DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTES OF HEALTH

NATIONAL ADVISORY COUNCIL FOR BIOMEDICAL IMAGING AND BIOENGINEERING

Summary of Meeting[1]
September 14, 2012

The National Advisory Council for Biomedical Imaging and Bioengineering (NACBIB) was convened for its 30th meeting on September 14, 2012, at the Bolger Center in Potomac, Maryland. Dr. Roderic I. Pettigrew, Director of the National Institute of Biomedical Imaging and Bioengineering (NIBIB), presided as Council chairperson. In accordance with Public Law 92-463, the meeting was open to the public from 9:00 a.m. to 11:40 a.m. for review and discussion of program development, needs, and policy. The meeting was closed to the public from 12:30 p.m. to 2:30 p.m. for the report of the Board of Scientific Counselors and consideration of individual grant applications.

Council members present:
Dr. John C. Gore, Vanderbilt University, Nashville, TN
Dr. W. Eric L. Grimson, Massachusetts Institute of Technology, Cambridge, MA
Dr. Hedvig Hricak, Memorial Sloan Kettering Cancer Center, New York, NY
Dr. Nola M. Hylton, University of California, San Francisco, CA
Dr. Cato T. Laurencin, University of Connecticut, Farmington, CT
Dr. Mark Musen, Stanford University, Stanford, CA
Dr. Buddy Ratner, University of Washington, Seattle, WA
Dr. Sheldon Weinbaum, The City College of New York, New York, NY
Dr. Michael Yaszemski, Mayo Clinic College of Medicine, Rochester, MN

Ex officio members present:
Dr. P. Hunter Peckham, U.S. Department of Veterans Affairs, Cleveland, OH
Dr. Anne Plant, National Institute of Standards and Technology, Gaithersburg, MD
Dr. Sohi Rastegar, National Science Foundation, Arlington, VA
Dr. James G. Smirniotopoulos, Uniformed Services University of the Health Sciences, Bethesda, MD

Ad hoc member present:
Dr. Bruce Tromberg, University of California, Irvine, CA

Council member absent:
Dr. Etta D. Pisano, Medical University of South Carolina, Charleston, SC

Ex officio members absent:
Dr. Francis Collins, National Institutes of Health, Bethesda, MD
Ms. Kathleen Sebelius, U.S. Department of Health and Human Services, Washington, DC

Chairperson:
Dr. Roderic I. Pettigrew

Executive Secretary:
Dr. Anthony Demsey

[1] For 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 conflict of interest may occur. This procedure only applies to applications that are discussed individually, not to "en bloc" actions.

Also present:
NIBIB staff present for portions of the meeting:

Mr. Angelos Bacas
Dr. Richard A. Baird
Ms. Sheila Barrett
Ms. Shirley Coney-Johnson
Dr. Richard Conroy
Ms. Zoe Ann Copeland
Ms. Christine Cooper
Ms. Nancy Curling
Ms. Marilyn Daly
Ms. Monique Day
Mr. Jeff Domanski
Dr. Henry Eden
Ms. Kate Egan
Ms. Angela Eldridge
Ms. Kathryn Ellis
Dr. Zeynep Erim
Ms. Shirley Finney
Ms. Carol Fitzpatrick
Dr. David George
Ms. Marie Gill
Ms. Pam Glikman
Dr. Ruth Grossman
Dr. John Hayes
Ms. Eunica Haynes
Dr. William Heetderks
Mr. James Huff
Dr. Rosemarie Hunziker
Mr. Tom Izzard
Dr. Chris Kelley
Ms. Margot Kern
Dr. Peter Kirchner
Dr. Brenda Korte
Dr. Steven Krosnick
Dr. Richard Leapman
Dr. Christina Liu
Dr. Guoying Liu
Dr. Hector Lopez
Dr. Shadi Mamaghani
Dr. Alan McLaughlin
Ms. Jessica Meade
Mr. Todd Merchak
Dr. Vinay Pai
Dr. Karen Peterson
Mr. Mohammed Rahamatullah
Dr. Mary Rodgers
Ms. Christine Rogers
Ms. Nicole Rohloff
Dr. Antonio Sastre
Dr. Belinda P. Seto
Mr. Shaun Sims
Dr. Manana Sukhareva
Ms. Florence Turska
Ms. Rachel Vizzi
Mr. Kwesi Wright
Ms. Li-Yin Xi
Dr. Ruixia Zhou
Dr. Steven Zullo

