National Science Foundation
WHERE DISCOVERIES BEGIN

Meeting of the BIO Advisory Committee Summary Minutes April 7-8,2005

THURSDAY, APRIL 7, 2005

Welcome and Approval of Minutes
Dr. Susan Stafford, BIOAC chair, welcomed the committee members, who then introduced themselves. The minutes for the November 2004 meeting were unanimously approved.

Directorate Updates

Budget and Current Issues: Dr. Mary E. Clutter
Dr. Clutter introduced the Director and Deputy Director of each BIO division and reviewed the BIO organizational chart. She explained that Emerging Frontiers (EF) is a virtual division with no Division Director or permanent staff. Before discussing the recent FY06 budget hearings, Dr. Clutter reminded the BIOAC that their suggestions for the upcoming FY07 budget would be valuable. She predicted that by 2007, the NSF budget would be back on the doubling track, as authorized by Congress and signed into law by the president in 2003. Dr. Clutter explained the recent reorganization of NSF's Congressional Committees. The FY06 NSF budget request was 2.4% above the FY05 request. However, since the enacted FY05 budget was below the amount enacted in FY04, the FY06 request was in reality a decrease. BIO's FY06 request was almost $600 million. Some programs slated for increases included Major Research Equipment and Facilities Construction and the Office of Polar Programs. The EHR Math Science Partnership Program, which was transferred to the Department of Education, decreased. She also presented the FY06 NSF budget priorities: strengthening core programs, supporting world-class cyber-facilities, broadening the participation of individuals and schools traditionally underrepresented in science and engineering, and organizational excellence.

The BIOAC discussed:

- Whether the increases in the FY06 budget were intended to make up for shortfalls in FY05 (Dr. Clutter said they were not)

- EF Programmatic Highlights:
  - In FY06 a Microbial Biology emphasis area will be created by moving several existing programs and some additional funds to EF
  - The Frontiers in Integrative Biological Research (FIBR) program will grow and continue to support the type of 'bold' research, which is the focus of new NSB Task Force study
  - The Ecology of Infectious Diseases Program continues to contribute to NSF's Homeland Security Portfolio
  - BIO-wide Broadening Participation activities will be augmented and enhanced

Priority Areas: Dr. Joann Roskoski, Executive Officer
Dr. Roskoski updated the committee on the status of NSF's Priority Areas: Information Technology Research (ITR), Biocomplexity in the Environment (BE), Human and Social Dynamics (HSD), Mathematical Sciences, and Nanoscale Science and Engineering (NSE). These high-visibility, limited-duration areas were begun in 1997/98 to address interdisciplinary research topics of national interest. Budget numbers show that, contrary to some public perception, these large initiatives did not take funding away from individual PIs. Dr. Roskoski noted the importance of the core program research base to the Priority Areas, which are managed by cross-directorate teams of Program Directors. ITR has now ended and as all the other Priority Areas end by FY07, NSF is working to continue supporting these areas and transition them into core programs. For example, the BE: Instrument Development for Environmental Activities (IDEA) has been folded into the Sensors competition in FY05 and research funded under the Coupled Biogeochemical Cycles (CBC) will be supported by an "Earth Cycles" competition in FY06. The NSF Working Group for Environmental Research and Education has also suggested the initiation of Grants to Leverage Understanding of the Environment (GLUE) as a mechanism for knitting together people doing research on a common topic. There was no information on whether new Priority Areas would be established once the current ones end.

The BIOAC discussed:

- BIO's role in nanotech initiatives at NSF. BIO invests $70 mil in nanotechnology research in general, although its specific role in the NSE Priority Area is relatively small
- The appropriateness of Engineering's dominant role in the NSE priority area, since engineering is where most nano findings are ultimately applied.
- NSF's involvement with interagency groups that focus on Priority Area topics
- The importance of disseminating information about these areas (e.g. through PI meetings, involvement of local community planners, and various public fora)
- The consequences of reductions in funding for educational programs and the need for further discussions on the topic of public relations

