

NIBIB WORKSHOP ON BIOENGINEERING AND BIOMEDICAL IMAGING TRAINING

Richard E. Swaja (NIBIB) and H. Troy Nagle (NCSU)

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EXECUTIVE SUMMARY

The National Institute of Biomedical Imaging and Bioengineering (NIBIB), the newest of the NIH research institutes, supports research and training that advances the multi-disciplinary areas of bioengineering (BME) and biomedical imaging (BMI). To ensure that NIBIB initiatives address important needs and issues, input is solicited from relevant extramural and intramural scientific communities during program development and implementation. To provide community input on BME and BMI training issues, the NIBIB conducted a workshop on August 26-27, 2002, at the Bethesda Marriott Hotel in Bethesda, Maryland. Thirty extramural participants from academia and foundations with direct interests in BME and BMI research training and eleven training staff members from government agencies (NIH and NSF) were invited to participate and provide their perspectives on training needs and issues. The general objective of this workshop was to develop specific recommendations for the NIBIB to consider in the development of its research training programs.

Taking into account (1) the strong associations of BME and BMI with specific extramural communities and (2) the similarities in research approaches and training needs, the workshop agenda was aimed at initially identifying issues and challenges specific to each area and then combining perspectives to develop consensus recommendations. Workshop discussions provided several common themes regarding important considerations for NIBIB training programs in general including the needs to consider the entire career continuum from pre-undergraduate through senior career levels; multi-disciplinary, integrative approaches to problem solving; collaborations among the NIBIB, other NIH institutes and centers, other federal agencies, professional societies, and academia; adequate infrastructure to support NIBIB training programs and demonstrate commitment to training; outreach and communication initiatives; consideration of under-represented populations and persons with disabilities; and a BME and BMI needs assessment to provide a basis for training programs.

Specific consensus recommendations resulting from this workshop included:

- Provide programs for institutional and individual training support (pre-and post-doctoral) using current or modified NIH mechanisms to stimulate inter-disciplinary, thematic programs. Provisions to include support for faculty salaries, curriculum development, materials, methods development and assessment, and infrastructure should be included. Emphasis on individual and institutional training programs at the pre-doctoral level is necessary to attract undergraduates majoring in bioengineering and the quantitative disciplines to graduate programs in BME and BMI.
- Develop NIBIB (and possibly interagency) programs to support:
 - Pre-undergraduate and undergraduate programs aimed at attracting quantitative science students to BME and BMI careers.
 - Junior graduate student fellowships.
 - New faculty research awards for young, untenured faculty.
- Develop an institutional training opportunity that addresses needs associated with trans-disciplinary training and current academic environments. The opportunity should allow flexibility for the principal institution to encourage and support horizontal (inter-departmental) and vertical (various stages of career development) integration in the implementation of the training program.
- Develop a one-year research-training program for radiology residents and radiologists aimed at attracting these persons to academic research careers.
- Support “centers of training excellence” that are multi-institutional and inter-departmental.
- Interface the clinical sciences, basic sciences, and industry in future NIBIB training initiatives.
- Support short-term faculty and student training courses on high-tech and new instrumentation.

These recommendations and other results of the workshop will be evaluated by the NIBIB and considered during the development and implementation of Institute training programs.

WORKSHOP SUMMARY AND RECOMMENDATIONS

BACKGROUND

Research institutes and centers at the National Institutes of Health (NIH) make significant investments in research training, education, and career development to assure the availability of future generations of highly-trained professionals to conduct biomedical research aimed at improving human health and quality of life. The development of trained investigators for biomedical research requires opportunities and support all along the career continuum including the K-12, undergraduate, pre-doctoral, post-doctoral, junior career, and senior career levels. Considering the benefits realized by multi-disciplinary integrative approaches to address problems in biology and medicine, training programs that involve trans- or cross-disciplinary interaction between the quantitative (engineering, physical, and computational) sciences and the biomedical sciences are important to effectively facilitate future advances.

The National Institute of Biomedical Imaging and Bioengineering (NIBIB), the newest of the NIH research institutes, supports research and training that advances the multi-disciplinary areas of bioengineering (BME) and biomedical imaging (BMI). To ensure that NIBIB initiatives address important needs and issues, input is solicited from relevant extramural and intramural scientific communities during program development and implementation.

To provide community input on trans-disciplinary training issues, the NIBIB conducted a workshop on August 26-27, 2002, at the Bethesda Marriott Hotel in Bethesda, Maryland. Thirty extramural participants from academia and foundations with direct interests in BME and BMI research training and eleven training staff members from government agencies (NIH and NSF) were invited to participate and provide their perspectives on training needs and issues. The agenda and the list of attendees (invited extramural BME and BMI participants, government and agency participants, observers, and NIBIB staff) are attached as Appendices A and B, respectively.