Non-NIBIB National Institutes of Health (NIH) employees:
Dr. Cathy Wedeen, National Institute of Child Health and Human Development

Non-NIH Federal employees:
None

Members of the public present for portions of the meeting:
Ms. Renee L. Cruea, Academy of Radiology Research
Mr. Michael Kalutkiewicz, Academy of Radiology Research
Mr. Michael Peters, American College of Radiology
Ms. Kathy Sedgwick, NOVA Research Company
Mr. Matt Sherman, National Capital Captioning
Ms. Naomi Webber, Lewis Burke Associates, LLC
Dr. Van Wedeen, Massachusetts General Hospital, Harvard University

I. Call to Order: Dr. Anthony Demsey

Dr. Anthony Demsey called to order the 30th meeting of the National Advisory Council for Biomedical Imaging and Bioengineering. He reminded attendees that the morning session of the meeting was open to the public, welcomed attendees, and introduced Dr. Roderic Pettigrew, who formally welcomed all participants.

II. Director's Remarks: Dr. Roderic I. Pettigrew

A. New Council Members

Dr. Pettigrew welcomed two new members to the Council. Dr. Bruce Tromberg is a professor of biomedical engineering, associate director of the Center for Biomedical Engineering at the Henry Samueli School of Engineering, and director of the Beckman Laser Institute and the Laser Microbeam and Medical Program at the University of California, Irvine (UCI). Dr. Tromberg is known for research in the development of noninvasive optical and spectroscopic techniques that enable probing and monitoring of cellular processes and applies these techniques to *in vivo* functional imaging of cancer, vascular disease, and the brain. A recipient of the Coherent Biophotonics Young Investigator Award, the UCI School of Medicine Clark Research Award, and the R&D 100 Award, he is a fellow of the International Society for Optical Engineering and the American Institute for Medical and Biological Engineering.

Dr. Sheldon Weinbaum is distinguished professor emeritus in the Department of Biomedical Engineering at the City College of New York (CUNY) and is a member of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine. In 2002, he became the first engineer to be awarded a Guggenheim Fellowship in molecular and cellular biology. Dr. Weinbaum discovered the pore through which low-density lipoprotein (LDL) cholesterol crosses the endothelium, and he is known for the Weinbaum-Jiji bioheat equation. He also conducts research into the role of cell size and microcalcifications and their involvement in rupture of fibrous caps of vulnerable plaques, which leads to thrombosis, heart attacks, and strokes.

B. Grantee Awards

Dr. Pettigrew described several grantee awards of note. Stephen Boppart has been recognized with the international Hans Sigrist Prize, which honors outstanding research in the field of diagnostic laser medicine. Rebecca Richards-Kortum, along with her colleagues, received the American Association for the Advancement of Science's Science Prize for Inquiry-Based Instruction with the essay "Engaging Undergraduates in Global Health Technology Innovation," published in *Science*. Michael Sheetz and Ron Vale will receive The Albert and Mary Lasker Foundation award for basic medical research for discoveries concerning cytoskeletal motor proteins, machines that move cargoes within cells, contract muscles, and enable cell movements. Biju Parekkadan was awarded the Presidential Early Career Award for Scientists and Engineers.

C. NIH FY12 Budget and Legislation

The House Rules Committee recently approved a six-month continuing resolution that is expected to go to the House floor today.

D. NIBIB Activities Update

HHMI-NIBIB Interfaces Training

In 2005, Howard Hughes Medical Institute (HHMI) and NIBIB launched the Interfaces initiative to develop predoctoral interdisciplinary programs at the intersection of the life and physical sciences. The initiative funded ten universities across the country to develop new curricula specifically to train interdisciplinary scientists. More recently, HHMI and NIBIB solicited Training Innovations Program Supplements (TIPS) applications from active NIBIB training programs to develop and disseminate strategies and best practices to advance interdisciplinary training. HHMI and NIBIB announced the three winning TIPS projects in August 2012:

- *Interactive Web-Based Training on Biomedical Imaging Physics* by Georges El Fakhri, Ph.D. (Massachusetts General Hospital) will focus on development of web-based video lectures and an online reference manual on the physics of biomedical imaging.