NEON – National Ecological Observatory Network: Dr. Elizabeth Blood (DBI)
Dr. Blood presented an update on the status of NEON, BIO's first large infrastructure project, which has been in the planning stages for almost a decade. Since FY01, budget requests for NEON have been declined without prejudice by the Congress. However, in the FY05 Budget, NSF was instructed to allocated $6 million for NEON planning and design. A grant made to the American Institute for Biological Sciences (AIBS) is funding the establishment of a project

office, management team, advisory board, and committees for National Network Design, Science and Human Dimensions, Education, Facilities and Infrastructure, and Consortium Development. An upcoming meeting in June will focus on deployment of NEON infrastructure across the US. Dr. Blood explained that the next phase of the process would shift to systems design, construction, and deployment of research infrastructure. She presented BioMesoNet Towers (which simultaneously record radiation, soil moisture, temperature, and other variables) as an example of a creative way to deploy sensors to measure climatic and ecological variables. NEON is envisioned as a 30-year undertaking.

The BIOAC discussed:

- NEON's efforts to involve a broad profile of individuals and institutions from across the US and the need for NEON to document the diversity of the planning workforce on informational websites
- Security issues associated with sensor deployment
- How sites will be selected: One method uses a model by Bill Hargrove (Oak Ridge National Lab) which uses suites of variables to characterize potential NEON infrastructure sites at different scales and examines different sensor deployment scenarios
- Developing the capability to add new variables and research teams to NEON over time
- The importance of communicating NEON's virtues to the public and to Congress (AIBS has hired a Public Relations person to address this)

Current Issues

Introduction: Dr. Mary E. Clutter
Dr. Clutter led a discussion about how to increase proposal success rate at NSF without cutting award size or duration. Historically the success rate was 30% but it is now much lower. Dr. Bement would like to see the success rate back up to 25%.

The BIOAC discussed:

- **Add a pre-proposal component to the review process:** It was noted that FIBR is run in this manner. However, there was concern that PIs would start sending in multiple pre-proposals, increasing the number of resubmissions and overall proposal load in core programs.
- **Limit the number of proposals per institution or per PI:** This would lead to preliminary review by institutions and would hurt broader participation, collaboration, and risk-taking while potentially creating conflicts of interest.
- **Make the university a partner:** Dr. Jelinski commented that "Overhead is the true cost of research".
- **Change the method of calculating success rate:** AC members agreed that it is important to consider how we define success rate. Care should be taken not to artificially inflate it. They discussed the NIH method of counting resubmissions as one proposal (if funded) and stressed the importance of good data collection and tracking systems.
- **Shift toward multi-investigator grants:** Could decrease the number of submissions.
- **Switch to one target date per year:** This would be difficult for young investigators who might need to submit a proposal four or five times before they get their first award.

Dr. Arden Bement, Director, National Science Foundation
Dr. Bement was present for part of this discussion. He suggested that NSF offer fewer, more focused solicitations and more advice to the community about the likely success rate. He noted the importance of incorporating interdisciplinary research in the funding opportunities NSF provides, but not at the expense of the core programs. He noted that the science community is currently using resources to review many meritorious proposals that the foundation ultimately cannot fund. The BIOAC discussed how young faculty members are particularly challenged by their deans to expend time and effort to submit proposals. They suggested allowing more exceptions for new investigators (e.g. permitting proposals to go to two agencies at once).

Dr. Bement noted the importance of science and engineering to the global economy and emphasized that NSF's investment in information technology requires an equal investment in educating the workforce to use this technology. Dr. Bement highlighted the importance of continuing partnerships that help increase the minority workforce in STEM fields.

The BIOAC and Dr. Bement discussed:

- The importance of involving more of the public in *doing* science and communicating more directly with scientists (in a recent poll only 18% of the public reported knowing a scientist personally)
- The need for more workshops to train science writers
- Informal science education programs and the utility of Internet presentations both in museums and in homes to engage the public
- The importance of local-level education initiatives to address public understanding of evolutionary biology as well as outreach that highlights aspects of biology of general appeal
- The future of Priority Areas and Math and Science Partnerships as their funding comes to an end: Dr. Bement explained that NSF's renewed focus on core programs includes finding ways to sustain the successes of the ending Priority Areas and encouraging new, transformative ideas.