The general objective of this workshop was to develop specific recommendations for the NIBIB to consider in the development of its research training programs. All participants were asked to identify (1) significant issues and challenges in BME, BMI, and multi-disciplinary training that need to be addressed and (2) the highest priority of these issues. NIH and agency participants were also asked to identify (1) current multi-disciplinary training programs at the NIH and other agencies and how the NIBIB can complement these programs, (2) the most effective mechanisms and methods for incorporating training into research programs, and (3) issues and concerns that the NIBIB needs to consider in the development and implementation of its training programs based on NIH and agency experience.

WORKSHOP FORMAT

For the purposes of this workshop, bioengineering and biomedical imaging were considered to be multi-disciplinary fields that involve the application of methods and principles from the quantitative sciences to address problems in biology and medicine. BME was considered to be a broad area that encompasses (1) the basic engineering discipline of “bioengineering” with cellular and molecular biology as the underlying core science and (2) “medical engineering” which represents the application of quantitative science fields to clinical medicine. Research associated with the former requires training in the biological sciences and includes the development of molecular-to-systems analytical models and the synthesis of new products such as engineered molecules and tissues. Research associated with the latter requires in-depth training in the physical, engineering, and computational sciences as well as some training in physiology and clinical medicine, and encompasses a wide range of endeavors such as devices, instrumentation, and materials. Medical engineering research does not generally require comprehensive training in biology especially at the cellular and molecular levels.

BMI is also a broad area that involves the application of quantitative sciences to detect and visualize biological and disease processes and to affect medical intervention. Biomedical imaging is very strongly grounded in radiology with related research encompassing the (1) clinical [whole-body] and (2) cellular-molecular levels. General approaches and training requirements for BMI research are consistent with those of the “bioengineering” and “medical engineering” fields associated with BME.

Taking into account (1) the strong associations of BME and BMI with specific extramural communities and (2) the similarities in research approaches and training needs, the workshop agenda was aimed at initially identifying issues and challenges specific to each area and then combining perspectives to develop consensus recommendations. Three separate breakout groups consisting of BME, BMI, and NIH/agency training staff met during the morning of August 27 to address the workshop objectives for their specific communities. Following these breakout sessions, the highest priority issues and challenges based on the community-specific morning discussions were identified during a plenary session and used as the basis for afternoon breakout sessions. During the afternoon sessions, three breakout groups each consisting of a mix of BME, BMI, and NIH/agency staff developed specific recommendations for the NIBIB to consider to address the priority issues. The groups assembled in a final plenary session after the afternoon breakouts and developed consensus recommendations for the NIBIB.

SUMMARY OF AREA-SPECIFIC DISCUSSIONS

During the morning breakout sessions, three separate groups met to discuss issues specific to their areas of interest. The following text provides summaries of the BME, BMI, and NIH/agency discussions.

Biomedical Engineering

BME representatives addressed (1) training program objectives and (2) priority issues for the NIBIB to address. With regard to objectives, consensus items that needed to be considered in trans-disciplinary training programs included:

- Quantitative approaches to biology.
- Inter-disciplinary approaches to research (team-based and integrative problem solving).
- Creation of advanced technologies.
- Understanding of modern biology.
- Opportunities for basic science, clinical science, and industry interactions.
- Training for life-long learning and adaptability.
- Applying engineering approaches to advance understanding of biology and medicine.

The BME highest priority issues for the NIBIB to address included:

- Institutional training grants – General training programs, targeted inter-disciplinary programs, supplements to major research programs (e.g., Bioengineering Research Partnership [BRP] and Program Project Grant [PPG]), and programs that stimulate the interface with basic science, clinical, and industrial sectors.
- Individual graduate fellowships.
- Support for early career development.
- Support for curriculum development including courses, materials, and assessment.
- Undergraduate research experience similar to the Research Experience for Undergraduates [REU] program.
- Supplements for training or short-course development on high-tech, complex instrumentation (e.g., atomic force microscopy, microarrays, and imaging) in ways that will impact the overall community.

The need to support training at the graduate level was emphasized by the group. There are probably more than 100 bioengineering undergraduate programs in the United States, and these will provide excellent students for graduate programs in bioengineering and biomedical imaging. Support for these students is a must to attract them to graduate school. New departments and programs will be challenged for resources. The group consensus was that institutional training grants and individual pre-doctoral fellowships should be given high priority to meet this need. Related

training initiatives must recognize the cost of high quality training programs and factor this into the development of specific solicitations.