- *Teaching Systems Biology: A Regional Workshop* by Arthur Lander, Ph.D. (University of California, Irvine) will articulate and disseminate effective training strategies, including teaching materials and web-based videos, to advance systems biology.

- *Disseminating Hands-On Training Experiences in Multi-Scale Biology* by Andrew McCulloch, Ph.D. (University of California, San Diego) will focus on development and dissemination of web-based training materials for lab-based courses in biomedical imaging, numerical analysis, neuroengineering, and tissue engineering.

Advisory Committee to the Director (ACD) Reports

Biomedical Research Workforce. The Advisory Committee to the Director (ACD) of NIH has narrowed the focus of the upcoming Director's Retreat to several topics, including the issue of training the optimal number of people and identifying the types of positions needed for a sustainable workforce to advance science and promote health. The Biomedical Research Workforce Working Group was charged with developing recommendations to NIH of specific actions that would support a sustainable biomedical research workforce. The full report is available at http://acd.od.nih.gov/Biomedical_research_wgreport.pdf.

Diversity in the Biomedical Research Workforce. The Diversity in Biomedical Research Workforce Working Group undertook the problem of diversity in biomedicine, which falls short of mirroring the diversity of the U.S. population and shows a discrepancy between the research grant success rates of white and black applicants. The Working Group was charged with providing concrete recommendations to improve recruitment, retention, and success of underrepresented/disabled/disadvantaged persons pursuant to the *Ginther et al.* findings of 2011. An executive summary of the Working Group's report is available at http://acd.od.nih.gov/06142012_DBR_ExecSummary.pdf.

Data and Informatics. The Data and Informatics Working Group focused on the issue of the accelerating growth of biomedical research data sets that present big opportunities and challenges for optimal learning and impact on health. The Working Group was charged with developing specific advice on the management, integration, and analysis of large biomedical data sets, including those related to basic science, clinical, and population research; grants administration data; and information technology at NIH. An executive summary of the Working Group's report is available at http://acd.od.nih.gov/06142012_DIWG_ExecSummary.pdf.

Celebration of Science

Several sessions during the Celebration of Science, a recent three-day event sponsored by FasterCures and the Milken Family Foundation, highlighted medical science and the impact of science on national and global health care. One entire day focused on NIH. NIH scientists, policymakers, patients, Congressmen, and Michael Milken made presentations on such subjects as HIV, neurological disease, and magnetic resonance imaging. A videocast is available at http://videocast.nih.gov/summary.asp?Live=11821.

E. NIBIB 10th Anniversary Highlights

NIBIB's 10th Anniversary celebration was held in June over two days. The first day began with an event on Capitol Hill sponsored by the American Institute for Medical and Biological Engineering, at which NIBIB Director of Extramural Science Programs Dr. William Heetderks recounted the impact that NIBIB has had on the national health care agenda. At dinner that night, 14 NIBIB visionaries—those who had a vision of the Institute and the fortitude to see it through to creation—were recognized. On the second day, a symposium and a technology showcase were held. The technology showcase featured NIBIB grantees and their supported technologies. The symposium was comprised of presentations, recordings of which are available online along with videos featuring six NIBIB grantees, photographs from the celebration, and a Senate resolution honoring NIBIB and its role in advancing biomedical emerging technologies.

F. Science Highlights

Design by Undergraduate Teams Challenge

NIBIB issued the Design by Undergraduate Teams (DEBUT) challenge last year, and three winners have been announced. Sixty-one teams entered, with almost 300 students involved. Each winning team will receive $10,000, to be presented at the Biomedical Engineering Society annual meeting this fall. A team from the University of California, Los Angeles, won in the Diagnostic Devices category for a microfluidics-based point-of-care device that identifies transitional cell carcinoma from a standard urine sample. A team from The Johns Hopkins University won in the Therapeutic Devices/Methods category for a low-cost, disposable quick-stitch suturing device that ensures proper stitch placement and tension and avoids accidental puncturing of organs, thereby speeding up surgeries and minimizing postoperative complications. A team from Washington University in St. Louis won in the Technology to Aid Underserved Populations and Individuals With Disabilities category for a low-cost spirometer to aid in the diagnosis of chronic obstructive pulmonary disease, a major affliction in many developing countries as well as the United States.

