Directorate for Mathematical and Physical Sciences
Advisory Committee Meeting Minutes
April 3-4, 2003

Thursday, April 3, 2003
Morning Session

Welcoming Comments

The MPSAC Chair, Dr. Joseph Salah, Chair of the Mathematical and Physical Sciences Advisory Committee (MPSAC) called the meeting to order at 8:30 A.M. Salah thanked everyone who had worked on the action items, and noted that much had been accomplished. In review of some of the primary outstanding topics, he asked about the status of the search for a new Assistant Director for MPS and of progress on enhancing the interactions between MPS and EHR, the Education and Human Resources Directorate. Dr. John Hunt, Acting Assistant Director of MPS, noted that a search committee for the MPS Assistant Director had been formed and suggested deferring this question until the following day, when the MPSAC would be meeting with the NSF Deputy Director. He then reported that the progress on the interactions with the EHR and its Advisory Committee would be covered in presentations later in the meeting. The minutes of the November 2002 meeting were then approved. Attendees at the meeting are listed in Appendix I.

Update of MPS Activities

Hunt congratulated Dr. Fiona Goodchild on receiving a Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring. He also congratulated Dr. Andrew Lovinger of the Division of Materials Research (DMR) within MPS for receiving the American Physical Society's Polymer Physics Prize, and noted this was especially noteworthy because it was for work done while Lovinger serves as an NSF program officer.

Hunt began with a discussion of the MPS FY2003 budget appropriation ($1,048,750,000). There were specific requirements within the appropriation, with the Division of Mathematical Sciences (DMS) and the Division of Physics (PHY) required to have bottom lines of $179,620,000 and $222,170,000 respectively. The appropriation also specified that $12,200,000 was to be added to the Division of Astronomical Sciences (AST) for the national facilities and that "adequate funding" was to be provided for the Giant Segmented Mirror Telescope (GSMT) planning. After these requirements what remained allowed for 10-13% increases to AST, the Division of Chemistry (CHE) and DMR.

With respect to the MPS budget request of $1,061,270,000 for FY 2004 Hunt noted that this request was not much over the FY 2003 appropriation. DMS has grown substantially over the last few years (DMS provides approximately 70% of research funds in mathematics to the academic community) and NSF was asking for additional funding in order to increase both grant size and duration. In fact, a survey of principal investigators had suggested that a doubling of grant size was required. The size of graduate student stipends has been increased in order to provide equity in funding compared to students supported on NSF research awards. It is felt this is a means of attracting and keeping US citizens and residents in science. Hunt noted that LIGO was now in full operations, and that MPS was providing support for the Large Hadronic Collider (LHC) and the Rare Symmetry Violating Processes (RSVP) project. The Physics Frontier Centers (PFC) received $10,000,000 in FY 2002 and he singled out the Center for the Origin and Structure of Matter at Hampton University in Virginia for doing a fine job.

DMS was now supporting 35 Vertical Integration of Graduate Research and Education (VIGRE) sites, and the number of mathematics majors was increasing. There were also investments in undergraduate mathematics education with the Directorate for Biological Sciences (BIO) and the Education and Human Resources Directorate (EHR). There were some particularly successful DMS collaborations with the Directorate for Geosciences (GEO) and an example was the work in Texas on surface and subsurface flows, which was particularly important for water conservation, and which had also attracted the interest of oil companies. In AST, there had been Congressional earmarks for the National Astronomy Centers. Also, the National Astronomy and Astrophysics Advisory Committee (NAAAC) had been set up to foster collaboration activities between the National Aeronautics and Space Administration (NASA) and NSF and the second meeting would be held the following week. In CHE there was action to increase the duration of awards, to provide for more instrumentation, and to make more Small Grants for Exploratory Research (SGER) awards. CHE also planned on funding several workshops to develop plans for support of new centers in FY 2004. DMR plans increased international support. There will be a significant increase for nanoscience in DMR and throughout NSF. DMR is encouraging support for underrepresented groups.

Hunt then discussed the MPSAC role in the MPS budget and planning process. MPSAC should advise MPS of community needs, discuss MPS strategic planning and priority setting, and make recommendations for the FY 2005 budget request.

Report on Follow-up Activities Related to MPS/EHR Coordination

Henry Blount noted that at the November 2002 meeting, the MPSAC identified several items for action by the Directorate. As reported in the Minutes of that meeting, two of these were:

- MPS will develop a chart describing directorate investments in education by division, similar to the chart shown by Dr. Eileen Friel on MPS investments in international activities; and

- MPS will prepare a brief report on educational projects already underway in the Directorate. This report will be distributed to the MPSAC when ready, but prior to the next meeting.

Blount indicated that he would address the first of these and that Judy Sunley would speak to the second.

- **<u>MPS Investments in Education, by Division</u>**

The Foundation’s three strategic outcome goals are People, Ideas, and Tools. While the largest MPS investment is in Ideas, the people educated and trained through MPS awards represent the most important outcome of the investments, as the strength of our technical and instructional workforce is dependent on an adequate supply of talented scientists and teachers. In FY 2002, MPS spent over $95 million on this strategic resource (Table I). This represents about one-third of the total MPS investment in researchers and students.

Table I. Summary of MPS Funding by Strategic Goal
(Dollars in Millions)

	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	Change Amount	Change Percent
People	95.81	116.53	124.67	8.14	7.0%
Ideas	594.91	597.11	670.25	73.14	12.2%
Tools	223.41	222.49	260.36	37.87	17.0%
Administration & Management	6.29	5.44	5.99	0.55	10.1%
Total, MPS	$920.42	$941.57	$1,061.27	$119.70	12.7%

To ensure a ‘diverse, internationally-competitive and globally-engaged workforce of scientists, engineers and well-prepared citizens,’ MPS makes investments in all phases of education. This includes K-12 through undergraduate, graduate, and continuing education, as well as outreach activities. All five of the MPS Divisions and the Office of Multidisciplinary Activities (OMA) are active investors as indicated in Table II.

Table II. Summary of FY 2002 Funding for People by MPS Division
(Dollars in Millions)

MPS Division	K-12	Undergrad	Grad/Prof	Other	Division Total
AST	0.11	2.00	5.21		7.32
CHE	0.12	3.71	19.03		22.86
DMR		4.95	11.18		16.13
DMS		3.31	25.29		28.60
PHY	0.82	4.53	3.33		8.68
OMA	1.93	1.62	7.32	1.35	12.22
Total, MPS	$2.98	$20.12	$71.36	$1.35	$95.81

Along the education continuum, undergraduate education represents a "pressure point" in the system. Decisions to enter research and teaching involving MPS fields are typically made during the undergraduate years. Undergraduates provide a considerably more diverse talent pool than is currently represented in the mathematical and physical sciences. MPS funding supports new programs and enhances existing ones at the undergraduate level that draw from this large, diverse group of students and provide more effective preparation for research and teaching. MPS also supports partnerships that lead to enhanced teacher preparation, broadened graduate and postdoctoral opportunities, and more informed teaching and learning strategies. Funds for development of new instruments and approaches will increase access to mathematical and physical sciences for both specialist and non-technical audiences. The MPS commitment to this wide range of activities is evidenced by the requested increase in MPS support for People from the $95.81 million in FY 2002 to $116.53 million in FY 2003 to $124.67 million in FY 2004 (Table III).

Table III. MPS People Investments
(Dollars in Millions)

	FY 2002 Actual	FY 2003 Request	FY 2004 Request
K-12	2.98	5.23	6.13
Undergraduate	20.12	23.46	25.21
Graduate & Professional	71.36	85.34	90.33
Other People Support	1.35	2.50	3.00
Total, People	$95.81	$116.53	$124.67

It is important to recognize that the MPS investment in education is far in excess of that defined by the taxonomy of the budget as 'People.' The vast majority of graduate students and postdoctorals in MPS are supported through individual investigator, group, and center grants that are included in the 'Ideas' strategic focus area, and through the grants and cooperative agreements that support MPS facilities, which appear under the 'Tools' strategic focus area. Likewise, undergraduate students who are learning through research and are supported through research grants other than Research Experiences for Undergraduate (REU) awards are not reflected in the 'People' category. Finally, a great many individual investigator and virtually all group, center, and facility awards support education and outreach activities that integrate research and education and significantly leverage the MPS research investment, but these do not appear as 'education' activities in the Directorate's overall bottom line. Table IV shows that in FY 2002, support of postdoctorals, graduate students, and undergraduates alone comprised almost one-half of the Directorate's total expenditures.

Table IV. People Supported in MPS Activities - FY 2002

Category	FY 2002 Actual	Salary and Fringe (Est.)	Indirect Costs (Est. at 50%)	Tuition (Est.)	Unit Cost, $K (Est.)	Total Cost for Category, $K
Senior Researchers	5,768					
Other Professionals	1,149					
Postdoctorates	2,215	40,000	20,000		60	132,900
Graduate Students	7,002	20,000	10,000	10,000	40	280,080
Undergraduate Students	5,047	5,000			5	25,235
K-12 Students	225					
K-12 Teachers	784					
MPS Total for Postdoctorates, Graduate Students, and Undergraduate Students:						438,215
Fraction of Total MPS FY 2002 Expenditures ($920.42 M):						48%

Salah thanked Dr. Blount for preparing this data and noted the impressive record of MPS in education. In the discussion following Blount's presentation Dr. Claudia Neuhauser noted with some concern that as the graduate student stipend goes up, principal investigators may shift money to postdocs and train fewer graduate students since postdocs are not much more expensive than graduate students.

- **Educational Projects Already Underway in MPS**

Judith Sunley reported on efforts at cooperation between MPS and EHR. MPS has been working to expand its efforts in integrating research and education and broadening participation. Many different types of educational activities cut across the MPS divisions in both formal and informal ways. These include: Integrative Graduate Education Research Traineeships (IGERT), GK-12, VIGRE, REU Sites and Supplements, Math & Science Partnerships (K-12), integrated research and education efforts by Faculty Early Career Development Program (CAREER) awardees, the educational and outreach activities of various centers and institutes [Materials Research Science and Engineering Centers (MRSECs), Research Sites for Educators in Chemistry (RSECs), Physics Frontier Centers, etc.] as well as activities included in unsolicited proposals.

Cooperation between the MPS and EHR Advisory Committees was stimulated through a joint symposium held in November 2002. Since then, NSF staff have discussed and shared with the advisory committee chairs the possibility of a joint subcommittee to enhance cooperation. Another area for cooperation is joint workshop planning, with preliminary planning underway for a workshop considering implications for undergraduate education involving the changing use of mathematics at the research frontier.

NSF priority areas provide an ideal venue for internal MPS/EHR cooperation. They include: Workforce for the 21st Century, Mathematical Sciences and Nanoscale Science and Engineering, Information Technology Research, Biocomplexity and the Environment, and Human and Social Dynamics. All of these priority areas have MPS participation and include significant educational components.

In exploring MPS joint interests in broadening participation, the Human Resources Development (HRD) division director met with MPS senior staff and MPS staff participated in the HRD principal investigator (PI) meeting. Potential areas of cooperation include the Louis Stokes Alliances for Minority Participation (LSAMP) and Alliances for Graduate Education and the Professoriate (AGEP) where connections can be made between MPS researchers and those participating in the alliances. Another internal effort at cooperation is the joint "Dear Colleague" letter soliciting supplemental proposals to advance education and training at the math/biology intersection at the undergraduate level.

There are increasingly many opportunities for the MPS and EHR communities to cooperate. For example, they are encouraged to jointly participate in partnerships and alliances such as the K-12 Math and Science Partnerships (MSP) and the LSAMP and AGEP programs mentioned above. In terms of broader impacts, industrial links can draw in minority graduate students and thereby provide for broader participation. Many MPS professional societies have activities aimed at education and/or broadening participation and NSF awards that provide partial support for the activities.

During the discussion a question was raised about the degree to which professional societies could contribute to education below college level. One argument that some in professional societies have used for not participating in undergraduate education is that NSF supports it already. Sunley commented that outside areas of NSF funding, professional societies are much less likely to be involved in educational activities.

There was an extended discussion about whether more students are entering the pipeline and how one evaluated EHR programs with that aim. EHR programs undergo assessment by external evaluators every three years. Metrics have evolved as the programs matured. In addition, each project is expected to have evaluation embedded in it. An assessment of the Louis Stokes Alliances for Minority Participation (LSAMP) program (now 10 years old) demonstrated an increase in minority participation. The LSAMP goal was to double the number of bachelor's degrees awarded to minority science and engineering students within 5 years. While most projects did not quite reach the 100% level of increase, there was about a 75% increase overall. The assessment studies have added more tracking of students to determine whether they are continuing in science and engineering. Preliminary data indicate that a large number of students go on to graduate study.

