

**DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTES OF HEALTH
NATIONAL ADVISORY COUNCIL FOR
BIOMEDICAL IMAGING AND BIOENGINEERING**

**Summary of Meeting¹
May 29, 2003**

The National Advisory Council for Biomedical Imaging and Bioengineering (NACBIB) was convened for its second meeting on May 29, 2003 in the Neuroscience Center, conference rooms C and D, 6001 Executive Blvd., National Institutes of Health, Bethesda, Maryland. Dr. Roderic I. Pettigrew, Director of the National Institute of Biomedical Imaging and Bioengineering (NIBIB), served as Chairperson.

In accordance with Public Law 92-463, the meeting was open on May 29, 2003 from 8:45 A.M. until 1:30 P.M. for the review and discussion of program development, needs and policy, and closed to the public from 1:30 P.M. until 3:30 P.M. for discussion and consideration of individual grant applications. Two subcommittees, the Training and Career Development Subcommittee and the Strategic Plan Development Subcommittee met in open session on May 30, 2003 from 8:45 A.M. until 10:30 A.M.

Council members present:

Dr. Linda C. Lucas	Dr. Janie M. Fouke
Dr. Rebecca R. Richards-Kortum	Dr. Stephen A. Williams
Dr. Shirley A. Jackson	Dr. James A. Zagzebski
Dr. Frank C. Yin	Dr. Carlo J. De Luca
Dr. C. Douglas Maynard	Dr. R. Brent Harrison
Dr. Norbert J. Pelc	

Council member absent

Dr. Barbara J. McNeil

Ex officio members present:

Dr. John R. Livengood, Centers for Disease Control and Prevention
Dr. Arden L. Bement, National Institute of Standards and Technology
Dr. Michael W. Weiner, Department of Veterans Affairs
Dr. James G. Smirniotopoulos, Department of Defense

Ex officio member absent:

Dr. Esin Gulari, National Science Foundation

Members of the public present for portions of the open meeting:

Mr. Scott Jenkins, The Blue Sheet, FDC Reports
Mr. Ed Nagy, Academy of Radiology Research
Ms. Vicki Conte, Equals Three Communication
Mr. Steven Stocker, Equals Three Communication
Mr. Andrew Noyes, Research USA

¹For the record, it is noted that members absent themselves from the meeting when the Council is discussing applications (a) from their respective institutions or (b) in which a real or apparent conflict of interest might occur.

Ms. Melissa Murray, American Society of Mechanical Engineers International
Ms. Joanne Hawana, The Blue Sheet
Dr. Jennifer West, Rice University

NIBIB employees present for portions of the meeting:

Dr. Roderic Pettigrew	Dr. John Haller
Dr. Joan Harmon	Dr. Brenda Korte
Ms. Yvette Gordon	Dr. Alan McLaughlin
Ms. Lillian Ashley	Dr. Peter Kirchner
Ms. Colleen Guay-Broder	Dr. Christine Kelley
Ms. Cheryl Fee	Dr. Grace Peng
Ms. Christine Hollingsworth	Dr. Peter Moy
Ms. Donna Pearman	Dr. William Heetderks
Ms. Pamela Clatterbuck	Ms. Anna Retzke
Ms. Ruby Akomeah	Mr. Todd Merchak
Ms. Sandra Talley	Dr. Richard Swaja
Dr. Meredith Temple-O'Connor	Ms. Mollie Sourwine
Ms. Yinka Abu	Ms. Annette Hanopole
Mr. Stephen Green	Ms. Lisa Moeller
Dr. David George	Ms. Nancy Curling
Mr. Huy Ho	Ms. Florence Turska
Dr. Mary Pastel	Mr. Nicholas Mitrano
Dr. Bonnie Dunn	Ms. Dona Mazzara
Ms. Mary Beth Kester	Dr. Robert Nerem
Ms. Danielle Lewis	Ms. Xi Li-Yin
Ms. Rene Nowland	Ms. Joan Starr
Ms. Yvonne Talley	Dr. Edward Staab

Other Federal employees present for portions of the meeting:

Dr. Zakir Bengali, CSR
Dr. Ro Nemeth-Coslett, NIDA
Dr. Peter Lyster, CSR
Dr. Paul W. Jennings, NSF