G-Protein Coupled Receptors Project

The NIBIB has been supporting a project by Stan Opella and colleagues at the University of California, San Diego, looking at the G-protein coupled receptors (GPCRs) transduction mechanism. The study uses x-ray crystallography, a technique that must change the conformation of the GPCRs in order to make them crystallize; residues must be added or removed in order to conduct analysis. Dr. Opella and his team now have successfully deciphered the structure of a GPCR, CXCR-1, in its native phospholipid bilayer without any of the compromising changes that are required for x-ray crystallography. A paper on this work is in press in *Nature.*

Discussion

Dr. Buddy Ratner recommended that NIBIB encourage intellectual property protection as part of the DEBUT program announcement, review, and requirements for funding in the future.

III. Review of Council Procedures and Regulations: Dr. Anthony Demsey

Dr. Demsey noted for the record that a quorum was present for this Council meeting. Council member Dr. Etta Pisano was unable to attend. Dr. Demsey welcomed visitors and members of the science press and scientific society constituencies. He thanked Ms. Carol Fitzpatrick and Ms. Pam Glikman for their work in organizing the meeting.

A. Council Regulations, Policies, and Procedures

Dr. Demsey summarized elements of the Government in the Sunshine Act and the Federal Advisory Committee Act that govern all Advisory Council meetings. These Acts require the U.S. Department of Health and Human Services to open Advisory Council meetings to the public except when proprietary or personal information is discussed. To comply with these regulations, NACBIB meetings are open to the public for all except the review of individual grant applications. Dr. Demsey reviewed conflict-of-interest, confidentiality, and lobbying guidelines.

Dr. Demsey recommended updating the Council operating procedures with a minor change to "Consideration of Applications from Already Well-Funded Investigators." The amount that triggers special Council consideration would be changed from $1.5 million total costs to $1 million direct costs. A motion to approve the updated operating procedures was forwarded, seconded, and unanimously approved.

B. Future NACBIB Meeting Dates

The next NACBIB meeting is scheduled for Friday, January 25, 2013. This meeting is planned to be held virtually. Dr. Demsey asked Council members to inform him about conflicts with any of the upcoming meeting dates listed at the bottom of the agenda.

C. Approval of the May 21, 2012, NACBIB Meeting Minutes

A motion to approve minutes of the May 21, 2012, NACBIB meeting was forwarded, seconded, and approved unanimously.

IV. Not so Tangled: The Geometric Structure of the Brain: Van J. Wedeen, M.D.

Dr. Pettigrew introduced Dr. Van J. Wedeen, associate professor of radiology at Harvard College, assistant neuroscientist at Massachusetts General Hospital, and director of Connectomics at the Athinoula A. Martinos Center for Biomedical Imaging. Generally known as the father of magnetic resonance angiography and tractography, Dr.Wedeen presented his work on the subject of diffusion tractography.

Dr. Jeff Lichtman has said, "Of all of the organs in the body, the brain is the one in which we know the relationship between structure and function least well." Because large (i.e., mammalian) brains have proven too difficult to dissect in adequate detail to understand how they are organized, science has pursued multiple directions, some of which are too disparate to add to a unified view of the brain. Neuroscience and neuromedicine, in all forms, have been paralyzed by the lack of understanding about connectivity within the human brain, and technology has been limited to methods that either damage cells or require the animal to die. Because these techniques produce only a little information about one point in the brain, researchers have been unable to learn about the relationships between pathways. Understanding these relationships is central to understanding the system of the brain, which must be stable enough to evolve gradually, with plasticity intact, in such a way that changes in structure can result in changes in function.

One difficulty in mapping the brain is that its pathways are not limited by space; multiple pathways often occupy the same location. Diffusion spectrum imaging maps the relative motion of water molecules around cells, which move faster when parallel to fibers than when perpendicular to fibers; thus, researchers can use the differential speed of water diffusion as a noninvasive tracer for which way the fibers are pointing. In 2000, Dr. Wedeen developed a method to increase diffusion spectrum imaging resolution enough to see detailed anatomic structure.

