

National Institutes of Health (NIH) and National Aeronautics and Space Administration (NASA) Meeting on Space-Related Health Research

Date: December 8, 2006

Location: NIH Campus, Building 31, C wing

Time: 10 am – 4 pm

6th floor, Conference room 10

Bethesda, Maryland

MEETING GOALS

- To share information across key Federal agencies about space-related health research interests and activities.
- To identify potential opportunities for collaborations to facilitate space-related health research.

AGENDA

Welcome, Introductions, and Overview of Meeting Goals

Dr. Stephen Katz, Director, National Institute of Arthritis and Musculoskeletal and Skin Diseases, NIH and

Dr. David Longnecker, Chair, Committee on Aerospace Medicine and Medicine for Extreme Environments, Institute of Medicine

NIH Perspective on Benefits of Collaborations

Dr. Elias Zerhouni, Director, NIH

NASA Advisory Council

Hon. Harrison Schmitt, Apollo 17 Astronaut and Chairman, NASA Advisory Council

NASA/NIH Center for Three Dimensional Tissue Culture

Dr. Joshua Zimmerberg, Chief, Laboratory of Cellular and Molecular Biophysics, National Institute of Child Health and Human Development, NIH

Current NASA Research Efforts in the Life and Health Sciences

Dr. Neal Pellis, Associate Director, Human Research Program Science Management Office, Space Life Sciences Directorate, NASA

Research Opportunities Using the International Space Station

Dr. Mark Uhran, Assistant Associate Administrator, International Space Station, NASA

Discussion led by Drs. Uhran and Pellis

Round Robin: Overview of Current Research Efforts and Future Interest Areas

Agency Representatives

Working Lunch

Round Robin (continued)

Strategies to Enhance Future Collaborations

Discussion led by Hon. Schmitt

Next Steps – Where Do We Go From Here?

Drs. Katz and Longnecker

Adjourn

National Institutes of Health (NIH) and National Aeronautics and Space Administration (NASA) Meeting

December 8, 2006

Round Robin: Overview of Current Research Efforts and Future Interest Areas

Order of presentations

(noon - 1:00 pm)

1. Dr. Roderic Pettigrew – National Institute of Biomedical Imaging and Bioengineering (NIH)
2. Dr. Jeffrey Sutton – National Space Biomedical Research Institute (Baylor College of Medicine)
3. Dr. Anthony Hayward – National Center for Research Resources (NCRR)
4. Dr. George Ludwig – U.S. Army Medical Research Institute of Infectious Diseases (Department of Defense)
5. Dr. Richard Hatchett – National Institute of Allergy and Infectious Diseases (NIH)
6. Dr. John Jessup – National Cancer Institute (NIH)
7. Dr. Henry Rodriguez – National Cancer Institute (NIH)
8. Dr. Willie May – National Institute of Standards and Technology

(1:30 – 2:30 pm)

9. Hon. Gale Buchanan – U.S. Department of Agriculture
10. Dr. Paul Coates – Office of Dietary Supplements (NIH)
11. Dr. Joan McGowan – National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIH)
12. Dr. Rocky Tuan – National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIH)
13. Dr. Lewis Schragar – U.S. Food and Drug Administration
14. Dr. Allen Dearry – National Institute of Environmental Health Sciences (NIH)
15. Dr. James Battey – National Institute on Deafness and Other Communication Disorders (NIH)
16. Dr. Richard Hodes – National Institute on Aging (NIH)

NATIONAL INSTITUTES OF HEALTH (NIH) AND
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

MEETING ON SPACE-RELATED HEALTH RESEARCH
DECEMBER 8, 2006

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National Institutes of Health (NIH)/National Aeronautics and Space Administration (NASA) Meeting on Space-Related Health Research

December 8, 2006

Building 31, C Wing, 6th Floor, Conference Room 10

10:00 AM – 4:00 PM

OPENING REMARKS

Dr. Elias Zerhouni, Director, NIH

Noting that Space Shuttle Discovery had been scheduled to launch on December 7, Dr. Zerhouni briefly described his experience when visiting Kennedy Space Center to view a shuttle launch and expressed his appreciation of the efforts and sacrifices involved in space exploration. The NIH and NASA have a strong history of collaborative activities, and many shared interests in the life and health sciences as they relate to space research. As research opportunities are becoming increasingly interdisciplinary and budgets are becoming particularly constrained, however, the NIH, NASA, and other Federal agencies must explore new ways to develop partnerships that serve shared scientific interests. Furthermore, frequent interactions between NIH and NASA investigators will create an intellectual environment where unanticipated breakthroughs can occur.