The group also identified the planned ending of the Whitaker Foundation in 2006 as an issue that needs to be considered. The Foundation has been a major catalyst for BME research and training, and consideration needs to be given to how program and funding gaps resulting from its ending can be addressed. In particular, two very successful Whitaker BME programs that should be considered include the new faculty research awards and the graduate student fellowships. Continuation of the new faculty research awards (career awards) is necessary in view of the large number of young, untenured faculty members in BME that are supported by Whitaker awards. Concern was expressed that if these awards are not replaced in some way, a large number of junior BME faculty will not be able to meet long-term career objectives. With regard to graduate student fellowships, support is needed for junior BME graduate students (i.e., ones that aren't eligible for traditional post-doctoral and graduate training awards). Whitaker has been a valuable source of funding for students at this level.

Biomedical Imaging

BMI representatives identified the following training issues for the NIBIB to consider:

- Identify biomedical imaging pipeline and educational needs.
- Acknowledge the existence of various types of biomedical imaging programs; i.e., those from medical physics, radiology, BME, biophysics, optics, etc.
- Programs that train individuals who will create fundamental knowledge and investigate/develop new imaging techniques.
- Programs need to be inter-disciplinary in nature.
- Continuum of education programs starting at high school and extending through undergraduate, pre- and post-doctoral, and career levels, and including basic science and clinical faculty.
- Funding for faculty including basic and clinical scientists (e.g., develop new curricula, train the trainers, etc.).
- Support of infrastructure.
- Need more trained PhD biomedical researchers and clinical scientists.
- Need to retain radiology residents and radiologists in academic research careers (i.e., provide one-year research training opportunity for radiology residents).
- Multi-institutional training programs.
- Learning and training centers of excellence (e.g., multi-institutional programs that combine research and training).

The group emphasized the need for a one-year training program for radiology residents or radiologists that is aimed at attracting them to research careers. The consensus was that while a two-year program might be more effective with regard to providing a comprehensive research experience, one year is probably more practical based on current radiology programs. The importance of providing competitive salaries for the trainees was also emphasized.

NIH/Agency

The eleven representatives of NIH and other agency (NSF) training staff identified (1) program development and implementation issues and recommendations based on their experience and (2) NIBIB actions to address the issues. The following issues and recommendations were discussed:

- Council emphasis – A subcommittee on training and career development should be part of the NIBIB Advisory Council to demonstrate the Institute’s commitment to this area.
- Adequate dedicated NIBIB training staff is needed to respond effectively and rapidly to inquiries and program changes and to provide a specific point-of-contact.
- Develop specific objectives for NIBIB training programs (e.g., define career paths and transition points, develop independent investigators and “team” players, promote inter-disciplinary training, provide the flexibility to use existing mechanisms or develop new ones, and determine the relationship of training programs to the research base and NIBIB research priorities).
- Develop program assessment strategies including types of data to be collected, collection strategies, best practices, etc.
- Maintain flexibility in programs to facilitate adjustment to changing needs and directions.
- Mentors need to be identified and developed.
- Trans-disciplinary training opportunities should include biomedical-to-engineering and engineering-to-biomedical options.
- Concern for under-represented groups should be a consistent issue for NIBIB training programs.

Recommendations for actions to address these issues include:

- Conduct a career needs assessment – Work with societies, agencies, foundations, etc. to determine near- and long-term needs for BME and BMI researchers. This information is needed early in the development process and will help to focus training programs and determine what areas need to be emphasized.
- Hire a training coordinator to provide a point-of-contact and to facilitate rapid response to inquiries.
- Mentoring workshops in conjunction with grantee meetings to develop effective training mentors.
- Develop programs for outreach and partnerships – Provide outreach activities with professional societies, research centers, and institutions to advertise programs and obtain continued feedback on Institute efforts.
- Provide outreach to students – This is especially critical for communicating opportunities and options to appropriate groups. The NIBIB must have adequate infrastructure to support positive Institute-student interactions.

- Work with other NIH institutes/centers and other federal agencies to develop complementary training opportunities. NIBIB could help coordinate intra-NIH multi-disciplinary training activities.
- Manage transitions between different career stages.
- Consider year-off BME and BMI training opportunities for medical students.
- Consider maximizing funding at the legislative cap at the post-doctoral level to be competitive.
- Incorporate training modules into center grants – allow the center to specify training programs.
- Offer training supplements for existing research grants including evaluation criteria to ensure adequate investigator investment
- Provide cross-disciplinary training for PhD-level scientists and possible MS training in some disciplines
- Support undergraduate research at graduate schools similar to the REU program.
- Consider training partnerships with NIH intramural programs. NIH intramural research programs offer research staff and equipment that could support biomedical training opportunities.