I. Call to Order and Opening Remarks – Dr. Roderic I. Pettigrew

Dr. Pettigrew welcomed Council members, guests, and staff to the second Council meeting and provided an overview of the upcoming program. He welcomed three new members to the National Advisory Council for Biomedical Imaging and Bioengineering (NACBIB). Drs. Norbert Pelc of Stanford University and Barbara McNeil of Harvard University Medical School complete the roster of twelve appointed members. Dr. James Smirniotopoulos joins as an ex officio member for the Department of Defense. Dr. Pettigrew announced that Drs. Barbara McNeil and Esin Gulari would not be present for the meeting, but Dr. McNeil would participate in the Training and Career Development Subcommittee by teleconference on the following day. Dr. Donna Dean, Deputy Director, NIBIB would also not attend the Council meeting.

Dr. Pettigrew noted that at the previous meeting the staff had provided Council with progress reports on the development of the NIBIB and information on the scientific portfolio. The focus of this meeting would be training. There would be three presentations on the National Science

Foundation (NSF) Interdisciplinary Graduate Education and Research Training initiative (IGERT). Council member Dr. Rebecca Richards-Kortum and a guest speaker from Rice University, Dr. Jennifer West would discuss IGERT programs at their institutions. Dr. Paul Jennings, Program Director for the NSF IGERT program would conclude the presentations with comments on the success of this initiative. The NACBIB meeting would move into closed session after the lunch break for the review of applications. On Friday, May 30, 2003, the meeting would open again for the concurrent first meetings of two new subcommittees of Council, the Training and Career Development Subcommittee and the Strategic Plan Development Subcommittee.

Dr. Pettigrew requested and received approval for the minutes of the January 2003 Council meeting.

Turning to meeting dates, Dr. Pettigrew announced the following dates for future meetings of the NACBIB:

- September 11-12, 2003
- January 26-27, 2004
- May 18-19, 2004
- September 2-3, 2004

II. Review of Regulations – Dr. Joan T. Harmon

Dr. Harmon summarized the requirements under the Government in the Sunshine Act and the Federal Advisory Committee Act. These Acts require the Department of Health and Human Services (DHHS) to open to public observation as many advisory committee meetings as possible, including the meetings of the National Advisory Councils. The Council meeting, therefore, would be open to public observation except during grant application review, scheduled to begin at 12:00 P.M. and concluding by the end of the day. The meeting would reopen for subcommittee meetings on May 30, 2003. Notice of the Council meeting was published in the *Federal Register* thirty days prior to the meeting.

Dr. Harmon also reviewed regulations concerning conflict of interest, and Council members were reminded that materials furnished for review purposes and discussion during the closed portions of the meeting are considered privileged information. All Council members present signed a statement certifying that they did not participate in the discussion of, or vote on, an application from any organization, institution, or any part of a university system, except for those which have multi-campus institution waivers or are specifically designated as separate organizations under 18 U.S.C. 208(a), of which they are an employee, consultant, officer, director or trustee, or in which they have a financial interest.

III. Procedures Update – Ms. Sandra T. Talley

Ms. Talley reviewed nine proposed changes to the NACBIB Operating Procedures adopted in January 2003. These proposals would result in the following revisions:

1. Addition of text describing more fully the guidelines for NACBIB subcommittees
2. Deletion of the requirement to bring unscored applications to Council
3. Deletion of the requirement to bring applications in response to Program Announcements with specific receipt dates (PARs) and Program Announcements with a set-aside of funds (PASs) to Council for individual consideration.
4. Addition of a requirement of written justification for recommendations for support of applications outside of the program plan. These Special Considerations would be considered with individual discussion items rather than with en bloc application lists.
5. Addition of a provision that would allow applications received in response to Requests for Applications to be considered through a special early en bloc concurrence procedure, with the prior approval of Council
6. Change the voting panel for early en bloc concurrence to three members from four and allow the Director, NIBIB to appoint the same Council members to the early en bloc concurrence panel for more than one Council review round
7. Language clarification and a decrease in the review period for early en bloc concurrence procedure to 10 from 14 days
8. Eliminate the requirement for staff to provide for Council a listing of three types of administrative actions: movement of a grant from one institution to another; change in the Principal Investigator; and extensions of project periods without additional funding
9. Permission for staff to add two permanent slots to institutional training grants without approval of Council