Dr. Zerhouni emphasized the importance of identifying resources that could be better leveraged to facilitate space-related health research, as such resources will provide a foundation for future collaborative projects between the NIH and NASA. He also noted the importance of pursuing interdisciplinary research both on Earth and using facilities available through the International Space Station (ISS). As an example of NIH-funded research that could benefit space-related health research, he mentioned the national network of Nanomedicine Development Centers that was developed through the NIH Roadmap for Medical Research.

Dr. Stephen Katz, Director, National Institute of Arthritis and Musculoskeletal and Skin Diseases, NIH

Dr. Katz emphasized that many Federal agencies have an interest in promoting health sciences research both on Earth and in space, and acknowledged representatives from the National Institute of Standards and Technology, National Science Foundation, U.S. Department of Agriculture (USDA), and U.S. Food and Drug Administration who were able to participate in the meeting.

The goals of the meeting were to:

- 1) Share information about space-related health research interests and activities.
- 2) Identify potential opportunities for collaborations to facilitate space-related health research.

He also noted that the presentations would inform discussions scheduled to occur in January at a NASA-sponsored meeting to explore opportunities through the ISS.

Dr. David Longnecker, Chair, Committee on Aerospace Medicine and Medicine for Extreme Environments, Institute of Medicine

Dr. Longnecker emphasized that the meeting was arranged to facilitate discussions about research that could take advantage of the truly unique environment provided by the ISS. The Congressional designation of the ISS as a National Laboratory provides an opportunity for new avenues of research, and potentially new funding for such research if the scientific community can present a cogent rationale for their proposed investigations.

Dr. Longnecker noted that much work needs to be completed in the life sciences area to support the President's Vision for U.S. Space Exploration. A National Academies of Sciences report, *A Risk Reduction Strategy for Human Exploration of Space: a Review of NASA's Bioastronautics Roadmap*, identified large "gaps" between the current research evidence and knowledge that is needed to support extended human space flight missions.

Dr. Harrison Schmitt, Chair, NASA Advisory Committee (NAC)

Dr. Schmitt emphasized that NASA Administrator Dr. Michael Griffin is particularly interested in space-related health research and would have attended this meeting had it not coincided with the scheduled launch of Space Shuttle Discovery mission STS-116. He also emphasized the importance of the day's discussions to the future of human spaceflight and space settlement as well as to research on basic human physiology when it is stressed in the unique environment of space.

He reiterated earlier comments that NASA's efforts, including mission STS-116, provide access to a unique research environment in which scientists can study human physiology. He explained that research leveraging the opportunities of the shuttle program and the ISS, like those of earlier NASA missions, are essential if humans are to become a space-faring species. He called on the NIH and NASA to enter into a formal agreement to promote these efforts.

NASA/NIH CENTER FOR THREE-DIMENSIONAL TISSUE CULTURE

Dr. Joshua Zimmerberg, Chief, Laboratory of Cellular and Molecular Biophysics, National Institute of Child Health and Human Development, NIH

Dr. Zimmerberg's presentation on the NASA/NIH Center for Three-Dimensional Tissue Culture set the stage for enthusiastic discussions throughout the day. The NASA/NIH Center for Three-Dimensional Tissue Culture was established at the NIH in 1994. The bioreactor, a gently rotating cylindrical tube, mimics microgravity conditions. By avoiding turbulence and shear forces that occur with normal mixing and the gravitational force that cells in culture dishes experience, cells in the bioreactor are able to form large spheres because they can grow in three dimensions.

Dr. Zimmerberg also described his experiences working with NASA astronauts, such as Dr. Carl Walz (in attendance), on the ISS and presented data showing that antibody production is

suppressed in human lymphoid cells cultured on the ISS, compared with those cultured under static conditions on Earth. He noted that basic phenomena that researchers take for granted on Earth are different in space. For example, the lack of convection causes solutions to mix differently and reduction of partial pressures affect surface tension surrounding bubbles. Later, in the round robin, participants revisited technical challenges related to conducting research in a microgravity environment.

CURRENT NASA RESEARCH EFFORTS IN THE LIFE AND HEALTH SCIENCES

Dr. Neal Pellis, Associate Director, Science Management, Space Life Science Directorate, NASA

Dr. Pellis emphasized that the human element is the most complex component of mission design. NASA has developed a Bioastronautics Research Roadmap that outlines 45 major risks to human health in space exploration, and is developing a Risk Mitigation Analysis Tool to guide decisions.