Research into the brain's structure since 2000 has been inconclusive. In 2008, Dr. Patric Hagmann created a connection matrix that diced the brain into approximately 1,000 spatial regions, some of which were interconnected. The magnetic resonance community approaches this connection matrix in two different ways: (1) a descriptive method from which to begin or (2) definitive, if imperfect, circuit diagrams. Dr. Wedeen expressed skepticism that this matrix accurately reflects the brain's structure.

The two techniques historically available for examining the brain—cross-sectional imaging (microscopy) and track tracing—cannot uncover the brain's geometric pathways; tracer studies show isolated pathways without context, and microscopy provides context but does not show pathways. Diffusion magnetic resonance imaging (dMRI) allows researchers to examine pathways near a given path. Dr. Wedeen and his colleagues conducted initial dMRI studies on owl monkeys, choosing one area in the brain, selecting a pathway in that area, and looking at what other paths pass through the initial pathway. The results were astonishing and mathematically unlikely. In the Sylvian fissure of the owl monkey brain, Dr. Wedeen found that the set of all paths near SLF-3 (a longitudinal pathway in the frontal lobe) form a single two-dimensional sheet of mutually parallel paths that cross SLF-3 at approximately right angles; multiple sheets—often on three axes—interweave to create a three-dimensional matrix. This motif was found to be characteristic of almost every location of white matter in every brain in the dozen species in Dr. Wedeen's library. Parallel fibers are found elsewhere in the body, but they do not form an interwoven sheet, as brain fibers do. Dr. Wedeen believes that the organization of these fiber pathways is a remnant of the primordial chemical concentration gradients found in the embryo that expand and then fold up or curve as necessary through all processes of development.

Through dMRI, major longitudinal pathways in the brain stem such as SLE-1, -2, and -3—traditionally considered relatively independent structures—are seen to fit together in highly parallel ways, becoming effectively one single structure containing local condensations. This concept is in direct opposition to the

traditional idea of root structure. Likewise, fibers that seemed to end abruptly now can be understood to be turning at a strong angle. Much like the interstitial branching of axons, with zero radius of curvature, these fibers take abrupt turns. Dr. Wedeen noted that what researchers think of as U-fibers may actually be two right angles; he posited that a gyrus is constructed by a perturbation of fibers running in three cardinal axes.

The reason this structure is so pervasive is based in evolution and development. A high degree of symmetry, as seen in bilateral animals, is necessary for evolution to happen in a predictable, incremental way. In evolution and development—plasticity and learning—brain structure and function must be able to change incrementally and concurrently. Dr. Wedeen suggested that this requires an architecture of connectivity that is continuous and homogeneous. The system is naturally adapted for coherence, in which the signal at one end is the same as the signal at the other end.

This research was conducted with *ex vivo* small animal material on a 4.7t MRI scanner. A scanner with higher gradient strength was needed to collect data of equivalent quality about the human brain. By encoding the diffusion in fewer microseconds, the protons move less and the picture is more precise; higher speed also garners more signal. The toxicity of such a scanner is no more than other scanners, but it requires a very large power supply and a very large cold water supply. A new MRI scanner with four power supplies, two gradient coils, seven times the gradient strength, four times the encoding speed, and a 64-channel brain array—providing a nearly ten-fold increase in sensitivity for high b value diffusion—was designed and built at the Martinos Center as part of NIH's Human Connectome Project. This scanner has allowed Dr. Wedeen and his colleagues to image the human brain in great detail in 20 minutes, illustrating the matrix structure Dr. Wedeen expected to see. In scans of a major gyrus, the longitudinal pathways and U-fibers were seen to be perpendicular to both of the association pathways—a step toward resolving the coordinate system structure of the human brain.

Dr. Wedeen noted several future directions of this research. Due to the brain's inherent complexity, it is imperative that diffusion tractography be corroborated by alternative methods, in other species, and in other organ systems. Dr. Adam Anderson (Vanderbilt University) has been conducting direct validation of diffusion models with microscopy. Diffusion scanning also provides insight into development, which future research should plumb more fully. Researchers often study only the mature brain; this newly understood fiber matrix might allow them to read development backwards from maturity to *in utero* through a sequence of steps from similar structures. The relationships between structure and function also must be further explored. In 2009, Drs. David Badre and Mark D'Esposito published findings that the distribution of cortical areas is gridlike and hierarchically organized from nose to tail; the question of functional capacity and plasticity is determined by connectional structure, even on the smallest scale. Finally, researchers also must develop mathematical tools to capture and harvest data from this grid structure.