After a brief discussion, Council approved a revised version of the NACBIB Operating Procedures incorporating all of the above changes with the exception of item 8. Council agreed to allow staff to eliminate changes in institutions and extensions without cost from the administrative actions listing. However, Council members emphasized that, during the review process, support for an application depends very heavily on an assessment of the abilities of the Principal Investigator who will lead the project. A change in the Principal Investigator, particularly to a researcher who was not part of the original proposal, represents a very significant alteration. Council therefore requested that staff retain changes in Principal Investigators on the listing of administrative actions for each Council meeting.

IV. Director's Report – Dr. Roderic Pettigrew

Dr. Pettigrew introduced his report by highlighting that consistent with the continued growth and development of the Institute, the NIBIB organizational structure had changed since the prior meeting. Significant in this new structure is a move to multidisciplinary research divisions from the old Divisions of Bioengineering and Biomedical Imaging. Replacing these divisions would be a Division of Discovery Science and Technology and a Division of Applied Science and Technology. Also included within the broad area of Scientific Programs would be a Division of Interdisciplinary Training and a Program Coordination Division. The remaining broad areas directly reporting to the Director, NIBIB would be a Division of Science Administration, a Division of Administrative Management and a future Division of Intramural Research.

Dr. Pettigrew announced that the President's fiscal year 2004 budget request for NIBIB included \$3 million for planning an Intramural Research Division. Discussions are underway with the National Institute of Standards and Technology (NIST) to obtain some space. He emphasized that existing lab facilities at NIST, such as programs in single cell imaging, tissue engineering, and neutron irradiation make this arrangement particularly attractive. Other potential collaborators include federal agencies such as the Federal Drug Administration (FDA) and the Department of Energy and other Institutes at the NIH such as the Clinical Research Center (CRC) and the National Heart, Lung, and Blood Institute. Citing the work of Dr. King Li in image-guided genomics at the CRC as an example, Dr. Pettigrew showed how these partnerships would enable NIBIB to immediately offer training opportunities in a number of research focus areas.

Dr. Pettigrew introduced several new staff members. Dr. Edward Staab, formerly of the National Cancer Institute, has joined NIBIB as the new Acting Director for the Division of Applied Science and Technology. Dr. Peter Lyster will move from the Center for Scientific Review to assume a position of Program Director in early summer. Dr. Bonnie Dunn has accepted a position as a Scientific Review Administrator with NIBIB, leaving a position as Deputy Director of the Center for Drugs of the FDA. The Scientific Review Branch of NIBIB also welcomes Ms. Brenda Mitchell as Grants Review Coordinator and Ms Yvonne Talley as a Grants Technical Assistant. Ms. Mary Beth Kester is a new Policy Analyst and Ms. Li-Yin Chi a new Budget Analyst. Two new Office Managers have been hired since January, Ms. Joan Starr for the Office of Science Policy and Ms. Lillian Ashley in the Office of the Director.

The NIBIB is currently recruiting for three Program Directors, one for the Discovery Science Division and two for the Applied Science Division, including a scientist with expertise in the area of optical imaging. The NIBIB will also hire two student interns to support the research divisions.

Dr. Pettigrew revisited with Council the proposed legislative change that will be submitted by the National Institutes of Health with the fiscal year 2005 budget request to increase the membership of the NACBIB to eighteen through the inclusion of six public representatives. He also reiterated his appreciation for Council participation on two new subcommittees, Training and Career Development and Strategic Plan Development that would meet in open session the following day.

The fiscal year 2003 budget for the Institute of approximately \$280 million approved by Congress on February 20, 2003 resulted in an operating budget of \$278 million after the departmental tap. The category of Research Project Grants continued to absorb approximately 78 percent of the budget. In assessing the amount allocated to training, Career awards (Ks) included in the Other Research category should also be considered in addition to amounts for fellowships (Fs) and institutional training awards (Ts). He underscored that NIBIB has budgeted a significant increase in funds to support training awards during fiscal year 2003 above the level allocated for fiscal year 2002. However, he noted that demand from the extramural community would determine future budget plans. The President's fiscal year 2004 budget requests approximately \$282 million for the NIBIB. NIBIB participated with other Institutes in the Congressional budget hearings in April and several positive comments about the NIBIB were

entered into the official record, included one regarding the March workshop on Imaging held at the University of Mississippi.