In addition to biomedical considerations—such as health monitoring, medical support, radiation protection, and specimen collection—that must be built into current missions, establishment of a lunar outpost will require health care resources that include diagnostic testing, expanded life support systems, and countermeasures to compensate for the effects of low gravity on the musculoskeletal system. When planning multi-year manned expeditions to Mars, systems must be in place to allow the crew to be completely autonomous with regards to their health. Countermeasures against exposure to galactic cosmic radiation or solar proton events will become imperative.

At present, little is known about the effects of long-term space flight on human physiology, behavior, and performance. Gravitational forces on the Moon and on Mars are 1/6 and 3/8 of that of Earth, but no one knows how cells, tissues, and organ systems behave when exposed to these conditions for an extended period of time. Although bone density decreases at an average rate of 1 percent per month in microgravity, for example, with significant individual variation, the effects of fractional gravity are unknown.

Related Discussion

Many issues presented by Dr. Pellis were brought up during the round robin. In the discussion immediately following the presentation, Captain Frederick Hauck and Dr. Schmitt commented on the effects of microgravity on eye-hand coordination. Dr. Schmitt noted that preventing lunar dust from contaminating moon-based equipment and living areas presents an engineering challenge, as it is pervasive and electrostatically active; it also causes respiratory problems in some people.

RESEARCH OPPORTUNITIES USING THE INTERNATIONAL SPACE STATION

Mr. Mark Uhran, Assistant Associate Administrator, International Space Station (NASA)

Mr. Uhran provided a brief overview of opportunities provided by the ISS, especially in view of its designation as a national laboratory. As noted by others throughout the day, the microgravity environment of space is a unique resource for studying molecular motion. Studies conducted in space will provide insight into how cells behave in the absence of gravity, and the microgravity environment may be advantageous for biomedical research activities such as growing protein crystals for structural analysis and engineering new three-dimensional tissues.

ISS laboratory space, data processing, and crew time will be available for researchers who are interested in having research conducted on the ISS once it is fully operational in 2011. He emphasized that it is not too early for NIH intramural researchers and those extramural investigators supported by NIH to begin proposing studies and arranging with NASA to have them conducted on the ISS. Commitment of ISS physical resources will be made on a first come, first serve, basis through strategic alliances to advance research in biomedicine and biotechnology. Such arrangements can be established through inter-agency memoranda of understanding. Although NASA would prefer that the research would be related to NASA mission needs, direct application is not essential.

Related Discussion

Mr. Jeff Bingham, staff for the Senate Committee on Commerce, Science, and Transportation, explained that The National Aeronautics and Space Administration Authorization Act of 2005 (P.L. 109-155) provided Congressional endorsement for NASA efforts to implement the President's Vision for Space Exploration while ensuring that NASA also supports aeronautics research and development, robotic missions, and Earth, space, and microgravity science. Congress is committed to making sure that America's investment in the ISS is used wisely and, by designating the ISS a "National Laboratory," the Congress was emphasizing that the U.S.-funded modules on the ISS will be available for use by other entities in addition to NASA.

ROUND ROBIN

Participants were invited to give brief presentations describing:

- Current areas of space-related health research in their agencies.
- Promising areas for future space-related health research collaborations.
- Existing resources could be better leveraged to facilitate space-related health research.

Participants and their presentations:

- Dr. Roderic Pettigrew – National Institute of Biomedical Imaging and Bioengineering (NIBIB), NIH
- Dr. Allen Deary – National Institute of Environmental Health Sciences (NIEHS), NIH
- Dr. Jeffrey Sutton – National Space Biomedical Research Institute (NSBRI)
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Discussion

Current and promising areas of space-related health research

Building on points made earlier about the need to provide health care to astronauts on extended space missions, Dr. Pettigrew described NIBIB research efforts to develop tools for image-guided surgery, biological sensors that can detect pathogens, and devices that can measure glucose levels non-invasively. Dr. Sutton noted that long-distance diagnosis and monitoring technologies (including remotely guided ultrasound) also are being tested by NSBRI investigators. Representatives from NIST, the USDA, and several NIH institutes also expressed an interest in technologies that could be applied to space-related health research or the health of humans in space.

Round robin presenters, like the participants who spoke earlier, emphasized the importance of understanding how biologic activities are affected by micro- and low-gravity. Processes mentioned included:

- Blood flow and the cardiovascular system (NSBRI, NIA).
- Bone and muscle loss (NSBRI, NCRR, NCI, USDA, ODS, NIA, NIAMS).
- Cellular and molecular repair processes (NIEHS, NCI).
- Embryogenesis, central nervous system development (NIEHS, NICHD, NIAMS).
- Endocrinology (NCRR, NIA).
- Immune function (NCRR, NCI, NIA).
- Stem cell activity and tissue regeneration (NCI, NIAMS).