It is sometimes hard to get institutions to provide administrative support for collecting and maintaining data for outcome studies. This led to a query from the MPSAC as to how MPS might collect assessment data for its education-oriented activities. The reply was that MPS would likely contract with outside groups to do this, particularly with regard to diversity data. For example, at the present time the REU program is undergoing evaluation with an outside contractor.

Dr. Fiona Goodchild stressed the need for more support to be able to track and evaluate progress. While it was easy to obtain measures and metrics on campus, support was needed to pull it all together. She noted that the CHE REU program has an outside group of evaluators. Dr. Shenda Baker described the CHE REU group (she had been on this group) and how it was supported.

Dr. Jeanne Pemberton asked if NSF should assume leadership in terms of defining course content, which is another area where more interaction between MPS and EHR is needed. Some considered the creation of a joint subcommittee of MPS and EHR Advisory Committees necessary prior to discussing content. The joint subcommittee might discuss how knowledge and skills required at the research level might impact what is going on in education. The joint "Dear Colleague" letter mentioned above is an example of this. It uses the "*Bio 2010*" report of the National Research Council [funded by the National Institutes of Health (NIH) and the Howard Hughes Medical Institute (HHMI)] as a springboard. It was noted that medical school groups must be involved as their requirements dictate much of what is taught in biology. However, the requirements for medical school admissions and the Medical College Admission Test (MCAT) do not meet the breadth of education needed for advanced study in biology, particularly in physical sciences. Pemberton felt that one should plan in the long term for a series of such workshops across all disciplines

The mechanism for EHR/MPS AC interaction has yet to be decided. EHR and its AC have not provided formal feedback as yet to the MPSAC suggestions arising from the November joint meeting. There was a solicitation of volunteers to interact with the EHRAC at their meeting during the second week in May. A formal request from the MPSAC to EHR aimed at continuing collaborative efforts will be drafted. Talks between John Hunt and Judith Ramaley (Assistant Director of EHR) have laid the groundwork for such efforts; she has broached the subject with the EHRAC. The MPSAC Chair will make a formal suggestion directly to EHR and the EHRAC. One objective should be a draft of what is needed for students to be well educated for interdisciplinary research.

Some expressed concern in that they sensed during the November breakout sessions some surprise from EHR that there is debate about what EHR does, as they consider their plans well developed and see MPS as assisting in their implementation. The MPS AC feels that MPS should be able to influence the substance of education activities. The request to EHR should address matters of content. Since EHR programs are directed to education in all science and engineering, tailoring to the specific needs of individual fields can be difficult. Often education programs stress methods rather than content. The general feeling was that the education paths of EHR and MPS should intersect rather than proceeding in parallel modes. There should be greater interaction between EHR and all of NSF, which should be led by the NSF director and deputy director.

It was agreed that the MPSAC would try to have a member participate in the EHR Advisory Committee meeting in May. Salah would write a letter to the EHR Assistant Director concerning this. The letter and response are attached to these Minutes as Appendix II.

Presentation of Division of Physics Committee of Visitors Report

Dr. James Gates presented the report of the Committee of Visitors (COV) for the Division of Physics (PHY) on behalf of its chair, Dr. Persis Drell. The COV met at NSF on February 26-28, 2003 and reviewed PHY actions for FY 2000, FY 2001, and FY 2002 according to the NSF guidelines for COVs.

Their major conclusion is that PHY is successful in its performance in pursuing major goals of the division and NSF. The integrity and efficiency of the processes are excellent and the COV applauded the use of target dates and review panels in the programs. They gave high marks for outstanding program management, especially under conditions of flat budgets and a critical shortage of staff. The turnover rate among funded PIs is appropriate and would be too high at the 30% level that is the goal of NSF. The start of two new programs, Particle and Nuclear Astrophysics and Physics Frontiers Centers (PFCs), shows that the division is flexible and responsive. The COV was pleased to hear of plans to start a mid-scale instrumentation program for funding instrumentation in the range between the Major Research Initiatives (MRI) program and the Major Research Equipment and Facilities Construction (MREFC) account. The quality and significance of the results of programmatic investments are excellent.

The COV identified the following issues for attention:

- There needs to be an agency-wide plan to support operations of the large array of exciting new facilities;
- Efforts to reach out to underrepresented groups have met with limited success, although there has been some improvement. They suggested that the goals of the CAREER program need rethinking;
- More attention should be paid to explaining Merit Review Criterion 2 to reviewers;
- PHY staff are overloaded in part because of the needs for oversight of large projects and for mandated NSF-wide programs; and
- When PHY budgets expand, priority should be given to the base individual investigator program; however, appropriate choices are being made given the current funding levels.

On priorities, balance, and strategy, the COV felt:

- Programs are responsive;
- Facility operations needs NSF management attention;
- Effectiveness of community input varies among programs and is important for all fields, especially now;
- Physics Frontier Centers are a valuable component of the PHY portfolio and their number should be determined by intellectual need; and
- Future directions should include biological physics, physics at the information frontier, and mid-scale instrumentation.

Some suggestions to improve the COV process include:

- Schedule more time for division-level issues and for reading jackets;
- Arrange an organizational conference call ahead of the meeting;
- Have national planning documents available at the meeting;

- Provide 10-year trend statistics with background material; and
- Appoint as chair of the COV a person who has past COV experience.

The MPSAC discussion of the report touched on the trade-off between grant size and duration, future reviews of the PFCs, the value of having panels in addition to ad hoc reviews, the importance of interagency partnerships, current NSF efforts to improve NSF management of large facilities, and future planning, especially in response to the National Academy of Sciences (NAS) report "*Connecting Quarks with the Cosmos*."

The MPSAC accepted the COV report. The Chair of the MPSAC was charged to write a letter to the Acting Assistant Director of MPS conveying the MPSAC acceptance of the Division of Physics COV Report. This letter is provided in Appendix III.

Report on the MPS/Intelligence Community Workshop

By way of background information to these minutes, the MPSAC has addressed the critical role that MPS basic research plays in national security in the document, "*Reinvestment Initiative in Science and Engineering (RISE)*"[1]. In May 2002, the MPSAC issued a document that responds directly to the February 2001, Hart-Rudman Report, "*Road Map for National Security: Imperative for Change.*" The MPSAC's document is entitled "*Recommended MPS Response to the Hart-Rudman Report*"[2]. In essence, the Advisory Committee urged the MPS Directorate to develop partnerships with appropriate agencies that can lead to joint programs through which the MPS scientific community can contribute to basic research and workforce development relevant to national security.

In response to the Advisory Committee's recommendations, the NSF and the Intelligence Community (IC) held a joint workshop on "*Approaches to Combat Terrorism (ACT): Opportunities for Basic Research*" in Chantilly, VA on November 19-21, 2002. This workshop was chaired by Dr. Ernest Moniz of the Massachusetts Institute of Technology, and Dr. John Baldeschwieler of the California Institute of Technology and brought together approximately 60 individuals from academic, industrial and government laboratories with approximately 15 representatives from NSF and the IC. The workshop report identifies representative areas where MPS basic research can make contributions, including energy sources, mathematical techniques, image reconstruction and analysis, sensors and detectors, and optical spectroscopies. While there is considerable activity currently supported by MPS in these and related areas, the workshop revealed the need to embolden the MPS community to identify approaches with the potential to provide "quantum leaps" in technology through support of basic research. The workshop also identified the development of a scientific workforce trained in the MPS disciplines as critical to national security.

Moniz briefed the MPSAC on the workshop. In his remarks he noted that terrorism, with its potential for international reach, has forced new ways of thinking about and new approaches to ensuring national security. The basic research community has a significant history of providing scientific and technological underpinnings of our national security posture, and he gave examples such as radar, nuclear weapons, and cryptography developed during World War II. It was examples such as these that led to the establishment of the very structure of the US basic research enterprise through Vannevar Bush's report "*Science—The Endless Frontier*," which, based on the impact of scientific research on the economy, health, and security, recommended establishment of a "National Research Foundation." This became reality in 1950 with the creation of the National Science Foundation. Since then, there has been a major increase in public support for science research and development, with a university focus for basic research linked to education.

Over the last half-century, he noted that military capabilities have most prominently provided the foundation for support of basic research by national security agencies. However, the asymmetric threat of international terrorism now places a considerable premium on strengthening U.S. technological capabilities for homeland defense and for intelligence collection. It was the aim of the workshop to familiarize the NSF/MPS and IC communities with their respective objectives, capabilities, and needs; to identify basic research areas and

[1] http://www.nsf.gov/mps/activities/acweb/may02/rise.pdf
[2] http://www.nsf.gov/mps/activities/acweb/may02/recommend_hartrudman_0502.pdf

opportunities that can underpin our security against terrorism; and to support some of the most promising research through the NSF funding mechanisms.

Moniz noted that the academic and intelligence communities will almost certainly face challenges as they seek areas of aligned interest. The academic community is an open environment that encourages maximum exchange of ideas, progress in building on shared results of earlier research and international collaboration, while the intelligence community generally has high levels of secrecy and compartmentalization of information. There will be a need for recognition and respect for the other's norms. There will also be a need to focus on open basic research that can enable technology development that, when integrated with other technologies, will enable major IC future capability in combating terrorism. Finally, there will have to be the development of appropriate mechanisms by NSF/MPS and the IC for recognizing basic research results of interest to the IC, along with tailored mechanisms for carrying that research through succeeding stages of technology development to deployment in appropriate settings.

Moniz went on to describe the motivation, aims, implications and challenges of the working groups assembled to focus on each of five enabling areas:

- Sensors and Detectors;
- Optical Spectroscopy;
- Energy and Power Sources;
- Image Reconstruction and Analysis; and
- Mathematics.

In addition, the following crosscutting themes were specifically mentioned:

- Nanotechnology and computational modeling for materials;
- Cross-disciplinary research and a peer-review process that can handle 'risky' proposals; and
- Overarching needs for education/training.

Dr. Jeanne Pemberton discussed the Hart-Rudman Report *vis-a-vis* the workshop report "*Approaches to Combat Terrorism (ACT): Opportunities for Basic Research*," suggesting specific ways MPS can serve as an enabler in implementing the recommendations of these reports. By way of possible improvements to the workshop report, the need was expressed for more technical background to be provided by the IC on "existing state-of-the-art." Also, greater participation of more technical experts from the IC would be beneficial to fostering more productive discussion of strategies for improving IC strategies.

The MPSAC recommendations in the response to the Hart-Rudman report were then reviewed:

- The National Science Foundation, and the MPS Directorate in particular, should expand its role as a steward of America's science research capability. NSF/MPS should continue to focus on its strength in basic research, while responding to national needs in defense, intelligence, homeland security, and science education.
- The MPS Directorate should play a leadership role with other agencies in establishing domains of interest and means of coordinating activities.
- The MPS Directorate should create and maintain an inventory of the research activities and capabilities in the disciplines that it supports. The inventory should start with current and recent grant awardees, but should be rapidly expanded to a comprehensive inventory of federally supported activities.
- The MPS Directorate should take actions that will support the formation and maintenance of a national community involved in carrying out research in areas relevant to national defense, intelligence and homeland security.
- The MPS Directorate should conduct a set of open workshops to define actions and organizational structures that will support the recapitalization of America's strength in science and education.

Dr. Tom Beahn, a government consultant, discussed aspects of federal efforts dealing with terrorism. The President's speech on "*Combating Terrorism*" delivered at West Point, New York, June 1, 2002 was quoted. He described needs identified by the President, and reviewed recent responses to these threats by providing information on the mission of the new Office of Homeland Defense, the FBI, and the Intelligence Community. The IC consists of DOD agencies and services and non-DOD Agencies. He focused on the specific roles of the IC in combating terrorism and the threat to the United States and to its interests worldwide from both conventional and unconventional weapons, especially weapons of mass destruction (WMD). He summarized the NSF-IC workshop discussions on opportunities for basic research in each of the key technologies areas:

- Power sources (needed to operate devices in hostile environments);
- Mathematical Techniques (many applications of advanced mathematical techniques, especially needed to sort through large volumes of data);
- Image Reconstruction and Analysis (for the best view of what's going on in all parts of the world, especially with respect to suspected WMD programs);
- Sensors and Detectors (all kinds needed); and
- Optical Spectroscopies (for remote sensing).

The importance of merging the NSF basic research culture with the IC culture to advance key technologies was emphasized.