Long Range Planning

BIO Leading Edge Presentations

Setting the Stage: Dr. Mary E. Clutter and Dr. Joann Roskoski

Drs. Clutter and Roskoski discussed the criteria and methods that BIO uses to develop budget priorities. In identifying important themes, the Directorate considers topics that have: demonstrable added value, readiness/timeliness, impact, an appropriate role for NSF, and the potential for synergy and partnerships. They reported that the recent Leading Edge meeting drew talks that spanned themes such as biology in context, plasticity and variation, and cyberinfrastructure. To showcase these ideas, BIO Program Officers gave presentations to the BIOAC on Biological Processes in Real Time and Real Space, Organisms as Integrators in a Changing Environment, and Drivers and Effects of Emergent Phenomena.

Biological Processes in Real Time and Real Space: Drs. Jerry Cohen and Mona Norcum (MCB); Dr. Christopher Greer (DBI)

This presentation focused on technologies that advance our ability to observe cellular processes in real time and real space and thus aid discovery and the learning process. Dr. Norcum described several examples of new research using this dynamic approach including: a study of the ordered vs. disordered structure of proteins; new protein labeling techniques that allow monitoring inter-cell communication; and studies of microbial processes *in situ*. She emphasized the need for better database organization to facilitate communication among scientists using these and other new techniques.

The BIOAC discussed:

- How these examples could inform future planning and what other research might be inspired by the ability to watch as cellular processes occur
- How to balance funding for research using static techniques and research being done using these new dynamic approaches
- The extent to which technology is leading research in new directions vs. research questions driving technological innovations
- The need to prepare for new technology with infrastructure and training programs

"Organisms and Integrators in a Changing Environment": Drs. Judith Verbeke and Cole Gilbert (IOB); Dr. Gerald Selzer (DBI)
Dr. Gilbert presented examples of recently submitted research proposals whose projects focus on the organism and bridge the gap between molecular and environmental studies. He described projects to investigate: the developmental biology of beak differentiation at multiple levels in the Galapagos finches; brain activity in unconstrained animals using new sensor technology; and bird habitat distributions using cell phone technology. Dr. Gilbert identified several important technological tools that enable frontier research in organismal biology including sensors, imaging, "the –omics", and computer modeling.

The BIOAC discussed:

- How research on this theme could be applied in management and for monitoring
- The appeal of viewing biology from an organismal perspective, making the science more tangible to the public
- Applying existing technologies to new questions

"Drivers and Effects of Emergent Phenomena: Challenges for Discovery and Forecasting": Dr. Penelope Firth and Dr. Susan Mazer (DEB); Dr. Elizabeth Blood (DBI)
Dr. Mazer informed the committee about recently funded projects that are seeking new ways to address emergent phenomena of communities and ecosystems. Her examples included studies of higher-level, non-additive, and context- or scale-dependent processes. Research projects focused on subjects such as the roles of fungal communities in nutrient cycling and the intricacies of interactions between fish community assemblages and fishermen. Dr. Mazer presented two current challenges for ecologists: (1) to achieve a broader understanding of the "universality" of mechanisms affecting ecological structure and function and (2) to predict ecological and evolutionary changes in response to known environmental disturbances and trajectories. Dr. Blood presented several examples of tools and technologies that enable the pursuit of these goals such as the fusion of *in situ* monitoring with remote sensing and databases that pull information together and allow predictive modeling.

The BIOAC discussed:

- How new programs such as Opportunities for Producing Understanding and Synthesis (OPUS) would be balanced with existing ones
- That frequent errors and inaccessibility of data sets could hinder information sharing, but the act of making data more available could lead to more self-correction
- The importance of documenting historical information using new forms of media (e.g. the observations of tribal elders, which also require proper attribution)

FRIDAY, APRIL 8, 2005

Long Range Planning (continued)

Recap and Discussion: Dr. Susan Stafford, Chair
The BIOAC decided to hold their discussion until after the presentations.

BIO Cyberinfrastructure Strategy: Dr. Michael Willig, Division Director (DEB); Dr. Robert Robbins, AC Discussant
See Appendix A.