Dr. Pettigrew described several recent workshops sponsored by the NIBIB. A workshop on imaging brought around fifty scientists to the University of Mississippi on March 17-19, 2003 to discuss future research needs and ways of maximizing the impact of biomedical imaging on health care. The group put forth the following recommendations:

1. Increase chemists in imaging science and research
2. Support imaging training programs
3. Promote multidisciplinary research teams
4. Improve methods for image analysis, segmentation, and visualization
5. Support molecular and cellular-level imaging
6. Support data integration and analysis across modalities, subjects and scales

Dr. Pettigrew noted that the NIBIB currently has initiatives in several of these areas. Highlighting the recommendations regarding molecular imaging and the training of chemists, Dr. Pettigrew indicated that he is currently chairing one of Dr. Zerhouni's Roadmap working groups focused on molecular and cellular imaging. These working groups have been charged with defining trans-NIH activities in fifteen key areas. Discussions in Dr. Pettigrew's working group have underscored the need to train more chemists and foster future development of this field.

Three NIBIB staff members, Drs. Christine Kelley, Donna Dean and Robert Nerem played key roles in a workshop on tissue engineering and regenerative medicine sponsored by the Department of Health and Human Services. Five working groups were created at the conclusion of this meeting to continue to explore trans-agency research opportunities in this field.

An April workshop on imaging the pancreatic beta cell, jointly sponsored with the National Institute of Diabetes and Digestive and Kidney Diseases, addressed the growing problem of diabetes. The meeting investigated how new imaging technologies could contribute to improvement in therapies for diabetes through a better understanding of the impact of beta cell quantity and function on the disease process.

Dr. Christine Kelley also represented the NIBIB at a May workshop on international research and development in biosensors. Representatives from several federal agencies came together to assess biosensor technology in the areas of biomedicine, agriculture and biodefense.

Dr. Pettigrew announced several upcoming workshops to be sponsored by the NIBIB. As the administrative home of the NIH Bioengineering Consortium (BECON), NIBIB has played a major role in the planning of the BECON symposium, "Catalyzing Team Science" scheduled for June 2003. NIBIB would also convene two grantee meetings and a workshop on "Entrepreneurial Science" or how to rapidly translate discoveries into health benefits for the public. In collaboration with four radiological professional societies, NIBIB would support a meeting in August to discuss ways of increasing the pool of investigators in imaging and the radiological sciences. Planned fiscal year 2004 workshops include:

- Neural Prosthesis Workshop - October 21-23, 2003

- NIST Satellite to the BISTI Symposium: *Information Science Standards to enable Biomedical Research* – October 4-5, 2003
- BISTI Symposium: *Digital Biology: the Emerging Paradigm* – October 6-7, 2003
- NIBIB/NIST workshop: *Metrology and Standards for Cell Signaling Impact on Tissue engineering* – October 14-15, 2003
- Polymer Network Conference – TBD
- DOE/NSF/NIBIB TeraHertz Workshop - TBD

Turning to the Institute's portfolio, Dr. Pettigrew stated that the number of unsolicited applications received in fiscal year 2003 equals 2.5 times the number of fiscal year 2002. The ten Requests for Applications issued by the Institute has generated a robust response of over 1000 applications, with over two thirds of these investigators identifying themselves as new to the NIH. Also indicative of interest in the Institute by a previously untapped pool of scientific talent is the very high proportion of SBIR/STTR applications received by the NIBIB relative to other Institutes.

Since January, Dr. Pettigrew also noted, the NIBIB has joined ten initiatives led by other Institutes and formally announced in the NIH Guide, NIBIB's interest in applications for many long-standing NIH Career awards (Ks). He also reviewed ongoing training initiatives.