Discussions during the NIH/agency training representatives session emphasized the needs (1) to have a solid research base (including academia, industry, and research laboratories) to support an effective research training program, (2) to base the training program on a detailed needs assessment, (3) to set specific goals and to develop mechanisms to assess the efficacy of the programs, and (4) to work in collaboration with other NIH institutes/centers and federal agencies. The recommendation to demonstrate the Institute's commitment to training by (1) having a training subcommittee as part of the NIBIB Advisory Council and (2) having a dedicated training coordinator was also emphasized.

RECOMMENDATIONS

To meet the primary objective of the workshop, the final plenary session provided consensus specific recommendations for the NIBIB to consider for (1) initial training initiatives and (2) issues to consider as programs are developed. General discussion indicated that similarities in research approaches and training needs for BME and BMI supports the development of training programs that bridge these areas. Discussion also emphasized the need to support training at all career levels, trans-disciplinary collaboration, and cooperative efforts with other NIH institutes/centers and other federal agencies. Communication and cooperation with the extramural science community through professional societies, foundations, and organizations were identified as being necessary to ensure the relevance and efficacy of the NIBIB's programs.

Specific consensus recommendations for initial NIBIB training efforts included:

- Provide programs for institutional and individual training support (pre-and post-doctoral) using current NIH mechanisms to stimulate inter-disciplinary and thematic programs. Provisions to include support for faculty salaries, curriculum development, materials, methods development and assessment, and infrastructure should be considered. Emphasis on individual and institutional training programs at the pre-doctoral level is necessary to attract undergraduate bioengineering and quantitative discipline majors to graduate programs in BME and BMI.
- Develop NIBIB (possibly interagency) programs to support:
 - Pre-undergraduate and undergraduate programs aimed at attracting quantitative science students to BME and BMI careers.
 - Junior graduate student fellowships.
 - New faculty research awards for young, untenured faculty.
- Develop an institutional training opportunity (similar to the NIH T32) that addresses needs associated with trans-disciplinary training and the current academic environments. The opportunity should allow flexibility for the principal institution to encourage and support horizontal (inter-departmental) and vertical (various stages of career development) integration in the implementation of the training program. These integrations would be aimed at fostering collaborations among diverse faculty and enabling students and staff at different career levels (high school, undergraduate, graduate, post-doctoral) to work side-by-side. The program should facilitate the establishment of a sequence of courses and research training opportunities that treat learning as a continuous process. Support and recognition for faculty coordinators, funding for materials and support staff, and funding for curriculum development would be important parts of this initiative. The opportunity should also recognize that cross-disciplinary training can be accomplished within a single program in addition to multi-departmental or multi-organizational approaches.
- Develop a research-training program for radiology residents and radiologists aimed at attracting these persons to academic research careers. A one-year research opportunity for radiology residents would be an appropriate initial action.
- Support “centers of training excellence” that are multi-institutional and inter-departmental. These centers could be supported by several federal agencies.
- Consider programs that interface the clinical sciences, basic sciences, and industry in future NIBIB training initiatives. These programs may be incorporated into multi-organizational research opportunities. An option is to incorporate training into multi-organizational, multi-disciplinary research collaborations modeled after the NSF IGERT or as part of NIH BRP-type programs.

- Support short-term faculty and student training courses on high-tech and new instrumentation (e.g., atomic force microscopy, microarrays, and molecular imaging) that will impact the broad research community.

Important issues that need to be considered by the NIBIB in the development and implementation of its training programs include:

- Conducting a formal career needs assessment to provide a basis for training programs.
- Communicating and working with professional societies, agencies, and foundations involved with BME and BMI to ensure that programs are relevant and effective.
- Clarifying the scope and relationship of training programs for BME and BMI.
- Demonstrating the Institute's commitment to training by providing (1) a training subcommittee as part of the NIBIB Advisory Council and (2) a dedicated training coordinator.
- Coordinating training efforts with other NIH institutes and with other federal agencies.
- Ensuring that mentors are adequately trained and assessed by developing appropriate criteria and conducting mentoring training seminars.
- Developing and implementing outreach programs to inform students and faculty about NIBIB opportunities and programs.
- Ensuring that under-represented populations and persons with disabilities are considered in all training initiatives.
- Encompassing the entire career continuum from pre-undergraduate through senior career levels.

SUMMARY

Recommendations resulting from this workshop will be evaluated and considered by the NIBIB in the development and implementation of its research training programs. Results of this workshop will be made available to other agencies, NIH institutes and centers, and professional societies by posting on the Internet.