In the discussion that followed Dr. Neil deGrasse Tyson asked whether the science community had been working with the IC prior to September 11, 2002. He also asked Beahn if he felt that 9/11 could have been prevented. Beahn said that developments from basic research activities have, over the years, been crucial to identifying suspicious activities. No one is saying that if the IC had had more advanced capabilities the events of September 11 could have been prevented. Homeland defense begins overseas. Moniz commented that the ACT Workshop covers areas that are relevant to 9/11 such as new approaches to describing loose social networks, dealing with communications in multiple languages, or tracking individuals using multiple names.

Dr. Lon Matthias noted that the emphasis seems to be on weapons of mass destruction (WMD). He felt that attention should also include acts of massive disruption such as cyber-attacks. Dr. Peter Green commented that the workshop should also have emphasized specific issues such as the signatures and the fate and transport of chemicals in the environment.

Dr. William Pulleyblank felt that a mechanism or process is needed to address short-term needs and long-term needs. The ACT Workshop addresses science needs in the "present context." What about two years from now? How will NSF and the IC jointly help to support basic research? What process is helping to keep the dialogue current? What role will the NSF play in bringing science-community-results to the attention of the IC community? Beahn responded by noting that members of the IC are presently visiting the universities, an Intelligence Community Science Board is being established, and there is now an IC post-doctoral program to encourage basic research, education and training in unclassified areas important to the IC.

Baker said that the NSF science community doesn't know about the specific needs of the IC. How can NSF better define its role in this "push-pull" IC environment? How will the NSF-IC cultures merge into relationships with specific institutions in areas of particular focus? De Graaf responded that MPS would provide for supporting work through grant supplements and Small Grants for Exploratory Research (SGER). There is an NSF-IC Memorandum-of-Understanding that deals with implementation of programs to provide joint support for areas of mutual interest. NSF will identify the modes of support, and the science community will identify the areas to be supported.

Salah asked how the National Imaging and Mapping Agency (NIMA) advertised the post-doctoral program. The response was that this is posted on the National Imagery and Mapping Agency website.

Green asked what role the National Laboratories play in identifying priority areas. Beahn responded that the National Laboratories provide scientific expertise to analyze developments over seas. An example was in areas related to nuclear sensors and nuclear physics. Dr. Jean Futrell commented that basic science community partnerships with the National Laboratories are an important interface that can nurture relationships between the universities and, through NSF, with the IC.

Matthias noted that there are ethical and philosophical questions to consider. How does defensive research turn into offensive research? NSF supports open basic research that other countries could use for mass destruction and mass disruption? Dr. Gary Sanders commented that as a result of 9/11 people are looking to see if there is something the scientific community has to offer. The IC working with the NSF is part of an enduring relationship. The fact that the ACT workshop report had not been completed in time to be available to the MPSAC for today's meeting was a missed opportunity.

Salah thanked all three speakers and the meeting was adjourned for lunch.

Thursday, April 3, 2003
Afternoon Session

The meeting of the MPSAC reconvened at 1:00 P.M.

Communicating Effectively with the Scientific Community, the Public and the Congress

Dr. Madeline Jacobs, Editor, Chemical and Engineering News, addressed the MPSAC on "*Communicating Effectively with the Scientific Community, the Public, and the Congress*." She identified numerous traits that scientists and journalists have in common. She noted that both are highly motivated, above average in intelligence, curious, competitive, skeptical, typically work to deadlines, worry about nature, resist attempts to steer, and selectively interpret data.

Jacobs believes that scientists have an obligation to convey their results to the public. Journalists are more likely to write a story if they receive a good news release and/or visuals. They are more likely to write about astronomy, astrophysics, and particle physics than about chemistry or mathematics. Journalists are representative of the general public in that many of them have little or no understanding of science. The same is true for editors. It is a daunting challenge for scientists to try to communicate to the general public, which includes journalists and members of Congress. Science education for journalists would be helpful, especially if it helps to explain the *process* of science. She suggested assisting local teachers, working with university public relations offices, and not worrying about appearing to be self-serving.

Panel Discussion Enhancing the Visibility of MPS

Tyson, as moderator of the discussion, provided his thoughts in reaction to Jacobs' presentation. He cited Carl Sagan as a popularizer of science who was severely criticized by the scientific community for his efforts. He thinks astronomers are more successful in reaching the public because their vocabulary ("black holes", "red giants", *etc*.) is more accessible than that of some other fields. He pointed out that every age of science thinks of itself as the "golden age." He noted that science is omnipresent on television, indicating some success in reaching the public.

Curt Suplee, head of NSF's Office of Legislative and Public Affairs (OLPA) agreed that vocabulary is a barrier to communication with the public. OLPA will help scientists find words, graphics, and context for communicating. He feels there is a longstanding public interest in science. "Just about *anything* is more!" Real science can out-compete pseudoscience. Jacobs noted that journalism is more interesting when there is controversy; scientists have to *think* about how to get their message across. Suplee noted that the OLPA is developing a kit about communication for scientists and encouraged the community to send summaries of their research results to his office, including good visual materials.

Discussion of Update on NSF and MPS Activities

Hunt continued the discussion he had begun in morning concerning NSF and MPS activities. He had attended a meeting of the Senate Appropriations Subcommittee in the morning and he described that meeting.

Dr. Rita Colwell, Director of NSF, Dr. John Marburger, Director of the Office of Science and Technology Policy (OSTP), and Dr. Warren Washington, Chair of the National Science Board (NSB) were also present at the meeting. Only two senators were present; Senator Bond (Republican) was present for the entire 65-minute session, and Senator Mikulski (Democrat) was present for about 30 minutes. Bond is the current Subcommittee Chair while Mikulski was the previous Chair. Both senators are strong supporters of the NSF. Mikulski spoke of how an organic chemistry class had kept her out of science; Bond spoke favorably of recent visits to the St. Louis Science Center, supported by NSF Informal Science Education, and the Plant Genome Center at the University of Missouri.

Bond is aware of the lack of funding parity between the physical sciences and life sciences. Mikulski commented that the NSF FY 2004 budget request is "paltry." She was also appreciative of the fact that although there is more money allocated for research, there is less for administration and management, and that budgetary limitations on travel and staff time make it difficult to do much oversight.

Salah said that he had not realized that the recent authorization by Congress for about 30 more FTE's for NSF was not funded. Dr. Tom Weber, Director of the Division of Materials Research (DMR) pointed out that it is actually only about 25 new slots after transfers. Hunt said that the new slots could be funded out of the existing budget, but only by cutting other areas, such as computer purchases, staff travel, *etc*.

Hunt was asked about the recent large increase in the budget for mathematics. Hunt replied that Colwell has been strongly supportive of increasing support for mathematics. The DMS budget is now larger than that of CHE. Dr. William Rundell, Director of the Division of Mathematical Sciences, noted that looking over a period of ten years one could see that the increase is not as large as it seems when stagnation is factored in.

Green asked about the rationale behind the big increases in funding for "initiatives." Weber said that the "nano" initiative hadn't hurt DMR, and that when an initiative's five-year lifespan is over, the money remains in the division. Hunt also discussed the relative changes in the funding of single-investigator grants as opposed to multiple-investigator grants. Support for single-investigator grants has increased, although not as fast as support for multiple-investigator grants. The funding rate has stayed about the same for individuals, but has dropped for groups. He feels that over the last 20 years, there has been a substantial change in the balance between research done by individuals and groups.

Salah asked about funds for mid-scale instrumentation in the FY 2004 budget, *i.e*. instrumentation with costs ranging between MRI and MREFC costs. Various COV's have supported the idea. Hunt was asked where funding for such projects would be obtained, and how would it be administrated? He replied that the instrumentation needs would be driven by divisional research, and that divisions would have to set their own priorities. Weber commented that DMR is hoping that part of the anticipated increases will be targeted for such equipment. Dr. G. Wayne van Citters, Jr., Director of the Division of Astronomical Sciences, noted that AST has been taking the funds out of its regular budget. Salah asked if there were any plans to ask for an initiative for such purposes, and Hunt replied that there are not any current plans for such, but that it could be part of the planning for FY 2005. Salah felt that this might be the best strategy for MPS. Futrell agreed that new money is needed.

Gates asked if there was any way that such funds might help out with university start-up funds for new faculty. Hunt noted that some of this has been done through a program called Chemistry Research Instrumentation and Facilities (CRIF). Pemberton asked Dr. Don Burland, Executive Officer of the Division of Chemistry, what the impact of the investment has been, and Burland replied that he didn't feel like they'd had enough funding in the program to make much of an impact. Dr. Joseph Dehmer, Director of the Division of Physics, discussed some of the instrumentation funding PHY has done in this cost range, and said that it has been done principally through *ad-hoc* proposals, and primarily for accelerator physicists. If the concept were elevated to the status of a regular program, PHY would be able to have cross-physics competitions.

Discussion on MPS Long-Range Planning

Salah noted that there were nine white papers provided by MPS that addressed long-range planning areas and this discussion was a continuation of a topic that had begun at the meeting of the MPSAC in November 2002.

Computational Science, Cyberinfrastructure, High-Dimensional Massive Data

Dr. Claudia Neuhauser provided a brief summary of the white paper on Computational Science. She commented that undergraduates should become engaged with the subject. They will use it to solve problems in many areas of research. Workshops are useful to make people aware of computational science. Pulleyblank observed that there is no broad consensus on its content since it crosses disciplines. But there is commonality because all scientific fields use simulations and scientists should be trained to do simulations. Sanders asked how this initiative would interact with other programs on going in NSF. Dehmer described it as a field to itself, and a discovery tool. It needs some level of support and infrastructure. Most initiatives have a limited lifetime but computational science will remain. It will be built into programs similar to instrumentation.

Futtrell asked if this area should be linked to High-Dimensional Massive Data and Cyberinfrastructure. Salah asked if Cyberinfrastructure involves more than MPS. Hunt replied that it does, and that an NSF-wide committee will look into this. Sanders asked if Massive Data stands alone as a program. Dr. Richard Hirsch, Acting Director of the Advanced Networking and Infrastructure Research (ANIR) Division, commented on the long-range plans for computational centers such as at San Diego and Illinois in terms of building a cyber infrastructure. The discussion concluded with the MPSAC charging Morrison to draft a short paragraph on the linkages and differences between the three areas. Other MPSAC members who have written on the areas should look at this and respond.

Connecting Quarks to the Cosmos (The Physics of the Cosmos)

Tyson observed that the five-syllable title had power (appeal) in garnering attention. The white paper provided 11 questions addressed by this initiative. Tyson noted that the questions are somewhat separate from NASA initiatives. Salah asked what should be done with the white paper. Blandford recommended that the MPSAC support it. They should endorse investigating the science questions (principles) that motivate the initiative. There was consensus that language that endorses the concept should be inserted into the white paper so that MPS could move forward with a recommendation.

Facility Stewardship Initiative

Saunders began discussion of the white paper by noting that this white paper was actually in the form of a recommendation. The impetus was to relieve the pressure of building an infrastructure facility and avoid having the operating costs eventually come out of the core support. Salah asked if this was an initiative or rather a recommendation promoting good management plans. Dehmers discussed “Underground Science” and the need for a “deep hole” to do certain types of experiments. The MPSAC asked that MPS keep them informed on the “Underground Science” discussions. The MPSAC endorsed the importance of support for large facility management and for planning for mid-range facilities.

Molecular Science and Technology (MOST)

Futtrell thought this was an extremely important topic. He pointed to the recently published (National Research Council (NRC) report “*Beyond the Molecular Frontier*” as evidence of interest in the community. However, he thought the white paper was broad and unfocused. Futtrell noted that tools and equipment would be important to the initiative, and expensive. What tools and equipment? Several examples were given including generating very high magnetic fields leading to new generation nuclear magnetic resonance devices and ion cyclotron resonance spectrometers. The interest in molecular science by OSTP was raised. Hunt replied that Dr. Arthur Ellis (Director of the Division of Chemistry) and others were planning to visit OSTP in several weeks to explore this. The discussion concluded with the recommendation that Pemberton and a small group undertake to focus on this topic and look further beyond the white paper.

Increasing Core Support in the Mathematical and Physical Sciences

Pemberton initiated discussion of the white paper. She felt the proposal was very broad and consequently may be ineffective. Perhaps it should focus on what will happen if core support is not increased. Dehmer said that this was a different matter than discussed in the other papers, but it was the most important. The timing is optimal for bringing it forward as Congress is poised to listen. Salah suggested that it be put up front. Should we make comparisons to NIH? Is it the highest need? The ideas were forwarded that the paper should define the core, how many people are supported and why they are being supported. Aizenman recommended that the word “core” be avoided. The recommendation was made that “basic investigator-driven research” be used.