Dr. Pettigrew briefly described some examples of research supported by the NIBIB in five broad areas:

Molecular imaging:

- Bioluminescent imaging (e.g. luciferase) sensitive to molecular and cellular process (Drs. John Gore and Duco Jansen, Vanderbilt University)
- In vivo imaging with quantum dots (Dr. John Frangioni, Harvard University and Dr. Mounji Bawendi, MIT)

Tissue Engineering:

- The tissue engineering microfabrication laboratory (Dr. Christopher Chen, Johns Hopkins University)

Biosensors

- Micro-mechanical sensors for virus detection (Drs. R. Bashir, D. Akin, M. Ladisch, and S. Broyles, Purdue University)

Multi-modality imaging

- 7T MR Imaging (Dr. L. Wald, Massachusetts General Hospital)
- Spatio-temporal Imaging: Viewing Novel Words (Dr. Anders Dale, Massachusetts General Hospital)
- Development of imaging and visualization tools and techniques using macular degeneration of the retina (Drs. M. Miller and S. Yantis)

Bioinformatics

- Brain-computer interface system (Dr. Jonathan Wolpaw, Wadsworth Center)

Dr. Pettigrew provided a brief description of some of the concepts under consideration for possible future initiatives. The NIBIB may lead initiatives on beta cell imaging and modeling across biological scales. Collaborative initiatives on the brain communication interface and computational neuroscience are also under discussion. In the area of training, the NIBIB is

exploring a medical residents research program to encourage physicians to pursue research careers. NIBIB has under development a program to facilitate the transition of junior investigators from postdoctoral fellowships to faculty positions. NIBIB will give high priority to programs to address infrastructure needs in existing NIH institutional training grants and mechanisms to ease transitions across career levels.

Dr. Pettigrew announced that NIBIB hopes to pioneer a new type of award at the NIH to support high impact research conducted by multidisciplinary science teams that will lead to a major paradigm shift in an aspect of health care. These “Quantum Awards” would fund research designed to achieve a great leap forward in health care. Examples of this type of research would be tissue engineering of blood to reduce the need for blood donations or an operating room designed with advanced technologies that would reduce the time and associated costs involved with operating procedures.

NIBIB continues to play a leadership role in Dr. Zerhouni’s Roadmap activities. Fifteen working groups are defining potential NIH activities in three broad categories:

- New Pathways to Discovery
- Developing Research Teams of the Future
- Re-engineering the Clinical Research Enterprise

Dr Pettigrew chairs a molecular imaging working group and Dr. Dean co-chairs one on regenerative medicine, two teams under the broad area of New Pathways. The molecular imaging group has discussed the challenge of a 100 to 1000 fold increase in the sensitivity of sensors to support practical usage as well as the development of an open database of known imaging probes to foster more research in this area. He noted that the NIBIB’s “Quantum Grant” concept and other activities and initiatives are aligned with a number of the focus areas identified in the Roadmap planning process.

In the discussion that followed, Council requested further information on the presented 1 – 1.5 percent increase in the NIBIB budget from fiscal year 2003 to 2004. Dr. Pettigrew explained that the President’s 2004 budget request actually provided a two percent increase, as it was based on the President’s 2003 budget request. The actual Congressional Conference 2003 budget for NIBIB as presented in the Director’s report exceeded the President’s fiscal year 2003 request by approximately \$10 million, producing in comparison this smaller percentage increase.

Council also asked Dr. Pettigrew to explain how NIBIB would address the costly infrastructure required for some of the research areas discussed such as quantum dots. Council asked whether NIBIB would incrementally support infrastructure collaborations with other agencies such as the National Science Foundation and the Department of Defense or whether NIBIB would rely on the existence of infrastructure developed for non-biomedical research projects. Dr. Pettigrew suggested and Council agreed that infrastructure issues may be best addressed at the NIH Director’s level or through trans-government collaborations rather than by individual Institutes. Council commended the Director on the Institute’s progress and underscored that the plan to pursue the innovative “Quantum Grant” concept had tremendous support within the extramural community. In response to a query on the NACBIB’s participation in the planning process for the proposed Intramural Division, Dr. Pettigrew proposed a full discussion on the Division at a

future meeting.

V. Workshop on Imaging the Pancreatic Beta Cell – Dr. Brenda Korte

Dr. Korte described an April 21-22, 2003 workshop organized jointly with the NIDDK and the Juvenile Diabetes Research Foundation International to examine current research on beta cell imaging, encourage further research in this area among diabetologists and imaging researchers, and to identify the obstacles to the clinical utility of beta cell imaging for the assessment of parameters believed to be key to understanding the disease.