ACKNOWLEDGEMENTS

The substantial contributions of Stephen Green, John Haller, and Mariaileen Sourwine of the NIBIB in the development and conduct of this workshop are gratefully recognized and acknowledged. The efforts of other NIBIB staff including Cheryl Fee, Kina Forrest, Sandra Talley, Meredith Temple, and Stacy Wallick in supporting logistics and information management are also gratefully acknowledged. Special acknowledgements are extended to invited workshop participants Dr's. Alison Cole, Maryellen Giger, Bettie Graham, Ronald Kalil, Linda Lucas, Kenneth Lutchen, Douglas Maynard, and Lawrence Schramm for their excellence in moderating the breakout sessions and providing summaries during the plenary sessions. The genuine concern and commitment demonstrated by all invited participants from academic organizations, NIH institutes and centers, and other federal agencies is recognized and very much appreciated by the workshop organizers.

APPENDIX A

NIBIB Workshop on Biomedical Imaging and Bioengineering Training

August 26-27, 2002
Bethesda Marriott Hotel
Bethesda, Maryland

AGENDA

Monday, August 26

6:00 PM – Orientation Dinner – Bethesda Marriott Hotel – Salon I

7:15 – Objectives and NIBIB Training Programs – Dick Swaja (NIBIB)

7:35 - NIH Training Programs and Mandates – Walter Schaffer (NIH/OER)

8:00 – Adjourn

Tuesday, August 27

8:00 – Welcome and Charge – Salon III

8:30 – Breakout Sessions I - Issues and Challenges in Multi-Disciplinary Training
Biomedical Imaging – Room 1626
Bioengineering – Room 1636
NIH and Agency representatives – Salon III

10:00 – Break – Session chairs prepare summaries – Salon III

10:30 – Plenary Session – Discussion of issues and challenges – Salon III

11:30 – Lunch Break – Salon III, Room 1626, and Room 1636

12:00 PM – Breakout Sessions II (Working Lunch) – Recommendations for NIBIB to
Address Issues and Challenges - Salon III, Room 1626, and Room 1636

1:30 – Break – Session chairs prepare summaries –Salon III

2:00 – Plenary Session – Discussion of Highest Priority Issues and
Recommendations – Salon III

3:30 – Adjourn

APPENDIX B

NIBIB TRAINING WORKSHOP PARTICIPANTS

Invited Biomedical Imaging and Bioengineering Representatives:

David J. Anderson, Ph.D.

University of Michigan
Electrical Engineering and Computer
Science Departments
1301 Beal Ave.
Ann Arbor, MI 48019-2122
Tel: 734-763-4367
Fax: 734-763-8041
E-Mail: dja@umich.edu

Angela Belcher, Ph.D.

Department of Chemistry and
Biochemistry
WEL 4.314
University of Texas at Austin
Austin, TX 78712
Tel: 512-471-1154
Fax: 512-471-8696
belcher@mail.utexas.edu

Patrick E. Crago, Ph.D.

Professor and Chairman of Biomedical
Engineering
Case Western Reserve University
Wickenden Building 319
Cleveland, OH 44106
Tel: 216-368-3977
Fax: 216-368-4969
E-Mail: Pec3@po.cwru.edu

Michael D. Devous Sr., Ph.D.

Professor of Radiology
Director, Center for Brain, Cognition,
and Behavior
Associate Director, Nuclear Medicine
Center
University of Texas Southwestern
Medical Center
Adjunct Professor of Human
Development (Neuroscience) and
Communication Disorders
University of Texas at Dallas
Dallas, TX 75390-9061
Tel: 214-648-3315
Fax: 214-648-5641
E-Mail:
michael.devous@utsouthwestern.edu

Katherine Ferrara, Ph.D.

Professor and Chair,
Dept. of Biomedical Engineering
1021 Academic Surge
One Shields Ave
UC Davis, Davis, CA 95616
Tel: 530-754-9436
Fax: 530-754-5739
E-Mail: kwferrar@ucdavis.edu

Gary D. Fullerton, Ph.D.

Director of Radiological Sciences
Malcolm Jones Professor of Radiology
University of Texas Health Science
Center
7703 Floyd Curl Drive
Radiology Department
San Antonio, TX 78229-3900
Tel: 210-567-5550
Fax: 210-567-5549
E-Mail: fullerton@uthscsa.edu

Maryellen L. Giger, Ph.D.
Professor, Department of Radiology
Director, Graduate Programs in Medical
Physics
University of Chicago
Department of Radiology, MC2026
Chicago, IL 60637
Tel: 773-702-6778
Fax: 773-702-0371
E-Mail: m-giger@uchicago.edu