Microbial Biology Emphasis: Dr. Maryanna Henkart, Division Director (MCB); Dr. Mary Lou Guerinot, AC Discussant
Dr. Henkart briefed the committee on BIO's increasing efforts to serve the microbial research community. A BIO working group on microbial biology is exploring whether current NSF programs match the research needs of the field as articulated at recent workshops and PI meetings. Specific BIO activities include the Microbial Observatories/Microbial Interactions and Processes (MO/MIP) Program. BIO also chairs an interagency co-ordinational activity called the Microbe Project, which includes the Departments of Agriculture, Commerce, Defense, Energy, Homeland Security, Health and Human Services, and NASA.

The BIOAC discussed:

- Exploring better platforms for comparative genomics
- Creating opportunities for mid-career training in new technologies
- Promoting the connections between microbial ecology and eukaryotic ecology and human health.

Broadening Participation: Dr. Thomas Brady, Division Director (IOB); Dr. Sally O'Connor (DBI); Dr. Cassandra Manuelito-Kerkvliet, AC Discussant
Dr. Brady discussed several BIO activities for faculty at Minority Serving Institutions (MSIs). For example, Quality Education for Minorities (QEM) workshops are being funded by BIO to introduce faculty from MSIs to NSF BIO Program Officers who work with them on developing data and writing competitive research proposals. A new program, Research Initiation Grants /

Career Advancement Awards (RIG/CAA), focuses on providing research support to faculty from underrepresented groups or at MSIs who have not yet received NSF funding. Awardees would receive $150,000 for 24 months and $25,000 in equipment. Minority Postdoctoral awards are also available for 2-3 years at $50K per year. Plans are underway for BIO to support BIO-focused Centers for Research Excellence in Science and Technology (CREST) at MSIs Dr. O'Connor presented an example of an Internet genomics teaching tool that is currently underutilized by faculty at MSIs in order to demonstrate the need to train more teachers to use such tools. Dr. Manuelito-Kerkvliet praised BIO's efforts to include more people from under-represented groups in BIO activities. She advised BIO to be more aware of including people with disabilities and to consider the unique difficulties that remote tribal colleges face in accessing and also efficiently using resources.

The BIOAC discussed:

- Focusing on funding programs for undergraduate rather than graduate level students in order to address a more crucial bottleneck
- The need for career-prep workshops to steer talented minority undergraduates and even high school students toward STEM fields (as an alternative to medical school)
- Programs outside NSF that successfully broaden participation (e.g. UMBC Meyerhoff Scholars program, NIH/NCRR Research Centers in Minority Institutions (RCMI))
- Finding ways to work with the American Indian Higher Education Consortium (AIHEC) to help tribal colleges get information about and manage grant opportunities
- Holding a BIOAC or other meeting at a tribal college (following the example of CEOSE)

NSB Report on Long-Lived Data Collections: Dr. Christopher Greer (DBI)
Dr. Greer told committee members about a recent NSB report on long-lived data collections which is available at https://www.nsf.gov/nsb/meetings/2005/LLDDC_Comments.pdf <https://www.nsf.gov/nsb/meetings/2005/LLDDC_Comments.pdf> . The committee was interested to learn that NSF met recently with the library community to discuss database management. Libraries generally collate data but do not address important issues about data quality. There are also few NSF requirements for researchers to make their data readily available to the public. There was agreement that NSF needs to establish its role in this issue.

Information Items

ITR Committee of Visitors: Dr. Michael Willig, Division Director (DEB)
Dr. Willig reviewed recommendations given by the ITR COV which included the need for additional mail reviews, stronger emphasis on both review criteria (especially broadening participation), and a means to identify which proposals are high risk or multidisciplinary. The COV noted that the ITR program, which has come to an end, enabled significant research contributions, played a key role in launching interdisciplinary projects within NSF, and would have benefited from more appropriate NSF staffing levels.