dMRI has the potential to transform science's understanding of the brain. When thinking about the heart, for instance, one is able to imagine an organ with a small number of components that fit together in a rational way that is easy to describe. The brain, on the other hand, has remained an incomprehensible organ of exceptionally odd and unevocative shape. dMRI provides the beginning of a different view, one that shows a simple general structure that is unified and orderly in relation to itself and the rest of the body. dMRI also reinvents the way the brain is imaged, putting the brain into a simple, objective framework. Some researchers argue for reductionism, with a belief that it is only possible to learn about the brain by looking at the circuit, the cell, the synapse, etc. However, there are also characteristic features that emerge only at the large, systems scale.

Discussion

Dr. Ratner noted that when looking at electrical currents, wires running parallel have very different external fields than those running at right angles. Dr. Wedeen responded that the brain does not seem to function in that way. In very early evolutionary times, before vertebrates, axons were not myelinated as they are now. The main question at this point is why there are only three grids and not four. Dr. Wedeen posited that, perhaps because the human is a segmental creature, the code of axonal pathfinding is presumably a three- or

six-letter code (up/down, left/right, front/back) that is established at a very early stage. The reasons for this structure were likely geometric before they were electrical.

Dr. Weinbaum asked about the intercommunicativity of systems within the body. Dr. Wedeen stated that intercommunicativity varies throughout the brain. For example, in lower parts of the brain, information travels in separable, rather narrow channels. In the cortex, information is associated laterally, and the degree and pattern of spread vary between cortical areas. However, there is no evidence yet that this structure reaches the dendritic level. Measuring intercommunicativity will be critical toward understanding the functional significance of activity in cardinal directions.

Dr. Weinbaum added that it is amazing to see the same basic structure performing so many different functions. Dr. Wedeen noted that an evolved brain is different than a designed brain; it had to survive, be useful, and be functional through all of the intermediate stages of evolution. Creatures without that kind of symmetry did not survive.

Dr. Tromberg asked about a possible relationship to vascular networks. Dr. Wedeen responded that large vessels have a peculiar anatomy related to the head and the heart, but small vessels have an elegant architecture. Vascular anatomy discloses a great deal of deep structure of the brain; it shows parallel and perpendicular cortical structure. Whether that correlates with Dr. Wedeen's matrix of the brain remains to be seen, but vascular microanatomy could provide critical clues for understanding the brain, and it has functional significance of its own and with respect to the functional imaging modalities that rely upon it.

Dr. Heetderks wondered whether Dr. Wedeen has traced convergence of different regions of the brain. Dr. Wedeen responded that he has considered these regions and their relationships, particularly with respect to deep brain structures. As soon as one looks at the basal ganglia, cerebellum, or brain stem, one must consider multiply connected systems.

Dr. Pettigrew asked Dr. Wedeen to expound on whether his findings could be based on artifact. Dr. Wedeen said he has used the same methods for years without controversy; this is just a different look at the identical data. The resolution of these data is greater than that of any other in the industry, and there is no evidence of bias in favor of right angles. Dr. Wedeen has not suggested that the system is made of right angles; rather, the important characteristic is that it is a three-axis coordinate system. There are many places in the data that are not right angles.

Dr. Pettigrew also wondered whether dMRI could be used to visualize neurons or pathways involved in injury recovery with epidural stimulation. Dr. Wedeen stated that a few more breakthroughs are needed with respect to the structure-function correlation. Researchers first must be able to identify the signatures of network effects in activation as well as structure.

V. Adjournment

The open session of the NACBIB meeting was adjourned at 11:40 a.m.

VI. Closed Session

The grant application review portion of the meeting was closed to the public in accordance with 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). The closed session was adjourned at 2:30 p.m.

Certification:

We certify that, to the best of our knowledge, the foregoing minutes are accurate and complete.[2]

_____

Anthony Demsey, Ph.D.
Executive Secretary,
National Advisory Council for Biomedical Imaging and Bioengineering
Director,
Office of Research 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

[2] These minutes will be approved formally by the Council at the next meeting on January 25, 2013, and corrections or notations will be stated in the minutes of that meeting.