Thomas R. Harris, M.D., Ph.D.
Orrin Henry Ingram Distinguished
Professor of Engineering, Medicine,
and Chemical Engineering
Chair, Department of Biomedical
Engineering
Room 5824B, Stevenson Center
Box 351724, Station B
Vanderbilt University
Nashville, TN 37235
Tel: 615-322-0842
Fax: 615-343-7919
E-Mail: Thomas.r.harris@vanderbilt.edu

Gary D. Hutchins, Ph. D.
John W. Beeler Professor
Vice Chairman for Research
Department of Radiology
Indiana University School of Medicine
541 Clinical Drive, Room 157
Indianapolis, IN 46202-5111
Tel: 317-274-3687
Fax: 317-274-8123
E-Mail: gdhutchi@iupui.edu

G. Allen Johnson, Ph.D.
Charles E. Putman University Prof. of
Radiology
Professor of Physics & Biomedical
Engineering
Director, Center for In Vivo Microscopy
Box 3302 Duke Medical Center
Durham, NC 27710
Tel: 919-684-7754
Fax: 919-684-7158
E-Mail: gaj@orion.mc.duke.edu

Ron Kalil, Ph.D.
Ophthalmology & Visual Sciences
Medical Sciences Building Room 173
University of Wisconsin - Madison
Madison, WI 53706
Tel: 608-262-4903
E-Mail: rekalil@facstaff.wisc.edu

Ella Kazerooni, M.D.
Department of Radiology
University of Michigan
1500 E. Medical Center Dr
Ann Arbor, MI 48109-0326
Tel: 734-936-4366
Fax: 734-936-9723
E-Mail: ellakaz@umich.edu

Elvira Lang, M.D.
Beth Israel Deaconess Medical Center
308 CC, Department of Radiology
Harvard Medical School
330 Brookline Ave
Boston, MA 02115
Tel: 617-754-2513
Fax: 617-754-2561
E-Mail: elang@caregroup.harvard.edu

John H. Linehan, Ph.D.
Vice President
The Whitaker Foundation
1700 North Moore Street, Suite 2200
Arlington, VA 22209
Tel: 703-528-2430
Fax: 703-528-2431
E-Mail: linehan@whitaker.org

Linda Lucas, Ph.D.
University of Alabama at Birmingham
100 Hoehn Engineering Building
1150 - 10th Avenue South
Birmingham, AL 35294-4440
Tel: 205-975-5890
Fax: 205-934-8437
E-Mail: llucas@eng.uab.edu

Kenneth R. Lutchen, Ph.D.

Professor and Chairman,
Biomedical Engineering
Boston University
44 Cummington St
Boston, MA 02215
Tel: 617-353-1956
Fax: 617-353-6766
E-Mail: klutch@bu.edu

Robert F. Mattrey, M.D.

Professor of Radiology
University of California
San Diego, CA 92103-6902
Vice Chairman, Director of Research
MRI Institute
410 Dickinson St.
San Diego, CA 92103-6902
Tel: 619-543-6766
Fax: 619-298-8559
E-Mail: rmattrey@ucsd.edu

C. Douglas Maynard, M.D.

Professor of Radiology
Wake Forest University School of
Medicine
Winston-Salem, NC 27157-1088
Tel: 336-716-7260
Fax: 336-716-4840
E-Mail: dmaynard@wfubmc.edu

Larry V. McIntire, Ph.D.

Department of Bioengineering
Institute of Biosciences and
Bioengineering
Rice University
6100 Main Street, MS-144
Houston, Texas 77005
Tel: 713-348-4903
Fax: 713-348-5154
E-Mail: mcintire@rice.edu

Norbert J. Pelc, Sc.D.

Department of Radiology
Stanford University
Lucas Center for MR Spectroscopy and
Imaging
MC 5488
Stanford, CA 94305-5488
Tel: 650-723-0435
Fax: 650-723-5795
E-Mail: pelc@stanford.edu

Ron Price, Ph.D.

Department of Radiology
Vanderbilt University Medical Center
Nashville, TN 37232
Tel: 615-322-3190
Fax: 615-322-3764
E-Mail: ron.price@vanderbilt.edu

Buddy D. Ratner, Ph.D.