Beta cells are responsible for the synthesis and secretion of insulin needed for the uptake of glucose from the blood. Beta cells are located in the pancreas and are part of the islet that comprise the endocrine pancreas. For the 17 million Americans with diabetes this function is compromised due to immune destruction of the beta cell in type 1 diabetes or inadequate compensation as a result of insulin resistance in type 2 diabetes. Because there is no current method available to visualize the beta cell, many questions still remain regarding the natural history of diabetes, information that is essential for the prevention and cure of the disease and for identification of a pre-disease state. Currently beta cell function is assessed in vivo through measurement of insulin secretion during a hyperglycemic clamp or a glucose tolerance test. It is unknown whether insulin secretion correlates well with the number and mass of beta cells and therefore a non-invasive method to visualize the beta cell is needed.

This workshop resulted from discussions between the Directors of NIBIB and NIDDK on complementary research areas and was responsive to encouragement expressed in Senate Report No. 107-216 for support of research on the development and application of imaging technologies to evaluate and track the progress of biologic events non-invasively, specifically the investigation and monitoring of beta cell destruction during the onset of type 1 diabetes and indications of graft rejection following the transplantation of whole organs, tissue, or cells.

The meeting served as a follow-up to a 1999 workshop on the same topic sponsored by the NIDDK. The goal of the first workshop was to jump start the field of beta cell imaging and to bring together the imaging and beta cell biology communities. In response to recommendations from this workshop, the NIDDK has twice issued an initiative to stimulate the development of techniques leading to the ability to non-invasively image or detect the pancreatic beta cell.

In addition to assessing the current state of research in this area, the April workshop focused on cross-education of the imaging and beta cell biology communities. A post-workshop discussion with the NIDDK Advisory Council on beta cells, expanded to include some workshop attendees, yielded the following recommendations:

- Sharing of information from the existing NIDDK beta cell biology consortium with the imaging community
- The development of imaging agents with an emphasis on FDA approved probes that could be extended to human studies and exploration of new approaches to facilitate FDA approval of new imaging agents
- Development of “minimally invasive” technology for micro-imaging

- Development of new approaches to imaging inflammation of transplanted islets
- Development of new approaches that use imaging to provide surrogate markers for clinical trials
- Incorporation of insulin-secreting cells within artificial matrices that can be implanted for the treatment of diabetes

Dr Korte noted that several of NIBIB's current initiatives address many of the challenges identified in the workshop, including RFAs on molecular and cellular imaging, small animal imaging, image-guided interventions, improvements in imaging technology, and tissue engineering. Possible future initiatives in this area may include one on micro-imaging of pancreatic islets in vivo and the chemistry/molecular biology of imaging agents.

VI. Integrating Graduate Education and Research – Dr. Rebecca Richards-Kortum

Dr. Richards-Kortum presented on her multidisciplinary graduate training program at the University of Texas at Austin (UTA). This program was funded in 1998 through the NSF IGERT program. Initiated in 1997 to meet the challenges of interdisciplinary education, the NSF IGERT program currently funds 100 sites involving 2000 faculty and 2000 graduate students. An overarching goal of this program is to support innovative projects that will catalyze cultural change in graduate education and training.

The UTA program in optical biomolecular engineering brings together twenty-two faculty within seven departments and two schools to train scientists to have a wide breadth of skills in optical engineering, biochemistry, and cellular and molecular biology. Organized around four primary research areas of: optical imaging; optical spectroscopy; optical manipulation; and optical biosensors, the program is designed to: provide knowledge crossing disciplines; impart skill in the effective management of multi-disciplinary collaborations; and vertically integrate optics education and research from single molecules to intact tissues.

Although the program initially included a terminal Masters as well as a PhD program, the former was eliminated. The PhD program is a "discipline plus" approach that requires trainees to obtain their degree from a chosen department with some additional requirements. Students must select co-advisors from two departments and design research that can be conducted jointly in both departments. Students must also complete a series of new multi-disciplinary courses and two new lab courses. Industrial internships are encouraged during the two years that students are supported under IGERT. Post-IGERT support is provided through advisors' research grants.