Dr. Battey noted that, like the NSBRI, the NIDCD is interested in spatial orientation and cognition, vestibular adaptation under various conditions (including micro- or low-gravity), and how the brain compensates for lost vestibular input. Other entities interested in human

performance include the OBSSR, NIDA, and FDA. For example, the FDA specifically is interested in effects of motion sickness and its countermeasures on mental-spatial tasks.

Dr. Schragger also stated that some of the physiologic effects of space travel (e.g., altered hemodynamics, decreased cardiac muscle performance, increased transit time of food through the gastrointestinal tract) may change the pharmacokinetic and pharmacodynamic properties of drugs. Studies of pharmacokinetic and pharmacodynamic alterations that occur during prolonged space travel may be able to be performed aboard the ISS, and the FDA has considerable expertise in pharmacological science could serve as a potentially valuable resource to NASA in the design of such studies. Understanding metabolic changes that occur during space travel was of particular interest to many participants, including those who had mentioned that medical or dietary interventions may be needed to maintain bone health, prevent damage caused by oxidative stress, or allow astronauts to maintain a regular sleep cycle.

Existing resources

Participants identified numerous resources in addition to ISS accommodations and the NIH/NASA Center for Three-Dimensional Tissue Culture that Mr. Uhran and Dr. Zimmerberg, respectively, described earlier. Other physical resources included:

- The NASA KC-135 Low-G Flight Research aircraft.
- Human centrifuge resources at the NIH General Clinical Research Center in Galveston, Texas, and elsewhere.
- USDA Agricultural Research Service Hydrology and Remote Sensing Laboratories, its Food Safety Intervention Technologies Research Unit, and the Jean Mayer Human Nutrition Research Center on Aging at Tufts University.
- NIST Advanced Measurement Laboratory, Advanced Chemical Sciences Laboratory, and Center for Neutron Research.

Dr. Hatchett noted that NIAID low-LET radiation exposure facilities may also be of use, because chronic, low-dose, low-LET exposures can result in health effects similar to chronic high-LET exposures. Dr. Hatchett, along with presenters from the ODS, NIA, and NIAMS, also mentioned animal models that could be relevant to space-related health issues. Dr. Hodes and others described population cohort studies such as the Baltimore Longitudinal Study on Aging, and Dr. Dearry from the NIEHS highlighted the NIH Gene-Environment Initiative and other databases to connect environmental exposures and health effects.

Several presenters noted that their colleagues have various areas of expertise that may be valuable to space-related health research. For example, NIST contributed expertise in cryogenic technologies for development of a prototype of equipment to liquefy oxygen produced from the carbon dioxide atmosphere on Mars. Dr. Tuan emphasized that the Cartilage Biology and Orthopaedics Branch of the NIAMS has a consortium of biologists, engineers, and surgeons who have experience in instrumentation design and prototype development, biomaterial scaffold production, adult stem cell technologies, and mechanical testing. The NSBRI has a cadre of top-tier academicians who are working in partnership with NASA at all stages of the research and development, testing, evaluation, and operational integration process. Moreover, the NSBRI,

USDA, and NIH have infrastructures to solicit, review, and award research grants. Dr. Schmitt remarked that, in the early 1980s, he had assisted the senior leadership of the NIH in developing an informal proposal to NASA for the latter to tap NIH expertise for the solicitation, topical organization, and review of applications. This proposal was not of interest to NASA at the time, however, he suggested that NASA and NIH leadership revisit that discussion.

Throughout the day's discussions, the former astronauts present (Schmitt, Hauk and Walz) provided information and answered questions relevant to their personal physiological and psychological experiences during spaceflight. The interaction of persons with spaceflight experience with researchers and managers at future discussions should be facilitated. A means also should be found to make actual past and future spaceflight medical data, as well as anecdotal information, available to a broader spectrum of the research community.

NEXT STEPS

Participants agreed that collaborations could occur when interests coincide. They discussed the possibility of talking to one another while developing initiatives so that space-related health research could be incorporated into requests for applications or program announcements, as appropriate, and emphasized that steps should be taken to notify NIH, NSF, and NSBRI investigators of research opportunities that will be available through the ISS. NAC members will contemplate possible synergies between NIH and NASA interests when discussing research opportunities available through the ISS in January. Dr. Schmitt suggested that the agencies consider forming a series of working groups, modeled after the on-going group for "Bones", for periodic interagency coordination and information transfer. And, at the next NAC meeting in February, Drs. Katz, Longnecker, and Schmitt will brief Administrator Griffin about this discussion as well as consider a next step to propose to him, Dr. Zerhouni and other agency heads.