Director, University of Washington
Engineered Biomaterials
Washington Research Foundation
University of Washington
Box 351720,
Bagley Hall 484
Seattle, WA 98195-1720
Tel: 206-685-1005
Fax: 206-616-9763
E-Mail:
ratner@uweb.engr.washington.edu

Charles J. Robinson, D.Sc., P.E.,

Max and Robbie L. Watson Eminent
Scholar Chair in
Biomedical Engineering and
Micromanufacturing, and
Director, Univ. Center for Biomedical
Engineering and Rehab. Science
(CyBERS)
Louisiana Tech University
711 S. Vienna
Ruston, LA 71270-5845
Tel: 318-257-4562
Fax: 318-255-4175
E-Mail: c.robinson@ieee.org

Lawrence P. Schramm, Ph.D.
Department of Biomedical Engineering
The Johns Hopkins University School of
Medicine
606 Traylor Building
720 Rutland Avenue
Baltimore, Maryland 21205
Tel: 410-955-3026
Fax: 410-955-9826
E-Mail: lschramm@bme.jhu.edu

Eva Sevick-Muraca, Ph.D.
Professor and University Faculty Fellow
The Photon Migration Laboratories
Texas A&M University
337 Zachry Engineering Center
College Station, TX 77843-3122
Tel: 979-458-3206
Fax: 979-845-6446
E-Mail: sevick@che.tamu.edu

Alan J. Snyder, Ph.D.
Hershey Medical Center
Pennsylvania State University
H151/C4864
500 University Drive
Hershey, PA 17033
Tel: 717-531-7068
Fax: 717-531-4464
E-Mail: asnnyder@psu.edu

Benjamin M. W. Tsui, Ph. D.
Department of Radiology
The Johns Hopkins University
JHOC, 601 N. Caroline St.
Baltimore, MD 21287-0859
Tel: 410-614-3249 (temporary office)
Tel: 919-454-3092
Fax: 410-955-8597
E-Mail: tsui@jhmi.edu

Dean C. Winter, Ph.D.
Southwest Research Institute
P.O. Box 28510
San Antonio, TX 78228-0510
Tel: 210.522.2681
Fax: 210.684.6147
E-Mail: dean.winter@swri.org

Dean Wong, M.D., Ph.D.
Professor of Radiology, Psychiatry, and
Environmental Health Sciences
Radiology Vice Chair for Research
Administration and Training
Johns Hopkins Medical Institutions
JHOC Bldg room 3245
601 N. Caroline St.,
Baltimore, MD 21287
Tel: 410-955-8433
Fax: 410-955-0696
E-Mail: dfwong@jhmi.edu

Ajit P. Yoganathan, Ph.D.
Regents Professor
Assoc. Chair, Biomedical Engineering
Georgia Institute of Technology
Room 1126 IBB Building
315 Ferst Dr.
Atlanta, GA 30332-0535
Tel: 404-894-2849
Fax: 404-894-4243
E-Mail:
ajit.yoganathan@bme.gatech.edu

Government and Agency Participants:

Carol A. Bean, Ph.D.
Extramural Program Officer
NLM
6705 Rockledge Dr, Suite 301
Bethesda, MD 20892-7968
Tel: 301-496-4621
Fax: 301-402-2952
E-Mail: beanc@mail.nlm.nih.gov

Alison Cole, Ph.D.
Program Director
NIGMS
45 Center Drive, Rm 2As.49k
Bethesda, MD 20892
Tel: 301-594-1826
Fax: 301-480-2802
E-Mail: colea@nigms.nih.gov

Walter Goldshmidts, Ph.D.
Associate Director, Research Training &
Career Development
NIMH
6001 Executive Blvd. Room 7200
Bethesda, MD 20892 MSC 9645
Tel: 301-443-3563
Fax: 301-443-1731
E-Mail: wgoldsch@mail.nih.gov

Lester Gorelic, Ph.D.
CTB/NCI
6116 Executive Blvd.
Room 7019 MSC 8346
Bethesda, MD 20892
Tel: 301-496-8580
Fax: 301-402-4472
E-Mail: gorelicl@mail.nih.gov

Bettie Graham, Ph.D.
NHGRI
31 Center Dr, Room B2-B07
Bethesda MD, 20892-2033
Tel: 301-496-7531
Fax: 301-480-2770
E-Mail: grahambj@mail.nih.gov

Richard Lymn, Ph.D.
Chief, Muscle Biology Branch
NIAMS
6701 Democracy Blvd, Suite 860
Bethesda, MD 20892-4872
Tel: 301-594-5128
Fax: 301-480-4543
E-Mail: lymnr@mail.nih.gov

John Norvell, Ph.D.
Program Director
NIGMS
Room 2As.13b
45 Center Drive
Bethesda, MD 20892-6200
Tel: 301-594-0533
Fax: 301-480-2004
E-Mail: norvellj@nigms.nih.gov

Charles Peterson, Ph.D.
Director, DBDR-OD
NHLBI
6701 Rockledge Dr.
Bethesda, MD 20892-7950
Tel: 301-435-0080
Fax: 301-480-0867
E-Mail: PetersoC@nhlbi.nih.gov