Research and Innovation Sites for College Students (RISCS)

Goodchild led the discussion of this white paper it was noted that Research and Innovations Sites for College Students (RISCS) were expected to expand research initiatives to lower level students and larger numbers than generally available. In response to a question whether these were to be new REU sites for high school students and was there a single model in mind, her response was that REU sites are very diverse and successful. The precise model should be left to the creativity and needs of the site directors. In response to a question as to whether this initiative was similar to the University Research Centers (URCs) initiative that the MPSAC had discussed and approved recently, Ellis replied in the affirmative and noted that Pemberton and Lee concluded a workshop this week on URCs. Pemberton described some of the recommendations of the workshop. The workshop concluded that URCs should involve all types of institutions–including community colleges and high schools. The students could be involved in original publishable research, service research projects, and perhaps even research that is original to them (while they do not know the answer it is not necessarily new knowledge). Several examples were presented at the workshop that generated enthusiasm among the participants. Goodchild commented favorably on the workshop summary. The size of the initiative, approximately $50,000,000, was discussed. Was this the right size? How much could one do with this? The cost of undergraduate research is always underestimated. Gates noted the difficulty of doing research with undergraduates and the need for different models. Pemberton proposed that topic be tabled until after the workshop report comes out and some URCs are operational.

Quantitative Biology

Baker briefly discussed the white paper and recommended endorsement. Burland referred to an OSTP/Office of Management and Budget (OMB) memorandum by John Marburger (Director of OSTP) and Mitchell Daniels (Director of OMB) that demonstrates interest at the highest levels. He commented on an existing working group involving MPS and BIO that is beginning discussions on topics of common interest. Morrison commented on the sequencing information from the genome project and thought that MPS should have a big role in this. It was recommended that Baker work on a better title for the initiative.

Scientific Discovery in the Face of Uncertainty

Gates led the discussion. There were comments that this was the most puzzling item among the white papers. There was a lengthy discussion of examples of how uncertainty enters into problems, and even initiates them. This sometimes leads to productive outcomes, new knowledge, and tools. The discussion of whether this should be an initiative or examined within the regular programs concluded with the MPSAC deciding that this matter be tabled for the moment.

Science Partnerships with Developing Countries

Green led the discussion. Mathias asked what goal MPS hoped to achieve in promoting this initiative. Gates discussed how South Africa might be of special interest because of its strength on the African continent and the potential it had to influence others. Dr. David Morrison wondered if this should be a MPS initiative. Sunley pointed out that in some directorates the questions that are examined necessarily drive a partnership (*e.g.* ecological or geoscience). In MPS, the science question usually does not intrinsically drive the partnership. Nevertheless, partnership can be mutually beneficial. It was pointed out that Kerry-Ann Jones, the new director of the Office of International Science and Engineering (INT), would address the MPSAC the next day. The consensus was that MPS should move without delay on some pilot program initiatives with selected countries.

Adjournment

The meeting adjourned at 6:00 P.M.

Friday, November 8, 2002
Morning Session

Salah convened the meeting of the MPSAC at 8:30 am.

International Cooperation

Dr. Kerri-Ann Jones, Director of the Office of International Science and Engineering (INT) described current NSF international activities. INT objectives are to serve as a visible focal point, both inside and outside NSF, for international science and engineering activities, promote the development of an integrated, NSF-wide, international strategy, and manage international programs that are innovative, catalytic and responsive to the broad range of NSF interests.

The INT portfolio includes cooperative research programs, international training experiences, and INT has regional offices in Tokyo and Paris, with an office opening in China in 2004. There are formal cooperative agreements with a number of countries.

The cooperative research programs have an emphasis on students and young scientists, and Jones described the geographical distribution of these awards and their distribution within the NSF Directorates. About 30% of the awards go to fields related to MPS disciplines. INT also supports fellowships and summer institutes.

With respect to INT goals and objectives, INT intends to develop targeted approaches, maintain country expertise and contacts, inform directorates of issues, conduct outreach to the science and engineering community, develop a list of priority themes, work closely with OSTP and coordinate with the United Nations Educational, Scientific, and Cultural Organization (UNESCO), and develop targeted programs with developing countries.

In the discussion that followed Jones' presentation, the question was raised concerning the role of INT with respect to large facilities. Jones responded that in each case the proposed agreements go through her office and INT works closely with the State Department on these arrangements. The question was raised concerning the role of INT in undergraduate education. Jones replied that INT had just begun to think of such issues, and that it was important to have an infrastructure in place. She noted that INT can only work with organizational counterparts in other countries. Gates noted that American students spend summers in South Africa to mentor students. He asked if there was a mechanism for support of such activities. Jones said that there was no support since this would need partnering with the US Agency for International Development (USAID).

Tyson asked if there were INT programs for the Islamic community. Jones responded that INT was organized by region, not religion. INT had to be careful not to become captive of political world. It had to maintain the values of NSF. Green noted that the relationship between the United States and developing nations (where there was no infrastructure in place) differs from the relationship with developed nations. The mutual benefits from the former were not clear.

Preparation for Meeting with Deputy Director

The MPSAC discussed questions they would pose to the Deputy Director. Topics that were suggested included MPSAC activities regarding prioritization, MPSAC activities with respect to education, staffing with respect to oversight over large facilities, the ongoing search for a new Assistant Director for MPS, and international activities.

Long Range Planning Discussion (continued from previous day)

It was suggested that the MPSAC review the draft of the long-range planning document and write it in language that would start the statements such as “We endorse...” Sanders felt that the quality of the writing had to be improved; each section needed a conclusion and recommendations. Each section should have the background, issues, *etc*. presented in an organized way, and then recommendations made. The author of each part should be identified so that questions could be addressed to that person.

Salah asked when the MPSAC recommendations on the white papers would be needed. Hunt said it would be the end of the month (April). Salah stated that he wanted to submit the MPSAC response by May 3, and asked MPSAC members to send in their drafts to within two weeks.

Coordination with the Intelligence Community

The discussion turned to a discussion of the previous day’s presentations concerning interactions between MPS and the Intelligence Community. Dr. Adriaan de Graaf, Executive Officer of MPS, noted that the report on the joint MPS/IC report was close to being done, and he expected that it would be ready for approval within two weeks. A proposal solicitation was being prepared. The solicitation was to be a joint activity between MPS and the Intelligence Community. The solicitation is for supplements to existing grants. A Memorandum of Understanding is being finalized. MPS would provide $2,500,000 for this activity and the IC would provide $1,000,000.

Salah asked how the fraction of support between MPS and the IC came to be agreed upon. Green felt that the IC had significant funds, but De Graaf stated that the IC had little for research. Most funds were for operations.
In response to a question from Green as to who determines which supplements are funded, de Graaf responded that the program officer makes the initial recommendation. In response as to how the IC participated in the decisions, he noted that the IC could carry out joint reviews with NSF. De Graaf also said that this activity was the first phase of a long-term partnership between the IC and MPS. He said that the IC was extremely interested in building connections with the larger science community. In response to a question whether the research would be open, Hunt replied in the affirmative. Morrison wondered if the perception that NSF is involved with security research might make NSF a target for terrorism. Morrison also asked about budgets anticipated for this activity in future years, and de Graaf responded that it depended on the IC budget and the world situation.

He noted that the IC was made up of 14 agencies and all were increasingly aware of the need for connections to the scientific community. Pemberton asked as to the length of time the current Memorandum of Understanding was valid. The response was for one year–until 2004. He thought the IC would increase the amount of their participation in 2005.

Green felt this collaboration was important in the long-term, and could involve National Laboratories. Gates suggested that an *ad hoc* subcommittee of the MPSAC be created to watch this activity, as it could become an additional drain on resources. Salah felt that MPS should be more aggressive in seeking a greater fraction of the costs from the IC and that the MPSAC should monitor this activity.

Pulleyblank suggested that this activity be kept on the agenda for future meetings, and Salah suggested that an IC representative be invited to MPSAC sessions when this topic is discussed.

NSF and the Federal Budget Process

Martha Rubenstein, Director of the Budget Division, described the mission and responsibility of NSF's Budget Division. She gave a detailed account of budget planning processes within NSF and how they fit within the federal budget process. She also described NSF's current activities involving assessment and accountability. She noted that NSF had received high marks from OMB for its performance.

The MPS Priority Setting Process

Pulleyblank presented his subcommittee's conclusions regarding the MPS annual priority process. Members of this subcommittee were Appelquist, Futrell, Green, Pulleyblank, Salah and de Graaf (MPS representative).

The goals of the subcommittee were to develop suggestions for improvements to the MPS planning process and to propose ways of increasing MPSAC participation in the process. He described the current budget process and timeline, and stated that the subcommittee thought that a facilitator might be useful in the terms of refining the budget process, and that various methodologies and tools exist to assist in prioritization.

During the discussion period a question was raised as to whether there are papers that go into the senior management retreat in addition to the initiatives that the MPSAC had reviewed. The response was that senior management mainly looks at new initiatives in the context of existing core programs. New initiatives normally have a five-year term. A question was raised as to the fate of papers tabled or rejected by the MPSAC. The response was that the MPSAC is an advisory committee, and the MPS Assistant Director would take the MPSAC recommendations into consideration. It was possible, for example, that an initiative rejected by the MPSAC could fit with initiatives from other directorates.

A question was raised as to what had been done with the MPSAC feedback on the papers presented by MPS at the November 2002 meeting. The response was that the MPSAC has input at two points in the process–the MPSAC comments to the November papers has been distilled into the papers that have been presented at this meeting.

The MPSAC felt it would be a good idea to use the November meeting to provide input on papers that are to be discussed at the March MPS retreat. MPS should also canvas the MPSAC membership for ideas for possible new initiatives in advance of the November meeting. MPSAC members could be provided with existing science papers, and asked to provide additional input. In order to make use of this process to its fullest extent, division breakout meetings should be held at an early phase of the meeting, rather than at the end.

Meeting with the Director and Deputy Director of NSF

Dr. Rita Colwell, Director, and Dr. Joseph Bordogna, Deputy Director of the National Science Foundation, met with the MPSAC during lunch.

Dr. Colwell welcomed members of the MPSAC and gave a brief report on the current state of NSF and MPS. She announced that NSF's FY 2003 budget was scheduled for an overall increase of 13 %, but that these funds are not yet in hand. NSF has good relationships with the U.S. Senate, and the five-year out-year budget request looks very promising. Search committees are active in reviewing candidates for the positions of Assistant Director for MPS and for the Engineering Directorates. She also noted the strong commitment of MPS to education and the efforts underway to merge the cultures of MPS and the Education Directorate to meet NSF goals.

Salah congratulated Dr. Colwell for the success in getting the 13 % increase in the budget. He also expressed his appreciation to the Acting Assistant Director of MPS for his leadership. After presenting a summary of the MPSAC discussions during the present meeting, Salah asked for other MPSAC questions and comments.

Tyson commented that while Colwell's arguments and rationales for an increased NSF budget had been made in the past, it was only in FY 2003 that success was achieved. He asked Colwell what factors caused this change.

Colwell responded that better communication among the various branches of the scientific community might have brought about this improvement. The scientific community has to talk with one voice on behalf of the NSF budget in order to make a positive impact on Congress and the Administration. Although she expressed her satisfaction with the outcome for the FY 2003 budget, she felt much more needs to be done. NSF's current priority areas are Information Technology, Nanotechnology, and Mathematics. She said that inadequate funding of research comes at a high cost to the nation and noted that about $15,000,000 in proposals that had been rated as "Excellent" cannot be funded due to an inadequate budget.

Tyson asked whether public awareness might be a factor in the increased budget. Did better public awareness help with the Congress? Colwell responded that the public awareness of science must be significantly improved to have an effect with elected officials.

Salah broached the topic of NSF-supported large-scale facilities. This is an issue that has not yet been successfully resolved. Sanders noted that the issues of oversight of facilities staff, facilities management, etc. had already discussed during the previous MPSAC meeting. Colwell responded that budget cuts were imposed by the U.S. Congress in parallel with an increase in NSF activities. She said that there appears to be a move to limit funds going to internal agency operations and transfer funds requested for these operations to support of research activities. There is, however, a limit to how much of this can be done. If NSF is to conduct proper oversight of the work it supports NSF needs to have an adequate staff to do the job.

Both Colwell and Bordogna pointed out that NSF has been working on this problem for five years, that many facilities are in place, and that more roles have been added to NSF's Strategic Plan. Also, NSF has the good will of Congress, Congress has recognized that NSF is doing a good job, that there is no mismanagement or misuse of resources, and that with the use of rotators we have a transparent system to avoid any such problems. She stressed that input from MPSAC is needed to maintain this good record and even improve on it.