The BIOAC commented on:

- Conflicts of interest issues such as the disproportional disqualification of potential reviewers in the northeast US to avoid COIs
- Conflicts that can develop when shared databases are involved

NSB Task Force on Transformative Research: Dr. Susan Lolle (IOB)
Dr. Susan Lolle, a rotating Program Director in IOB presented her recently published research as an example of an NSF-funded study at the frontier of plant science. Dr. Lolle and her colleagues provided evidence for the inheritance of ancestral sequences in Arabidopsis, a departure from Mendel's classic laws (Nature 434 , p. 505 – 509).

Around the Table Discussion of Success Rate

Dr. Stafford raised 5 questions about the success rate issue for the BIOAC to consider:

1. Is NSF success rate an issue for you?
2. Is the success rate currently too low?
3. Is there a correct success rate for which to strive?
4. What advice do you have for the director?
5. Is there another issue that is as critical or more critical for NSF to address?

AC members agreed that low success rate stems from a number of significant problems, requiring careful analysis and a multi-stage solution. Recalculating the numbers or imposing artificial submission requirements to raise the success rate could lead to political disadvantages when trying to request more money from Congress. Dr. Stafford emphasized that it is important send a clearer message to PIs; to tell them whether NSF's primary goal is to simply improve success rate or if it is to receive more, broad, cutting-edge, fundable proposals (in spite of flat budgets). Dr. Robbins said that NSF would need to determine what to optimize. If we want to minimize the amount of fundable proposals that go unfunded we need to think about individual researchers rather than proposals.

Future Business

- Subcommittees: Cyberinfrastructure – Chair will be Dr. Robbins
- Fall and Spring Meeting Dates: November 17-18, 2005 and April 6-7, 2006

APPENDIX A

BIO Cyberinfrastructure Strategy: Dr. Michael Willig, Division Director (DEB); Dr. Robert Robbins, AC Discussant (Friday, April 8, 2005)
Dr. Willig presented an overview of activities regarding cyberinfrastructure (CI) at the level of the Biological Sciences Directorate and at the level of the Foundation in general. He began by explaining the charge to his working group (CIBS: Cyberinfrastructure for the Biological Sciences) in the context of previous activities in BIO (i.e., the report from the BIO-AC Working Group [included in AC binders), and recognized the contributions of the working group members, which draw on personnel from each of the four Divisions in BIO. In general, his presentation was a broad overview of the content of the draft Strategic Plan that was authored by CIBS and included in the AC folder. Because so many of the members of the BIO-AC were

new, Dr. Willig summarized BIO's portfolio from both programmatic and thematic perspectives. He then introduced the key elements of the Strategic Plan: (1) Vision and Goals; (2) External Activities; and (3) Internal Management.

The Vision for CI emphasized its role in integrating education and research, catalyzing leading edge investigations, and democratizing the science and education enterprise. In essence, CI is viewed as an effective tool to transform the kinds of biological investigations that are undertaken and to broaden participation at all levels of research and education.

External activities focused on targeted areas to stimulate scientific discovery, understanding, and synthesis, and were organized around issues of (1) workforce, (2) resources, (3) access, and (4) interoperability. **Workforce** issues addressed mid-career scientist, postdoctoral, graduate student, undergraduate student, and teacher programs; it included considerations of faculty at primarily undergraduate institutions as well as those members of historically underrepresented groups. **Resource** issues included consideration of long-lived data (see also https://www.nsf.gov/nsb <https://www.nsf.gov/nsb>), data centers, and grid computing. **Access** issues focused on basic resources, high-end computing, resource location and archiving, and intellectual property rights. **Interoperability** issues included physical, logical, and semantic dimensions. Detailed recommendations appear in the draft strategic plan included in AC folders.

Internal management focused on issues related to (1) professional staff, (2) interagency interactions, and (3) frontiers of integrative activities. CI issues regarding **professional staff** include considerations of Program Director training in CI, relationships between BIO and CISE-SCI (the Division of Shared CyberInfrastructure in the Directorate for Computer and Information Science and Engineering), awareness of CI activities at other agencies, and concerns about increased workload. BIO's involvement in **interagency activities** should carefully distinguish between situations in which the Directorate assumes a leadership role versus those in which it is an engaged participant. Finally, staff in BIO needs to be cognizant of opportunities at the **frontiers of integrated** research and education, and be prepared to catalyze and support components of initiatives such as, but not limited to, the Biosphere Simulator, Environmental Genomics, Phenomics, and a National Systematics CI Projects.