Dr. Richards-Kortum is investigating optical imaging methods that will enable early detection of cervical cancer. As an example of the type of collaboration facilitated by the IGERT, Dr. Richards-Kortum described research that is being conducted in her lab in conjunction with the Chemistry Department. One of Dr. Richards-Kortum's advisees is attempting to develop organic fluorescent contrast agents, which are conjugated to monoclonal antibodies against biomarkers that are known to be expressed in cervical cancer and to develop miniature microscopes to visualize those contrast agents in vivo. Dr. Richards-Kortum works with a second student in the Chemistry department on a project to develop contrast agents based on metal nanoparticles that

also uses some of the microscopy techniques developed in Dr. Richards-Kortum's lab to image those contrast agents in vivo.

Dr. Richards-Kortum emphasized the positive impact of IGERT students and the program on research at UTA in opening up new sources of research funding and expanding opportunities for interdisciplinary projects.

A formal assessment of the IGERT program revealed several challenges for students and faculty. Student projects that originated with two advisors and departments work better than those that add a second discipline after formulation. Students also tend to find the additional requirements of the IGERT program somewhat burdensome. The faculty involved in IGERT has experienced some difficulty in developing courses for a diverse group of students from different departments and in obtaining teaching credit for team-taught courses. Dr. Richards-Kortum indicated that the institutional impact of IGERT can be seen through the establishment of multidisciplinary efforts at UTA, including a new Center for Nano and Molecular Science and Technology and a new Biomedical Engineering Department. There has also been an increase in the number of interdisciplinary publications and participation in inter-disciplinary patents by IGERT faculty.

The renewal application for the IGERT grant will emphasize cellular and molecular imaging for diagnostics and therapeutics. The proposal adds a certificate program in multi-disciplinary coursework and a requirement for a third advisor to support students in clinical internships that elucidate technology assessment and transfer issues.

Dr. Richards-Kortum described steps taken by UTA to integrate undergraduate education and research. With support from the Howard Hughes Medical Institute Professors Program, UTA is using technology assessment as a basis for integrating research and education. Undergraduate courses have been developed that examine major human health problems, technologies that address these problems, and the process of assessing these technologies through clinical trials.

For the NIBIB, Dr. Richards-Kortum suggested beginning with initiatives for undergraduates that will support them in becoming critical thinkers who understand the need to work in teams with multi-disciplinary approaches to research. This preparation will enable them to work in a similar manner at a higher level as graduate students and become the multi-disciplinary practitioners in their chosen fields.

In response to questions from Council on outcomes, Dr. Richards-Kortum indicated that two IGERT students had postdoctoral positions where their multi-disciplinary training was viewed as an asset and one student went to industry. The time to degree averages five years, a time fairly typical for the Engineering Department. Undergraduate biomedical engineering students appear to receive the same foundation as students in more established engineering departments. Sufficient data are not available to assess the impact of the undergraduate research experience on the choice to pursue graduate education.

VII. Graduate Training in Cellular Engineering – Dr. Jennifer West

Dr. West presented on the graduate training program in cellular engineering at Rice University established originally under the leadership of Dr. Larry McIntire with support from an NSF IGERT award. With many existing interdisciplinary collaborative research institutes, Rice possessed a long-standing commitment and the administrative structure to easily accommodate the IGERT program. Close proximity to the Baylor College of Medicine and the University of Texas Health Science Center facilitate shared programs and research.

The IGERT is housed in the Institute of Bioscience and Bioengineering. It provides a stipend and some travel funds for ten doctoral students during the second and third year of training and a summer training experience for ten undergraduates. Bringing together twenty-four faculty members from the Departments of Natural Sciences and Engineering, the program supports research focused in four theme areas: muscular and skeletal tissue engineering; cardiovascular tissue engineering; cell migration and motility; and metabolic engineering. The program aims to train scientists and engineers with skills that cross the fields of molecular and cell biology, biochemistry, and engineering.

The program shares many features with the UTA IGERT program. Each student is guided by an advisor from a bioscience department and one from engineering, complete coursework and special seminars in the biosciences and engineering, and participate in a University sponsored industrial internship. This work is complemented by a variety of activities, including research retreats, professional society meetings, and special seminars. To expose students to areas of cellular engineering not represented by Rice faculty, the program invites outside scientists from academia, industry and government to spend a semester or year at the school.