Pemberton pointed out that education issues were discussed at the November MSPAC meeting with the EHRAC and noted that nearly 50 % of the MPS budget is invested in education. Colwell felt that every student should be required to take one semester to one year of science courses in his/her education. Pulleyblank commented on the cultural gap that exists between science and education. Bridging the gap between these two communities is necessary but will require additional funding. Colwell responded that several hundred million dollars are invested in education *via* research projects and supplements. This is particularly strong in the bioscience community.

Pulleyblank asked about the role that the National Laboratories play. Both Colwell and Bordogna responded that NSF has very good relations with the National Laboratories, especially those associated with the Department of Energy.

Green asked about NSF's vision concerning carrying out long-term projects with developing nations. Colwell responded that in this area NSF's focus is on very difficult science problems, such as, for example, helping deal with the problem of the water table in Bangladesh. The water table has been contaminated with arsenic. NSF is working on developing programs with other countries.

Bordogna noted that the priority in FY 2003 is the 'Tools' area of NSF's Strategic Plan. Without up-to-date tools research cannot be done. Here again it is the input of MPSAC that would be of help to NSF.

Colwell noted that facilities require competent and sophisticated management. Help from MPSAC is needed in this oversight activity.

The meeting adjourned at 1:00 P.M.

Divisional Meetings

The meeting reconvened at 2:00 P.M. and the MPSAC met in breakout groups with the MPS Divisions to discuss divisional implications of the MPSAC recommendations concerning new opportunities for MPS.

Divisional Reports

Division of Materials Research

Goodchild said that three items were discussed. The MPSAC group discussed international initiatives in DMR and was impressed by the community response and the number of awards for international joint work. The group had questions about the disparity between the size of the awards made by the international partners compared by the size of the DMR awards. They felt that the budget for international activities should be better defined. The group also discussed long-term planning.

Division of Chemistry

Baker said the discussion with staff centered on the initiatives and the white papers discussed by the MPSAC. Specifically, they discussed Quantitative Biology and Molecular Science and Technology. With respect to Quantitative Biology, they endorsed the white paper and recommended that it be vetted with BIO.

With respect to Molecular Science and Technology, the MPSAC group members felt this effort was broadly applicable and endorsed the concept..

Baker also reported on the discussion of the Division's undergraduate teaching and research centers (RISCS). This approach would represent a paradigm shift with a larger initiative possible in the future. The MPSAC group who met with Divisional staff would like to see how these projects were going before making a positive recommendation on this activity.

Division of Astronomical Sciences

Tyson said that the MPSAC group discussed how increases in the AST budget were being distributed–in particular, with respect to new initiatives. The MPSAC group felt that while it supported the new initiatives, NSF should not lose track of its basic mission to fund the basic foundations of science. It is this that serves as a basis for these new initiatives and those that will come in the future.

The issue of support of mid-scale instrumentation was also a concern. Such projects need continual support until their mission is done. Support should be at the level of the division and not through some type of centralized authority.

Division of Mathematical Sciences

Pulleyblank reported that the group discussed the shortage within DMS of staff to handle the increased proposal load and interdisciplinary work. The group was concerned that the increase in dollars for targeted solicitations means that the core programs are being underfunded. The group felt that the focus has to be redirected again to be the core. The group was pleased to learn of the increased communications between DMS and the DMS community and to learn of the May 9, 10, 2003 opportunities workshop that has been scheduled in Crystal City. The group noted that there was also a critical need for DMS rotators.

Division of Physics

Sanders, in reporting on the meeting with the Division of Physics, suggested that the divisional meetings should occur earlier in the agenda so that, after an MPS overview, there was more time to discuss discipline-specific issues with Division staff and bring these issues to the attention of the MPSAC.

An item discussed with the division concerned the entire life cycle cost issue of facilities. There needs to be a careful process for one-of-a-kind facilities that properly accounts for life cycle costs and allows also for flexibility. Planning for longer duration and larger facilities will become increasingly important over the years.

He commented there appears to be a very clear budget tension between the need for the large facilities and the regular programs both in Physics and Astronomy.

Action Items and Future Activities

In the discussion concerning action items and future activities of the MPSAC, Tyson commented that the search for a new MPS Assistant Director is on track, and list is narrowed down to people who are willing to be considered for the position. Criteria used are based on national recognition, broad experience in different areas covered by MPS, and administrative skills, knowledge and abilities. He also commented that for proper instrument maintenance, upgrades and upkeep, and interaction with scientists, mid-scale instrumentation programs should be handled at the divisional level, and not at the NSF level. Finally, he noted that new initiatives are becoming very popular with Congress, and they are putting more funds into these initiatives. But the increased funding for new initiatives should not be at the expense of core programs in support of basic sciences.

Salah had the following comments with respect to MPSAC action items:

- He would like to have increased interactions and developing collaborations between MPSAC and EHRAC.
- He requested input to the long-range planning and new initiatives from Advisory members, with a submission of a draft report by April 21st.
- He asked for planning inputs from Baker on mid-scale facilities, and from Pulleyblank and Pemberton on National Security related areas.[3]
- He asked that science white papers to MPSAC from different divisions should follow a uniform format for consideration by next years advisory meeting, which is planned on November 6 and 7th, when it is expected that a new Assistant Director for MPS will have been appointed.

Adjournment

The meeting was adjourned at about 3:00 p.m.

Appendices

[3] The MPSAC Report, submitted to MPS on May 15, 2003, is provided in Appendix IV.

APPENDIX I

ATTENDEES

<u>MPSAC Members</u>
Thomas Applequist, Yale University
Shenda Baker, Harvey Mudd College
Roger Blandford, California Institute of Technology
Jean Futrell, Pacific Northwest National Laboratory
S. James Gates, University of Maryland
Fiona Goodchild, University of California-Santa Barbara
Peter Green, University of Texas-Austin
Robert Hilborn, Amherst College
Lon Mathias, University of Southern Mississippi
David Morrison, Duke University
Claudia Neuhauser, University of Minnesota
Willie Pearson, Georgia Institute of Technology
Jeanne Pemberton, University of Arizona
William Pulleyblank, International Business Machines
Joseph Salah (Committee Chair), Massachusetts Institute of Technology
Gary Sanders, California Institute of Technology
Neil deGrasse Tyson, American Museum of Natural History

<u>MPSAC Members Absent</u>
David Siegmund, Stanford University
Julia Phillips, Sandia National Laboratories

<u>MPS Staff</u>
Morris Aizenman, Senior Science Associate, MPS
Laura Bautz, Acting Executive Officer, Division of Physics
Donald Burland, Executive Officer, Division of Chemistry
Henry Blount III, Head, Office of Multidisciplinary Activities
Joseph Dehmer, Director Division of Physics
Arthur Ellis, Director, Division of Chemistry
Eileen Friel, Executive Officer, Division of Astronomical Sciences
Adriaan de Graaf, Executive Officer, MPS
Lance Haworth, Executive Officer, Division of Materials Research
John Hunt, Acting Assistant Director, MPS
Deborah Lockhart, Acting Executive Officer, Division of Mathematical Sciences
William Rundell, Director, Division of Mathematical Sciences
Judith Sunley, Senior Advisor, MPS
G. Wayne van Citters, Jr., Director, Division of Astronomical Sciences
Thomas Weber, Director, Division of Materials Research

<u>Visitors</u>
Thomas Beahn, Consultant
Joseph Bordogna, Deputy Director, NSF
Rita Colwell, Director, NSF
Richard Hirsch, Acting Director, NSF Advanced Networking Infrastructure Research Division
Madeline Jacobs, Editor, Chemical and Engineering News
Kerri-Ann Jones, Director, NSF Office of International Science and Engineering
Ernest Moniz, Professor, Massachusetts Institute of Technology

Martha Rubenstein, Director, NSF Budget Division
Curt Suplee, Director, NSF Office of Legislative and Public Affairs

APPENDIX II

Date: Mon, 07 Apr 2003 17:36:50 -0400
From: Joseph Salah <jsalah@haystack.mit.edu>
To: Williara@pg.cc.md.us, JRamaley@nsf.gov
Cc: jbhunt@nsf.gov, pembertn@u.arizona.edu, jsalah@haystack.mit.edu, maizenman@nsf.gov, hblount@nsf.gov
Subject: MPS-EHR Interactions
Dear Dr. Williams and Dr. Ramaley,

The NSF MPS Advisory Committee, which I currently chair, held its Spring meeting last week, and the subject of interactions with EHR and its Advisory Committee was discussed. Last November, the two advisory committees and NSF staff from both directorates enjoyed an interesting joint mini-symposium and committed to working together in the pursuit of joint educational activities. The interest in such collaborative work continues to be high in MPS and its AC, although some of our committee members are anxious for such interactions to occur on a faster track. We all realize however that successful interactions need time to be developed properly and have to be placed on a strong foundation so they can be sustained in the long term. By this note, I am relaying the continued interest of the MPSAC to work with the EHRAC.

I attach for your information the draft proposal prepared last December by our MPS subcommittee on education that contains some suggestions for future collaboration. We were informed that the EHRAC will be meeting in early May, and we hope that the subject of the interactions can be placed on your agenda for some brief discussion. A member of our MPSAC would be willing to attend that portion of your agenda when such potential interactions are discussed, if you feel that this would be useful and appropriate. Dr. Jeanne Pemberton (U. Arizona) from our committee indicated that she will be in DC in early May, and can participate if you wish for her to attend that part of your meeting. Please let us know if this is desirable.

Please do not hesitate to contact me or Dr. Pemberton about any aspect of the above. We look forward to hearing from you and to working with you.

Joe

Dr. Joseph E. Salah <jsalah@haystack.mit.edu> Phone: 781-981-5400
MPSAC Chair (2002-2003)

xc: Dr. Jeanne Pemberton <pembertn@u.arizona.edu> Phone: 520-621-8245
Dr. John Hunt, MPSAD <jbhunt@nsf.gov>

MPS-EHR Collaboration on Education and Broader Impacts

Mission:

To foster collaboration and exchange of ideas between the MPS and EHR Directorates and their Advisory Committees so as to further strengthen the integration of research and education in programs supported by NSF.

Objectives:

- Initiate dialogue that will communicate the goals, needs and detailed activities of each Directorate to the other.
- Explore areas of collaboration and cooperation involving workshops, symposia and outreach to constituents in areas of mutual interest, including needs, emerging areas of discovery and concern, infrastructure issues and evaluation of program impacts.
- Develop white papers and working documents to explore how educational and research opportunities can be combined for the benefit of students at all levels.
- Explore focus areas and programs that would be co-reviewed and co-funded in the areas of STEM education and in satisfaction of the 'broader impacts' criterion.
- Explore development of an inventory of disciplinary expertise in science education.
- Promote communication mechanisms to NSF personnel and NSF constituents describing activities, available resources, upcoming workshops, online assistance and NSF funding opportunities.

Possible mechanisms:

1. Establish a short-term joint subcommittee comprised of members of both Advisory Committees (AC). Results of their work would be shared with both the EHR and MPS Advisory Committees.

   For example this subcommittee might:
   - Keep the two AC's informed about matters of mutual interest.
   - Host occasional joint sessions, such as the one held on November 7, 2002.
   - Write joint white papers to provide guidance to the two AC's.

2. Recommend ways of exchanging NSF personnel and external reviewers on panels for proposals that integrate scientific and educational research.

From: "Ramaley, Judith A." <jramaley@nsf.gov>
To: "Joseph Salah" <jsalah@haystack.mit.edu>, "Williara@pg.cc.md.us" <Williara@pg.cc.md.us>, "Ramaley, Judith A." <jramaley@nsf.gov>
Cc: "Hunt, John" <jbhunt@nsf.gov>, "Lightbourne, James H." <jhlightb@nsf.gov>, "Ramaley, Judith A." <jramaley@nsf.gov>, "pembertn@u.arizona.edu" <pembertn@u.arizona.edu>, "maizenman@nsf.gov" <maizenman@nsf.gov>, "Blount, Henry" <hblount@nsf.gov>
Subject: RE: MPS-EHR Interactions
Date: Mon, 7 Apr 2003 21:13:12 -0400

I am delighted to hear of the continued interest of the MPS advisory committee in developing a collaboration with the EHRAC. We have already asked Dr. John Hunt to join us to discuss next steps. I am sorry that the two meetings did not overlap as they did last fall. We would welcome the participation of Dr. Pemberton and I will ask Jim Lightbourne to arrange for her to get a copy of our agenda as soon as it is ready to go and will also check to see when Dr. Hunt is planning to join us so that Dr. Pemberton can join him if her schedule permits.