Judith Podskalny, Ph.D.
Program Director
NIDDK
6707 Democracy Blvd, Room 667
Bethesda, MD 20892-5450
Tel: 301-594-8876
Fax: 301-480-8300
E-Mail: Jp53s@nih.gov

Sohi Rastegar, Ph.D.
Program Director
Engineering Research Centers Program
Engineering Education and Centers
Division
National Science Foundation
4201 Wilson Blvd, Rm 585
Arlington, VA 22230
Tel: 703-292-7946
Fax: 703-292-9052
E-Mail: srastega@nsf.gov

Walter Schaffer, Ph.D.
Deputy Director and NIH Research
Training Officer
Office of Extramural Programs
OD/NIH
6705 Rockledge Drive, Rm 3537
Bethesda, MD 20817-7911
Tel: 301-435-2687
Fax: 301-252-9343
E-Mail: SchaffeW@od.nih.gov

Observers:

Laurence Clarke, Ph.D.

Acting Branch Chief, Image Guided
Therapy
Biomedical Imaging Program
National Cancer Institute
Tel: 301-435-9190
Fax: 301-480-3507
E-Mail: lclarke@mail.nih.gov

Edward C. Nagy, Ph.D.

Executive Director
Academy of Radiology Research
Suite 505
1029 Vermont Avenue, N.W.
Washington, DC 20005
Tel: 202-347-5872
Fax: 202-347-5876
E-Mail: acadrad@aol.com

Fei Wang, Ph.D.

Laboratory of Molecular Cardiology
National Heart, Lung, and Blood
Institute
National Institutes of Health
Rm 8N202, 10 Center Dr. MSC1762
Bethesda, MD 20892-1762, USA
Tel: 301-496-6887 or 05639
Fax: 301-402-1542
E-Mail: wangf@nhlbi.nih.org

NIBIB Staff:

Cheryl Fee

Policy Analyst,
Office of Science policy, Planning and
Analysis
NIBIB/NIH
31 Center Dr. Room 1B43
Bethesda, MD 20892-2077
Tel: 301-451-
Fax: 301-480-4515
E-Mail: feec2@mail.nih.gov

Kina Forrest

Program Assistant
Office of Science Policy, Planning and
Analysis
NIBIB/NIH
31 Center Dr. Room 1B37
Bethesda, MD 20892-2077
Tel: 301-451-6769
Fax: 301-480-4515
E-Mail: forrestk@mail.nih.gov

Stephen Green, B.A.

Administrative Support
NIBIB/NIH
6707 Democracy Blvd, Suite 900
Bethesda, MD 20892-5469
Tel: 301-451-4784
Fax: 301-480-4973
E-Mail: greenst@mail.nih.gov

John Haller, Ph. D.

Division of Biomedical Imaging
NIBIB/NIH
6707 Democracy Blvd, Suite 900
Bethesda, MD 20892-5469
Tel: 301-451-6769
Fax: 301-480-4974
E-Mail: hallerj@mail.nih.gov

H. Troy Nagle, Ph.D., M.D., P.E.

Professor of Electrical and Computer
Engineering
North Carolina State University
432 Daniels Hall
Raleigh, NC 27695-7911
Tel: 919-515-3578
Fax: 919-515-5523
E-Mail: t.nagle@ncsu.edu

Sandra Talley, Ph.D.

Division of Extramural Affairs
NIBIB/NIH
6707 Democracy Blvd, Suite 900
Bethesda, MD 20892-5469
Tel: 301-451-4790
Fax: 301-480-4974
E-Mail: talleys@mail.nih.gov

Meredith Temple, Ph.D.

Division of Extramural Activities
NIBIB/NIH
6707 Democracy Blvd, Suite 900
Bethesda, MD 20892-5469
Tel: 301-451-4792
Fax: 301-480-4974
E-Mail: templem@mail.nih.gov

Mariaileen Sourwine, M.S.

Biomedical Engineer
Division of Technology Development
and Integration
NIBIB/NIH
6707 Democracy Blvd, Suite 920
Bethesda, MD 20892-5469
Tel: 301-451-4775
Fax: 301-480-4974
E-Mail: sourwine@mail.nih.gov

Richard Swaja Ph.D.

Acting Director, Division of Technology
Development and Integration
NIBIB/NIH
6707 Democracy Blvd, Suite 920
Bethesda, MD 20892-5469
Tel: 301-451-4779
Fax: 301-480-4974
E-Mail: swajar@nibib.nih.gov

Stacy Wallick, B.A.

Program Analyst
Office of Science Policy, Planning and
Analysis
NIBIB/NIH
31 Center Dr. Room 1B37
Bethesda, MD 20892-2077
Tel: 301-451-4733
Fax: 301-480-4515
E-Mail: wallicks@mail.nih.gov

END