring<br>- Improving expression systems<br>- Mammalian and microbial cell physiology<br>- Development of selective, high capacity purification methods<br>- High throughput process development<br>- Validation of scale down / miniaturization processes<br>- In vitro and in vivo glycosylation engineering<br>- Post-translational protein processing (in vivo), protein refolding, stability, and formulation of therapeutic protein | - Bachelor's training should include more biological understanding, which may require revamping the traditional chemical engineering curriculum.<br>- Creation of a Masters Degree in Biochemical Engineering with full accreditation. |
| | **NSF can promote and facilitate closer ties between academia and industry through existing programs**<br><br>- i.e. Combined Research and Curriculum Development Program, GOALI awards<br>- NSF should provide a biotechnology thrust initiative and earmark funds for industrial projects<br>- Creating an industrial advisory group to the NSF to draft Research Requests for Proposals<br>- Developing guidelines for standard IPR agreements would facilitate university/industry partnerships |
| **ACCELERATING MATHEMATICAL-BIOLOGICAL LINKAGES:** | |

| REPORT OF A JOINT NSF-NIH WORKSHOP<br>February, 2003 | |
|---|---|
| **Issues** | **Recommendations** |
| | **Institutional Recommendations**<br>Two large scale initiatives should be aggressively pursued by both NIH and NSF:<br><br>1. large competition(s) to foster new biological breakthroughs through high impact research made possible by mathematical applications and theory;<br>2. the creation of a national research center for Biological Research Interfacing with Mathematics, to review and fund proposals that would bring multidisciplinary groups of scientists from around the world to the center to work together on major unsolved issues in both fundamental and applied arenas.<br><br>- Establish and provide sustained support for a federated network of data resources for biological information from the genomic and proteomic levels through organismal organization and up to environmental information to better enable biomedical and biological multiscale integrative research. This initiative should build on existing community databases and resources to take advantage of investments and research in cyber-infrastructure, to create an integrated (but distributed) set of resource for the community.<br><br>- Formalize publishing standards for model development to improve the quality and level of access to data and models.<br><br>- Create a federation to coordinate |

| | |
|---|---|
| | Math/Biology societies, to provide a united voice for major funding initiatives, for enhancing cross-disciplinary interaction, and for interdisciplinary undergraduate and graduate education.<br><br>- Examine existing programs within NSF and NIH, and assess what changes could be readily achieved to improve research and education at the math-bio interface. Develop a subprogram within IGERT, focused on the issue of math-bio linkage training. |
| | **Education and Training Recommendations•**<br>- Create new interdisciplinary postdoctoral programs at the interface between mathematics/statistics/computer science and biology/biomedicine.<br>- Convene a high level (e.g., NAS) workshop that attracts department chairs from biology, math, computer science and statistics departments to identify means to promote cross-disciplinary curricula and training appropriate for the kind of biological questions being explored, including support for double degrees in math and biology.<br>- Create joint faculty positions at the interface between mathematics/statistics and biology/biomedical sciences, with appropriate mentoring and clear expectations for interdisciplinary work.<br>- Develop summer math/bio programs for high school math, computer science, and biology teachers and their students, to introduce them together to the interface between math and |

| | |
|---|---|
| | biology.<br>- Develop K-12 educational material for the math/biology interface.• Develop a central website and a listserv to disseminate information on research and training opportunities at the math/biology interface. |
| | **Strengthening Ties among the Researchers Recommendations**<br><br>- Compile a list of the top ten most challenging and promising areas in mathematical biology, including modeling of multilevel systems, integrating probabilistic theories, data mining and inference, and computational tools.<br><br>- Organize a national meeting in Washington D.C. on Mathematical Biology, to showcase (over 3 – 5 days) successes where mathematics and computations have helped solve important problems in medicine and to motivate new directions and opportunities on all levels of biology from cells to organs to ecology to the biosphere<br><br>- Develop a series of advanced educational' workshops for mathematicians and biologists to learn about the other discipline, to facilitate communication and interaction.<br><br>- Strengthen the publication ties between mathematics and biology, through merged databases online journal access, and foster the publication of interdisciplinary papers. |

# APPENDIX E

## SUMMARY LIST OF ISSUES AND CHALLENGES FOR INTERAGENCY COLLABORATIONS CONTRIBUTED BY PARTICIPATING FEDERAL AGENCIES

The following list is a summary of the primary issues and challenges for interagency collaborations contributed by the ten participating Federal agencies during the "Agency Perspectives" session at the May 10, 2004, Interagency Workshop. The text is taken directly from agency contributions and has not been edited.

- Agreeing on common endpoints and evaluation measures combined with timing, review processes, and cultural differences.
- Genuine engagement of scientists from different disciplines.
- Development and support of research-enabling user facilities.
- "Not invented here"
- Concepts too abstract/generic to be appreciated as useful or better than status quo.
- Communication of products/critical paths with industries and funding agencies.
- Availability of research tools that advance product development.
- Opportunity for FDA to compete for extramural funding.
- Availability of critical path funds.
- Evolving agency goals and strategic plans – challenge to maintain research links with partners during agency evolution.
- Effective communication/collaboration among research agencies engaged in parallel research at a level of awareness that spans discrete projects.
- Lack of effective and dedicated communication among agencies on resources, problems, and collaboration mechanisms.
- Need staff who understand technical and biomedical issues.
- Interagency communication/procedures – cultural, financial, general knowledge

- Differing agency cultures and emphasis of missions; i.e., mission/research, intramural/extramural

- Continuity of funding commitment

- “New start” collaborations in the face of severely constrained budgets.

- Form coherent vision, joint planning, and flexible collaboration implementation mechanisms.

# APPENDIX F

## SUMMARY LIST OF PRIMARY RECOMMENDATIONS FOR COURSES OF ACTION CONTRIBUTED BY PARTICIPATING FEDERAL AGENCIES

The following list is a summary of the primary recommendations for courses of action contributed by the ten participating Federal agencies during the "Agency Perspectives" session at the May 10, 2004, Interagency Workshop. The text is taken directly from agency contributions and has not been edited.

- Agree upon goals and bring equal contributions to the table.
- Interagency development of and support for a network of high-throughput user facilities addressing diverse systems biology needs of many agencies.
- EPA is developing a sustainability research strategy to improve environmental performance – invites participation.
- Development of critical path research programs focused on issues like standards, methods, clinical trail designs, etc., that are complementary to and draw from advances in basic sciences and new technologies.
- Support for interagency working groups at the HQ level to span research disciplines and optimize resources.
- Selection of projects (regional and national) that address agency mandates and advance broad fields of research.
- Establish a multi-agency science consortium to facilitate communication and organizational collaborations.
- Develop programs for sharing and cross-training staff among agencies.
- Identify key problems/needs at the interface of the life/physical sciences (OSTP/OMB Guidance Memo)
- Executive Branch support for changing traditional funding paradigms to stimulate sustainable partnerships across agencies and disciplines
- Provide financial incentives for interagency programs.

- Create strategies for enhancing cross-agency synergies.
- Interagency working groups (IWG) for coordinated planning and implementation.

END