We are eager to move forward.

Judith

APPENDIX III

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April 7, 2003

Dr. John B. Hunt, Assistant Director
Directorate for Mathematical and Physical Sciences
National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230

Dear John,

The report of the Committee of Visitors (COV) to the Division of Physics (PHY) submitted by Dr. Persis S. Drell, Chair of the COV, was reviewed and discussed at the MPS Advisory Committee (MPSAC) meeting on 3-4 April 2003, together with the MPS/PHY response. I am pleased to inform you of the formal acceptance of the COV report on behalf of the MPSAC, which endorses the COV's findings and recommendations.

The report was very supportive of the PHY program and identified some issues that need specific attention in the future. The MPS/PHY response to the comments and recommendations is also accepted by the MPSAC, and we urge continued attention to the issues raised by the COV.

In particular, we find in this COV report some elements that are common with other recent MPS Division COVs, such as staffing and facility management. It would be useful for MPS to identify such common issues so that they can be addressed in an integrated manner at the next MPSAC meeting.

We are grateful to the PHY COV and its Chair for the excellent and in-depth review of the PHY program, and to the PHY Division Director and his staff for their preparations for this COV review and for their commendable work.

Sincerely yours,
Joe
Joseph E. Salah
Director, MIT Haystack Observatory
Chair, MPS Advisory Committee (2002-2003)

xc: P. Drell, J. Dehmer, L. P. Bautz

APPENDIX IV

RECOMMENDATIONS OF THE MPS ADVISORY COMMITTEE
FOR THE LONG-RANGE PLAN OF THE MPS DIRECTORATE

May 15, 2003

EXECUTIVE SUMMARY AND RECOMMENDATIONS

At the meeting of the MPSAC at NSF on April 3-4, 2003, various initiatives were presented by the MPS Directorate and its Divisions and were discussed as part of the long-range planning activity for MPS. The MPSAC is pleased to be actively involved in this important activity and to offer its recommendations as outlined in this document.

MPSAC strongly endorses the newly-proposed strategic planning and prioritization process for MPS, as outlined in the presentation on April 4 by the special MPSAC subcommittee chaired by W. Pulleyblank. Furthermore, **MPSAC recommends that, in the future, white papers be prepared in a uniform format by the various MPS Divisions for both disciplinary and interdisciplinary initiatives and presented at the annual Fall meeting** for review and discussion. The papers should provide the science background, projected impact, proposed goals, and the rationale for recommended actions, with authors identified. MPSAC would then provide its feedback and input, and propose additional initiatives for consideration. This material would then be further reviewed and used in MPS Divisional and Senior Management retreats and planning meetings.

The eleven sections that follow in this document represent the initiatives discussed by the MPSAC and recommended for implementation as part of the FY2005 MPS program. Abstracting from and summarizing the discussion of each of the eleven initiatives in the order of the topics presented in this document, the **MPSAC recommends the following**:

(1) A re-investment in the nation's future by increasing the financial support of the MPS core research program.

(2) Establishment of Computational Science as a priority area within MPS.

(3) Development of an initiative that enables the processing of high-dimensional massive data.

(4) Consideration be given to the establishment of a special subcommittee consisting of MPSAC members, MPS Division staff, and possibly experts from the broader community, in order to outline the preparations needed for MPS to take full advantage of the NSF-wide Cyberinfrastructure initiative.

(5) Implementation of programs and facilities that respond to the challenges posed by the NAS study *"Connecting Quarks to the Cosmos"*. MPSAC endorses the approach that has been instituted to coordinate a joint NSF-NASA-DOE research plan for this initiative under OSTP leadership.

(6) Development of the Molecular Science and Technology initiative to help launch the 'molecular age'.

(7) Promotion of an initiative to address Mathematical and Physical Sciences at the Biological Interface.

(8) Execution of a clear and visible step to address the need for planning for life-cycle costs of major projects. MPSAC endorses the proposed Facility Stewardship Initiative as presented to the AC at its April 2003 meeting.

(9) Development of a funding path for projects at the mid-size scale (between MRI and MREFC). In particular, MPSAC recommends the start of a planning process within MPS where each Division prepares a plan for its needs for projects that fall within mid-size infrastructure guidelines, so that an overall timeline and prioritization process based on readiness and funding allocation can be developed.

(10) Continued support of basic research that benefits the Nation's security, in collaboration with other Federal agencies. Review mechanisms, allocation of resources, and the role of the national laboratories should be examined.

(11) Support of pilot programs for science partnerships with developing countries tailored for specific region of the world. These programs can then provide the basis for the development of models for future collaborations in the region.

1. Increasing core support in the Mathematical and Physical Sciences

Background: From the X-ray luggage scanner at an airport to the Magnetic Resonance Imager in the local medical facility, from modern synthetic techniques for manufacturing cheap pharmaceuticals to the neutron scattering facilities used to develop new materials and unravel the molecular basis for disease, and from the data encryption algorithms that safeguard electronic funds transfers to the wondrous discoveries that we have made about the world inside the atom and within the universe at large, we are surrounded by the fruits of research into mathematical and physical science in our everyday, economic, and cultural lives. As well as seeking a fundamental understanding of nature, research in the MPS disciplines provides the foundation of our technological society and the basis of our national defense. And research and training in MPS disciplines has repeatedly led to the emergence of new fields of science and technology.
Scientists trained in MPS disciplines were key players in the revolutionary development of molecular biology and computer science in the 20th century, and research in mathematics and the physical sciences has proven to be an engine for economic growth including, especially recently, growth in the biomedical, communications and information sectors.

Projected Impact: The pace of discovery in basic mathematical and physical sciences will be even higher in the 21st century than it was in the 20th. While it is important to support broad efforts in areas that build on the previous discoveries, the need to invest in mathematical and physical science research – to replace the seed corn – has never been greater than it is today and yet, by most indicators, this investment has lagged and we are now seeing the consequences. Our premier research laboratories are not as well equipped as needed. Our brightest young people, who might once have devoted their lives to the discipline of a research career, are being lured away by easier and more lucrative alternatives. Perhaps most damaging of all, the appreciation of mathematics and physical science and the confident understanding of its most basic principles have been seriously eroded in the population at large, from those who rely on technology to carry out their work to politicians charged with making difficult economic choices.

Proposed Goals: A major reinvestment in the MPS core, i.e. the basic research by the individual investigators, is absolutely essential in order to create the knowledge and develop the physical and human resources needed for the Nation's economic well-being and security in the 21st century. The field of mathematical and physical science encompasses a vast collection of strongly linked, active subfields. Although some areas of rapid growth, such as nano-technology, can be identified, the majority of the most significant discoveries – the next lasers, transistors and imaging devices – will continue to arise in an unscripted manner from the core program. This is the very nature of research. The National Science Foundation has an enviable record of success in identifying and fostering promising investigations out of the core research program in addition to supporting its more concentrated and programmatic research. There is now an historic opportunity to re-energize the mathematical and physical sciences and usher a new age of achievement in their service to society.

Recommendation: **The MPSAC recommends a re-investment in the nation's future by increasing the financial support of the MPS core research program.** This recommendation adds to identical calls for such an increase in support for the physical sciences by PCAST and the authorization and appropriations bills for FY 2003.

Information technology and the rapid growth in high-speed computing and high-capacity data storage and dissemination have enabled major advances in the Mathematical and Physical Sciences. The following three initiatives are interrelated but distinct, and serve to further advance the methods for computation: ***'Computational Science'****, the handling of the information:* ***'High-dimensional Massive Data'****, and the tools for transporting the large data volumes:* ***'Cyberinfrastructure'****. Each of these initiatives is described below.*

2. Computational Science

Background**:** Over the past decade, scientific computing has evolved into a discovery tool for science and engineering. Computations are now as much part of the scientific toolkit as theory and experiment. Today, most research in the physical and biological sciences as well as in engineering is unthinkable without a strong computational component. Computational science---the aggregate of activities needed to advance the frontiers of science through computations---is emerging as a new discipline, which is already being recognized in several university programs and practiced on a routine basis by many researchers in the field.

Computational science is a distinct mode of scientific inquiry. It is driven by discipline-specific applications, but is also concerned with the discovery of general principles (models and algorithms) underlying the computational process. It introduces a paradigm shift comparable to Newton's introduction of calculus, unifying seemingly disparate practices in scientific computing and thus building the foundation for new discoveries through the application of advanced computational techniques.

Projected Impact: Scientific computing has been recognized and encouraged in each MPS division for several years, and significant resources have been devoted to it. Yet, despite tremendous advances in the computational infrastructure, many challenging problems remain unsolved, either because the computational models are poorly understood or the existing algorithms lack the necessary structural stability. Multiscale phenomena in physics, chemistry, and materials science, as well as effects due to general relativity in astronomy, provide challenges that are well beyond current capabilities. A focused research program, involving disciplinary scientists, algorithm developers, and computational scientists, that addresses the fundamental computational issues (models and algorithms) common to the various disciplines would advance the state of the art of scientific computing and thus push the frontiers of science through computations.

Proposed Goals: MPS Divisions have sponsored various workshops and reports addressing issues of computation in their respective disciplines, and each has led to the formulation of specific goals. In the Spring of 2002, a Steering Committee on Computational Physics produced a report to the NSF on "Computation as a Tool for Discovery in Physics." Computational issues figure prominently in the Workshops on Opportunities in Materials Theory organized by DMR (the most recent workshop took place in October, 2002), as well as in the DMR Computational Review held in June, 2002, at UIUC. The CARGO program in DMS addresses computational issues in the recognition of geometric objects, and the division has sponsored workshops in the recent past on computational issues in Statistics and Algebra, Number Theory and Combinatorics, with reports forthcoming. A workshop on "Computational Science, Mathematics, and Engineering" is being organized by the Society for Industrial and Applied Mathematics (SIAM) under DMS sponsorship and scheduled for March 2003.

Thus, computational science crosses boundaries by its very nature. No part of MPS escapes involvement with computational science, and there are growing opportunities with biology, the geosciences, and engineering. Different disciplines face similar problems; Computational Science is the new discipline that addresses these problems. MPS has an opportunity to actively support and help shape the future of solving scientific problems with computational tools.

Recommendation: **MPSAC recommends that Computational Science be established as a priority area within MPS.**

3. High-Dimensional Massive Data

Background: Data have always been essential to advancement throughout science and engineering, whether through experimental validation of new theoretical insight, or through new hypothesis arising from the study of existing data. With the almost incredible amounts of data now being amassed, the 21st century promises to propel scientific advances to hitherto undreamed-of levels. In order to fulfill this promise we need tools to extract the relevant information from high-dimensional massive data sets, tools for a better understanding of the underlying science, tools based on sound scientific insight, tools that account realistically for uncertainty and ignore spurious distractions. Focused and interdisciplinary efforts are absolutely critical to developing these tools.

Projected Impact: Technological advances in instrumentation development and the exponential growth of computing power have made it feasible to collect massive amounts of data, often with many variables being measured (which is what makes the data high-dimensional). While computer scientists have developed some efficient algorithms for looking at certain features of massive data, these are almost always deterministic. The proposed initiative will contribute to establishing the necessary links to the underlying scientific process and to the development of correct conclusions based on the available data.

As an example, data sets in astronomy have grown enormously, both in size and complexity. Critical astrophysical questions, such as the estimation of cosmological parameters from observations as disparate as galaxy clustering and the cosmic microwave background, and the study of galaxy formation and evolution from very large but low signal-to-noise samples, depend on the development and interpretation of sophisticated statistical techniques, and especially on a proper accounting for uncertainty when data are plentiful but the quality in some of the observations is not uniform. There are also numerous examples in other MPS disciplines, e.g. massive data from experiments in high-energy physics, massive data from remote sensing applications, and massive data to compare images and recognize patterns.

The underlying scientific processes can be widely different. The structure of the data can vary widely as well, including its format, context, and noisiness. It must be accessible in a way that is transparent, seamless and quick. Massive data is becoming ubiquitous in science and is the door to new levels of understanding. It is a door we must open more effectively at the beginning of the 21st century.

Proposed Goal: The primary goal is to develop appropriate and efficient tools that enable the extraction of features and patterns that are linked to and provide insight into the underlying scientific process. Achievement of this goal will offer a unique opportunity to revolutionize the advancement of science.