Through a partnership with a Houston school district, the program's community outreach component contributes to science education in this district enrolling 85 percent minority students. Rice students develop instructional modules on topics in science, teach in high school classrooms, and encourage high school students to pursue careers in science and engineering, possibly beginning with an internship at Rice through the University's High School Science Academy. IGERT students also play a major role in the Undergraduate Research Program, acting as mentors and coordinating a summer seminar series for program participants.

One student has obtained a doctorate through this program and several are slated to complete the program this year. In response to a question regarding the difficulty of bringing students from different backgrounds to the same level, Dr. West agreed that this challenge remains, especially bringing life science students into engineering, with the level of math required. A student's background in math has become a critical selection factor for the program.

VIII. Graduate Education and Research: An Interdisciplinary Perspective – Dr. Paul W. Jennings

Dr. Jennings, Program Director for the NSF IGERT Program summarized some of the developments that led to the creation of the initiative. In the 1980's and 90's, discussions on graduate education led to the publication of many papers on the need to address several aspects of graduate training, including breadth of perspective, career development, mentoring, diversity,

global awareness, and communication and computer skills. The IGERT program challenges universities to devise experimental, flexible approaches to graduate training to address some of these issues and to create students and faculty who have the portfolio of skills needed to solve complex problems in science. The solicitation requests proposals that have a problem based research theme, address professional and personal development, attract a diverse group of students, impart a global perspective and support the development of multidisciplinary skills.

IGERT programs are located at one hundred characteristically varied sites, with concentrations on the east and west coasts. Some institutions have several programs. These are five-year awards of roughly \$500,000 - \$650,000 per year. NSF makes twenty to forty awards each year. While NSF had been receiving in the range of 250 to 300 applications, this year 425 came in, out of which 103 have passed the first round of review.

In assessing the IGERT program, Dr. Jennings indicated that NSF is looking at the impact of the programs on the students, faculty and institutions. Successful programs lead to increased productivity and more faculty collaborations. Cohort learning and less competitive interactions among students are encouraged. A multi-authored thesis or a seminar featuring students from different disciplines addressing the same topic is a frequent occurrence. Interdisciplinary concepts are introduced many times in the first year to provide context for prioritizing knowledge. In short the IGERT program is supporting behavioral change that hopefully will mutate into permanent cultural change.

Many of the barriers to success have fallen since the IGERT's inception. However, the program has experienced limited success in attracting minorities, enrolling only 8-9 percent overall.

Responding to questions from Council, Dr. Jennings indicated that the measurement of success for the IGERT program would be the impact of the program on the students, faculty and institutions. NSF is gathering data to ascertain if campuses are changing, including vertically up to the administration, and if the concepts are moving from one campus to another and beyond the borders of the United States. Models created through the program are being adopted in Korea and Switzerland.

Returning to an earlier question on the preparation of biomedical engineering students relative to other engineering students, it was stressed that these students fare equally in the placement process, with biomedical engineering students sometimes being preferred. In the current job market, much consideration is given to the type of courses completed.

IX. Closing Remarks – Adjournment – Dr. Roderic Pettigrew

Dr. Pettigrew drew attention to the framed gavel and photograph on display from the first NACBIB meeting. He acknowledged the staff for organizing the meeting and for all the work since the last Council. The open portion of the meeting was adjourned at 12:15 P.M.

X. Closed Session – Review of Applications

This portion of the meeting, involving specific grant review, was closed to the public in accordance with the provisions set forth in Section 552b (c) (4) and 552b (c) (6) Title 5, U.S. Code and 10(d) of the Federal Advisory Committee Act, as amended (5 U.S.C. appendix 2).

We certify that, to the best of our knowledge, the foregoing minutes and attachments are accurate and complete.

Joan T. Harmon, Ph.D.
Executive Secretary
National Advisory Council for Biomedical
Imaging and Bioengineering
Deputy Associate Director, Office of
Science Administration
National Institute of Biomedical Imaging
and Bioengineering

Roderic I. Pettigrew, Ph. D., M.D.
Chairperson,
National Advisory Council for Biomedical
Imaging and Bioengineering
Director
National Institute of Biomedical Imaging
and Bioengineering

The Council will consider these minutes at its next meeting. Corrections or notations will be incorporated in the minutes of that meeting.