Recommendation: MPS is uniquely positioned to lead in this initiative since researchers in its disciplines are both “tool makers” and “science makers”. **MPSAC therefore recommends that emphasis be given to the further development of an initiative that enables the processing of high-dimensional massive data**, drawing from the large data bases in its disciplines, their instrumentation, and applications.

4. Cyberinfrastructure

Background: Cyberinfrastructure involves high performance computing, databases, instrumentation and fabrication facilities, human interfaces, visualization and associated interconnecting distributed networks. Cyberinfrastructure encompasses developing a revolutionary new way to do science by harnessing the tremendous advances in information technology to forge a powerful and global tool for discovery, analysis, synthesis, collaboration, and education. The participation of disciplinary sciences, each of the mathematical and physical sciences prominent among them, is crucial in defining how cyberinfrastructure is realized. Owing to the often profound differences in research cultures, each discipline must determine how to effectively harness powerful IT resources for advances at scientific frontiers.

Projected Impact: Cyberinfrastructure is a central factor to many research and education opportunities by MPS in the decades ahead. A few examples illustrate the potential of cyberinfrastructure: global GRID technology for management and execution of data intensive research; distributed networks of computers that will enable use of computational science as a discovery tool; online, remote operation of experimental resources located anywhere in the world; distributed human interfaces that will surmount barriers of geography and physical handicap enabling collaborative interactions; new concepts in education that bring the world's best activities to the desktop; and information resources that are a quantum leap beyond the WWW.

Examples of the use of cyberinfrastructure in future research by MPS disciplines are numerous and growing rapidly, and the anticipated impact on these disciplines will be formidable. The global GRID will enable management of terabytes of data to be managed with distributed assets; and it will enable researchers and their students equal access to the discovery opportunities in huge data sets being generated in distant facilities, e.g., LIGO, LHC, SDDS, other observatories abroad and in space. This facility with remote assets extends to the use of remote experimental facilities by researchers located anywhere in the world. The federation of data archives, the development of analysis and visualization tools that share common protocols and ensure interoperability among distributed data sets, as is being done with the National Virtual Observatory, are essential to realizing the promise of research. The GRID will also focus-distributed supercomputers on frontier problems such as calculating the mechanical properties of materials starting from atoms and microstructure. The effective use of advanced computation as a discovery tool in all forms of research will require new paradigms from disciplinary sciences together with advances in computer science; the result will be a new generation of cyberinfrastructure.

Projected Goals: A primary goal of cyberinfrastructure is the seamless integration of all data handling activities in research, thus empowering a researcher to access experimental data, compute, and interchange ideas all in a digital environment. The overarching goals in the development and exploitation of cyberinfrastructure require two main elements, namely (1) collaboration with the IT community and (2) investment in the disciplinary programs to support their particular needs, which vary among fields and are rapidly evolving.

Recommendations: Exploiting this emerging opportunity requires several forms of strategic planning, collaboration, and investment. The development of the global GRID needs to be done through collaboration between CISE and MPS programs. For example, GRID development at the present time is being driven by the needs of the LHC collaboration, with a collaboration involving PHY, CISE, DOE, CERN, and the European Union. This collaboration is well along in organizing and needs the resources to succeed. Similar examples show scientific disciplines across MPS are likewise involved in conceptualizing the GRID. Computational science requires sophisticated use of distributed resources, with the necessary hardware, software, security, dedicated IT staff, etc. Use of distributed facilities on all scales requires the infrastructure to enable scientists to become directly involved in the operation and use of facilities distributed across the country and beyond. Educational and collaborative systems are being planned and require substantial development.

MPSAC recommends that consideration be given to the establishment of a special subcommittee consisting of MPSAC members, MPS Division staff, and possibly experts from the broader community, in order to outline the preparations needed for MPS to take full advantage of the NSF-wide Cyberinfrastructure initiative.

5. Connecting Quarks to the Cosmos: The Physics of the Universe

Background: As the new century begins, science is confronted with a set of major questions at the intersection of physics and astronomy. The answers require combining observations of our universe to examine processes occurring on the largest length scales with fundamental physics, which addresses processes occurring on the smallest length scales (subatomic particles).

This observation about the interconnectedness of astronomy and physics contains a powerful insight, namely that the study of cosmic processes answers questions about the most fundamental particles and forces of nature, while the study of elementary particles can answer questions about the origin, evolution, and fate of the universe. This is the guiding principle of a recent National Academy of Sciences/National Research Council study, "*Connecting Quarks with the Cosmos,*" (National Academies Press, 2002). The report identifies "*eleven science questions for the new century*." This report, along with several related long-range plans and assessments published recently, namely *"Astronomy and Astrophysics in the New Millenium,* and *"Physics in a New Era: An*

Overview" (both from the National Academies Press), forms the intellectual framework and community input for a possible coordinated interagency research plan.

Projected Impact: The study of the science questions posed in this initiative represents the coming revolution in the physics of the Universe. As the 21st century begins, one can confidently predict that our ideas about elementary physics and cosmology are about to undergo a radical transformation. This prediction rests on three extant circumstances. First, two of the great intellectual achievements of the 20th century, the Standard Model of Particle Physics and the Standard Cosmological Model, together, provide a powerful and elegant framework for understanding the physics of the universe. Second, major questions, summarized below, make it clear that our present knowledge is still woefully inadequate to describe the physics of the universe. Third, experimental and theoretical approaches, driven by the tension between the first two observations have set the stage to provide the breakthrough discoveries that will revolutionize our understanding.

The eleven questions that express the prospect for this revolution are: What is Dark Matter? What is the nature of dark energy? How did the universe begin and how did its present large-scale structure come to be? Did Einstein have the last word on Gravity? What is the mass of the Neutrino and how have Neutrinos shaped the evolution of the Universe? How do cosmic accelerators work and what are they accelerating? Are Protons Unstable? Are there new states of matter at exceedingly high density and temperature? Are there additional space-time dimensions? How were the elements from iron to uranium made? Is a new theory of matter and light needed at the highest energies and electromagnetic fields?

Proposed Goals: This is the right time to attack these science questions as a result of a confluence of recent advances in technology, discoveries made in the last few years, and advances in theoretical ideas. New technologies have put us on the verge of measuring Einstein's gravity waves for the first time and make it possible to produce telescopes with adaptive optics and detector arrays with unprecedented resolution. Colliding beam accelerators are reaching deeper and deeper into the fundamental structure of matter; and heavy-ion colliders are being used in hopes of re-creating the quark-gluon plasma, predicted to exist immediately after the Big Bang. The nature of dark matter remains a stubborn mystery; but physicists and astronomers may be close to learning its nature. The recent discoveries that neutrinos have mass and that the expansion of the universe is accelerating have caused physicists and astronomers to revise basic doctrines of scientific faith. And new facilities that create ultra-high energy density plasmas offer a way to investigate extreme environments that exist throughout the various phases of the lifecycle of stars. Sometimes predicting and sometimes reacting to this progress, theoretical advances have created a host of new concepts to explain and guide the observational advances.

Recommendation: The **MPSAC recommends the implementation of programs and facilities that respond to the challenges posed by the NAS study**. MPSAC also endorses the approach that has been developed to coordinate a joint NSF-NASA-DOE research plan under OSTP leadership.

6. Molecular Science and Technology (MOST)

Background: Civilizations are often defined by their capabilities: The Iron Age and Bronze Age, for example, reflected society's extensive use of those materials thousands of years ago. Today, atoms and bits define our civilization. Our exquisite control of bits has led to the Information Age, which has profoundly affected how we communicate and how we collect, manipulate, transmit, and store data. By comparison, our control of atoms and molecules is still, in many respects, at a primitive stage. The recently released NRC report, "Beyond the Molecular Frontier," makes a compelling case that we are on the verge of what might be called the "Molecular Age". In particular, breathtaking advances in synthetic, instrumental, and computational tools over the past few years, and the cross-fertilization of expertise across traditional disciplines, make this an ideal time to invest in the Molecular Science and Technology (MOST) initiative.

Projected Impact: The basis of the MOST initiative is exploring new dimensions in chemical bonding and chemical transformations. The central unifying theme for chemical and allied sciences in the past century was the chemical bond and transformation of chemical bonds to create new molecules and new materials. To launch the Molecular Age, however, will require mastery of a far more formidable challenge—namely, the control of chemical transformation and molecular geometries in complex systems. One of the most critical unsolved issues in molecular science and technology is learning how to control strong, covalent bonds and weak, non-covalent interactions simultaneously. Achieving this goal will enable scientists and engineers to control the connectivity, architecture, reactivity, and emergent behavior of molecular structures. The MOST initiative is complementary to current initiatives in nanotechnology and in quantum science and technology. The basic principles of chemical bonding are fully understood and emerging high performance computers can, in principle, calculate the continuum of forces ranging from weak to strong and the temperature dependence of these concepts. However, entirely new science will be discovered if this initiative is vigorously and successfully pursued. As one example, evolutional biology has discovered highly favored pathways for efficient assembly of functional proteins—a challenge which presently escapes our understanding. Insights are provided by such concepts as multi-center hydrogen bonds that evolve into more traditional hydrogen bonds; transient electrostatic interactions are also an important part of the problem. The late Linus Pauling's descriptor for the cooperative interactions that control the structure and function of very large molecules was "molecular Velcro bonds". A direct link to information technology is posed by the question of how many bits does it take to describe the structure of a protein in three dimensions? The collection of weak interactions described for proteins can occur not only within a molecule, but also between molecules, and between molecules and surfaces. Collective molecular interactions thus are important in such diverse areas as prediction of crystal structures, drug design, catalysis, biomimetic nanotechnology, transport of chemical species in the environment, and preparation of biomaterials.

Proposed Goals: The MOST initiative seeks to develop scientific understanding leading to the control of chemical transformation and molecular geometries in complex systems. The strategy for achieving the breakthrough science essential to this endeavor is the coupling of theory, modeling and simulation with analytical measurements to confirm or challenge predictions. Key to progress in this endeavor is the development of instrumentation, particularly instrumentation which enables dynamic measurements. Investments in spectrometers that could be coupled to, for example, neutron sources would permit detailed investigation of hydrogen bonding. Next-generation mass spectrometers, nuclear magnetic resonance spectrometers, and X-ray diffractometers would likewise lead to a clearer picture of bonding in chemical systems characterized by weak bonding interactions. Parallel developments in theory, modeling and simulation will be needed to interpret data that are acquired and to design both chemical systems with desired properties and appropriate new experiments for advancing and verifying theory. With an appropriate suite of chemical imaging methods and tools, single molecule detection methods can be developed to track large collections of molecules in space and time. Application of these chemical imaging methods to cells would revolutionize our understanding of metabolomics (the study of the multiple, coupled chemical reactions that govern the life of a cell) and its connections to proteomics and genomics. Application of these tools to surface-molecule interactions could be used to link cells to computer or sensor hardware surfaces; to prepare artificial tissue, bones, and teeth for human repair; and to self-assemble materials through supramolecular chemistry that possess a range of functionalities. Investment in molecular studies of complexity phenomena will enable us to address the grand challenge: *"What is the molecular origin of life?"*

Recommendation: **The MPSAC supports the development of the MOST initiative**. Advances in molecular science and technology that would be enabled by this initiative will build upon and will be complementary to existing NSF investments in nanotechnology, quantum science and technology, information technology, biocomplexity, and mathematics. With its elucidation of cooperative molecular interactions, the MOST initiative will produce a comprehensive view of bonding that can be applied across the full spectrum of science and technology and can lead to advances in such diverse areas as manufacturing, environmental quality, health and medicine, and information technology.

7. Mathematical and Physical Bio-Sciences

Background: Many scientists with training in the mathematical and physical sciences are currently applying the tools and techniques of those fields to problems in the biological sciences. At the same time, the bio-sciences themselves are becoming more mathematical, finding that the tools and techniques of the physical sciences are necessary at the frontiers of bio-science. However, broad support for mathematical and physical scientists and bio-scientists who want to work at this interface has not yet been realized. The need for improved connections between these disciplines has been recently articulated in the National Academy study: "*BIO2010 – Transforming Undergraduate Education for Future Research Biologists*". The proposed initiative described here is aimed at providing a bridge that connects the mathematical, physical and biological sciences.

Projected Impact: The proposed initiative should enable better communication between MPS, the Directorate for Biological Sciences, and other federal agencies. The initiative will promote complex mathematical modeling and physically-based measurements concerning biological questions that can best be addressed by collaborative, interdisciplinary teams working together at the interface rather than working independently.

Proposed Goals: Three basic goals are proposed: (1) Support the growing number of MPS scientists working at the interface of the physical and biological sciences; (2) Increase the communication between scientists in the biological sciences and MPS fields; and (3) Solve problems in mathematical and physical bioscience that are not currently being addressed or even perhaps considered. These problems often require intensive computing capabilities, complex mathematical modeling and tools and ideas that are typically used by physical scientists.

Recommendation: The MPSAC supports initiatives that position NSF to assume a leadership role in promoting the sciences and engineering. With the rapid growth of the use of physical and mathematical techniques in the life sciences, it is timely to have MPS launch an initiative that strengthens the connections between the biological sciences and the fundamental mathematical and physical sciences to complement and enhance the more traditional approaches to biology. This initiative should include collaborative efforts between MPS and the Directorate for Biological Sciences and other federal agencies such as NIH as well as private foundations such as the Howard Hughes Medical Institute. MPS is particularly well positioned to provide opportunities for people with training in mathematics and the physical sciences to contribute to the biological sciences. The **MPS AC strongly recommends that MPS develop an initiative to address Mathematical and Physical Sciences at the Biological Interface.**

8. Facility Stewardship Initiative

NSF and MPS have developed and will continue to develop large facilities to support cutting-edge scientific research. Many of these large facilities are proposed under the Major Research Equipment, Facility and Construction (MREFC) account. Prudent management requires proper budgeting for the lifecycle costs of a project and this is an essential component of any newly-initiated project under the MREFC project. The absence of such planning creates a severe and asymmetric funding pressure on the associated discipline's Research & Related Activities (R&RA) funding. The imperative to effectively operate a new "Tool" may eliminate funding for a large group of single investigators, impacting the most closely associated strategic goals of the NSF, namely "People" and "Ideas".

A proposed Facility Stewardship Initiative was presented to the MPSAC in a white paper at the April 2003 meeting. The paper points out that the cost estimates for construction of an MREFC-class project may represent only a fraction of the total cost to operate the facility through its lifecycle. The paper properly identifies the lifecycle phases to include preconstruction R&D, design and engineering, acquisition of long lead time components, construction, commissioning, operations and maintenance, IT infrastructure, research costs, and upgrades. The MREFC account may not support all phases and the facility costs through this lifecycle may, perhaps, double the MREFC cost through the first decade of the project.

Given the many new opportunities in the NSF portfolio offered by large facility projects, the MPSAC urges that consideration be given to creating either an NSF-wide account or a budgeting mechanism to assess and provide for facility lifecycle costs. The white paper properly recognizes that this initiative is facilitated by prospects for significant increases in the overall NSF budget. Even with more modest budget growth than current optimistic scenarios, though the number of facility projects may be limited, we urge that the prospective planning and budgeting for full lifecycles be adopted. In the absence of such an initiative and reform, modest budget growth will lead to even more severe impacts from the asymmetric budget pressures caused by facility construction projects.

The initiative described in the white paper presented to the MPSAC calls for creation of a foundation-wide funding line, perhaps in the R&RA account, that can support major facilities during phases other than construction. Our highest support is directed towards consistent planning for and providing the costs for all phases of the lifecycle of a facility. Whether this can be accomplished through an increment to a Foundation-wide account is a matter for consideration by the NSF management. **MPSAC endorses the idea that a clear and visible step be taken to address the need for planning for life-cycle costs of major projects, and endorses the proposed Facility Stewardship Initiative as presented to the AC at its April 2003 meeting**.

9. Mid-size instrumentation program

The MPSAC is aware of many opportunities for scientific tools that lie between the costs of the Major Research Instrumentation (MRI) program and the Major Research Equipment, Facility and Construction (MREFC) category. Increasingly, however, this level of opportunity has become important for researchers across the MPS disciplines. There is an emerging need for leveraging science such as can be enabled by the development of beam lines at neutron and light sources, high magnetic field laboratories, advanced computing facilities, and moderate-scale astronomical observing facilities and instrumentation. In addition, support for upgrades (such as new detectors or data collection techniques) can dramatically improve the efficiency and sensitivity of existing instrumentation at a much-reduced cost. These opportunities compete for support with the individual investigator grants.

However, a plan for staffing and operating such instruments at a particular facility or beamline must be established in order to assure that NSF's investment will best be optimized by users. At most institutions, the hosting institution will take responsibility for future operation and maintenance of and instrument funded by NSF. In such instances as is not expected by the facility to providing continued support, a plan for sustained operation and management, including allocation of instrument use to the PI's and other users of the instrument during its lifetime must be provided in the proposal to NSF. In addition, a reasonable allocation of dedicated time to the PI group should be allocated for a limited time span, for example a 25% direct use over 3 years. This funding, planning and maintenance plan must be established before the instrument is built.

A task force of the National Science Board recently released a report for comment "*Science and Engineering Infrastructure for the 21st Century: the role of the National Science Foundation*" (draft: December 4, 2002). This report identified the importance of mid-size instrumentation, and recommended the establishment of a program to address the mid-size infrastructure funding gap. **MPSAC recognizes the importance of mid-size instrumentation projects within the MPS disciplines and endorses the development of a funding path for such projects.** In particular, **MPSAC recommends the start of a planning process within MPS where each Division prepares a plan for its needs for projects that fall within the mid-size infrastructure guidelines, so that an overall timeline and prioritization process based on readiness and funding allocation can be developed.** Discussions and review by the MPSAC at its meetings would provide useful feedback and advice for this important effort.

10. Supporting National Security

Background: At its meeting in November 2001, the MPSAC considered the recommendations in the Hart-Rudman report *"Road Map for National Security: Imperative for Change"*, and as a result of the tragic events of September 11, 2001, assembled a subcommittee to develop a response to the Hart-Rudman report and a plan to engage MPS researchers in contributing to the issues of our Nation's security. The recommendations of the MPSAC regarding national security were presented in a 'white paper' entitled, *"Recommended MPS Response to the Hart-Rudman Report"*, May 2002. A key recommendation of MPSAC was for MPS to continue the focus on its strength in basic research while responding to issues of national priority such as homeland security and science education. Another recommendation was for MPS to establish domains of interest and means for coordinating activities with other Federal agencies including the planning of a multi-disciplinary workshop to determine how best the MPS community can contribute to research and workforce development relevant to national security.

MPS organized a workshop on "*Approaches to Combat Terrorism: Opportunities for Basic Research*", jointly convened in November 2002 by NSF/MPS and the Intelligence Community (IC) – a group of federal agencies involved in national security. A report on the workshop results is expected to be released soon, and will outline representative areas where MPS basic research can contribute to national security. These include mathematical techniques, image reconstruction, sensors and detectors, and energy sources.

MPS has announced a program solicitation (NSF 03-569) encouraging proposals with the potential to contribute to national security. A budget of $3.5M is available for such work, and has been provided jointly by NSF/MPS and the IC.

Projected Impact: The MPSAC commends MPS for following its recommendations and for creating opportunities for MPS researchers whose work can contribute to national security. It is important that NSF undertake such a role in national security and for that role and contribution to be recognized, since the basic research supported by the NSF can and will make a fundamental impact on national security.

While U.S researchers in the MPS disciplines are clearly willing to fulfill their obligation to their Nation's security when their research can make a useful contribution, it is clear that MPS's support must continue to emphasize basic research, while other federal agencies seek the applications of that research. In addition, the basic research by MPS researchers must continue to be fully open and accessible.

Recommendations: As a result of the interactions with the workshop convenors and representatives of the Intelligence Community at the April 2003 MPSAC meeting, several suggestions and recommendations were drawn. These include:

(a) **MPS and MPSAC should review on a regular basis the progress in the MPS-IC interactions** and evaluate the short- and long-term plans in this area. In addition, since the reviews of proposal supplements and SGER awards in this area will be made internally to MPS, it is suggested that a review be undertaken by an MPSAC subcommittee every two years as part of the regular MPSAC meetings in order to determine the effectiveness of the work.

(b) **The role of the national laboratories in this collaborative between MPS and IC should be examined**, since such laboratories can provide an excellent bridge between the basic research community supported by NSF and others who are developing the applications of that basic research with support of the Intelligence Community or others.

(c) **Funding allocations for this initiative need to be equitably shared with the IC**, and MPS should pursue an increasing share of costs from the IC for investigator research associated with national security. In addition, the possibility of MPS administering the IC-supported post-doctoral research appointments within its programs should be examined since MPS has access to a larger community of academic researchers.

11. Science Partnerships with Developing Countries

"Science and engineering research is now a global enterprise. Science and engineering have changed in ways that make international cooperation in research and education essential for the advancement of knowledge. We must find new ways for scientists and engineers around the world to work together." – Dr. Rita Colwell, NSF Director.

Background: MPS has played a leading role in building highly successful research partnerships between US scientists and educators and their colleagues in foreign countries, notably in Europe and the Americas. The development of large-scale facilities such as GEMINI and the LHC as well as smaller-scale collaborations in other areas of the physical sciences, such as materials research, have been highly successful and mutually beneficial. These partnerships exist in scientific areas of common interest, where the intellectual contribution and level of effort on both sides are balanced. In this regard, they have avoided a one-way flow of scientific and engineering talent to the US from the partner countries. The well developed scientific infrastructure and funding base, particularly in Europe, have largely been responsible for the success of these programs.

The development of commensurate relationships with developing nations of Africa, Asia and the Middle East promises to be more complex and each region poses unique challenges and opportunities. NSF expects a ‘counterpart agency’ in the partner country or region to support an equivalent level of effort, which may not always be feasible in developing countries (legally NSF cannot directly fund a foreign entity). The lack of a strong scientific infrastructure in most of these nations poses obvious concerns. While some ‘economically developing’ countries such as India and China, are ‘scientifically developed’ in many ways, with a substantial body of scientists making significant contributions to the scientific knowledge base, the benefits of developing partnerships with developing, or underdeveloped, nations are not as obvious. In a similar manner, the status of the scientific infra-structure of South Africa offers unique opportunities for NSF investment that can have continental-wide impact.

Projected Impact: There exist excellent benefits to be gained from forging partnerships with developing nations if other variables are considered in the equation. Potential gains are considerable in all MPS disciplines including astronomy (examples include educational partnerships, southern hemisphere access, longitude coverage, access to good infrared and sub-millimeter conditions, radio-quiet and dark-sky sites), chemistry (e.g. water quality and environmental protection), materials science (e.g. ‘green’ materials, energy sources and distribution, structural, electronic and optical materials, communications), physics (international facilities), and mathematics (e.g. international outreach through mathematical sciences research institutes, international exchanges and workshops).

The US as a whole would also benefit from these collaborations. For example, problems that affect some countries can have a far reaching impact on us in the US. These might include diseases that affect produce that we import from developing nations. Contamination of natural resources might also affect US interests abroad. Diseases that exist in one corner of the globe can readily proliferate, as we have recently experienced. We should anticipate that some developing nations, such as China and India, might have larger investments in some areas of science that might be of benefit to us.

Finally, apart from the international experience collaborations provides for US scientists and students, the development of the scientific base in underdeveloped nations is important because it underpins their long-term economic prosperity and self-reliance. Theretofore, the development of scientific partnerships with developing nations is mutually beneficial.

Proposed Goals: The goal of this initiative would be for MPS and INT to jointly develop a new area of emphasis to foster international collaboration in the physical sciences between US researchers and educators and their counterparts in developing and underdeveloped nations. With regard to the issue of financial support for this initiative, NSF may need to develop partnerships with the State Department and/or other entities such as USAID, World Bank and UNESCO.

Recommendation: In view of the above, each region of the world offers unique challenges and opportunities. Therefore the nature of the partnerships would have to proceed along a unique path in different parts of the world. To this end, the **MPSAC recommends the development of pilot programs for science partnerships with developing countries tailored for each region of the world. These programs can then provide the basis for the development of models for future collaborations in the region.**

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APPENDIX V

Certification of Accuracy of Minutes of April 2003 MPSAC Meeting

July 21, 2003

Date: Mon, 21 Jul 2003 09:20:17 -0400
From: Joseph Salah <jsalah@haystack.mit.edu>
To: jbhunt@nsf.gov
Cc: maizenman@nsf.gov
Subject: [Fwd: Re: Minutes of MPSAC meeting, April 2003]

Dear John,

I have reviewed the final version of the minutes of the MPSAC meeting, April 2003 (attached), and am pleased to certify the accuracy of these minutes. I appreciate Morris' efforts in getting these minutes prepared and accommodating our input.

I would also like to take this opportunity to thank you and the MPS Directorate staff for the dynamic interactions during the past year, particularly in enhancing the function of the MPSAC as part of the long-term planning for MPS, and for the support during my tenure as MPSAC chair.

With best wishes,

Regards,

Joe Salah

xc: M. Aizenman