The CyberInfrastructure Initial Working Group (CIIWG) recently was created by Dr. Bement to catalyze activities at the foundation level that impinge on development of CI (Dr. Willig is the BIO representative). With respect to CI, the WG is charged with (1) clarifying NSF roles and goals, (2) quantifying and categorizing the NSF's portfolio of investment, (3) suggesting a management structure for CI activities at the foundation-level, and (4) placing NSF activities regarding CI in the context of activities being developed by others (i.e., international groups, federal agencies, private sector, and NGOs). The recommendations of the CIIWG will be submitted to the Office of the Director at the end of April, with the anticipation of the formation of a CI Coordination and Implementation Panel (CICIP), which will extend and amplify activities of the CIIWG in the coming years. In particular, the CICIP will make recommendations to a Council of ADs, chaired by Dr. Bement, with the Council subsequently providing guidelines and establishing policy that the CICIP will implement and coordinate.

The BIOAC Discussed:

- The need to design a cyberinfrastructure that is clear enough to be accessible to all, but robust enough to handle many different types of data that develop over the long term.
- The need to deal with CI problems at the proper level of scale and abstraction. It is important for large-scale IT system design to be conceptualized at different levels of abstraction.
    - For example, data models that are ideal for meeting the needs of multiple communities are often more complex than is needed by any one community. Yet at the level and scale of multiple communities, the more complex data model is better than the simpler one that meets the need of an individual community.
    - It is helpful if efforts are made to clarify what is being optimized in wide-area cyberinfrastructure and what is being traded away to achieve those optimizations. For example, packet-switched networks were designed to optimize the ability of communication systems to maintain functionality even in the face of severe local degradation. That is, internet protocols had to be designed to accomplish reliable file transfer even if reliable packet transfer could not be guaranteed. The solution (intra-packet checksums, packet serial numbers, packet retransmit protocols, etc.) introduced considerable overhead into the communication process. At the time, this was severely criticized for being inefficient. But, because the developers of packet-based networking knew their goals and the trade-offs they were willing to accept to achieve those goals, they were able, rightly, to ignore the criticisms of inefficiency.
- The need to support more work on developing the appropriate INFRAstructure in the CI space.
    - For example, current internet protocols are designed to facilitate interactions among arbitrary pairs of machine resources on the net. Very few protocols exist to facilitate the arbitrary interaction of people and machines. That is, no fully functional, generic identity management, authorization, authentication, access-control, and auditing systems are yet available to the research community. In consequence, each research community that wishes to develop a distributed, grid-like approach to cyberinfrastructure is obliged to develop some custom code to accomplish these key tasks. To be sure, some Internet2 initiatives are addressing these problems, but the solutions are not yet at hand. And, too many biologists are unaware of the I2 initiatives.
    - Also, it is important for agency planners to recognize that access to very fast computers is not the rate-limiting step for most science. For example, some recent studies have suggested that thousands of small molecular biology laboratories are now rate-limited by the data-management challenges associated with managing the logistics of modern molecular research and by managing the high volumes of data that flow from modern molecular research.
- Need to recognize the value in developing “information appliance” tools to meet specific data management needs, often in association with specific types of high-throughput data-generating research equipment, such as sequencers, genotypes, cell sorters, etc.
- CI could benefit from some investigations into the conceptual and data-model challenges to be faced as a true cyberinfrastructure for biology becomes available. For example, most concepts, most notions of object identity, most definitions are well defined only with a particular context. As the CI expands, resources developed using

different contexts will begin to interoperate. Little research has been done on the idea of semantic linking in a context free environment. Yet the real promise of CI for BIO is in the potential linking of all IT infrastructure for all biology (indeed, all science) and at a global level this will surely involve a context-free environment.

- Cyberinfrastructure is different from physical (bricks and mortar) infrastructure in several ways.
  - CI components at different location need to interoperate with one another in a manner that is not meaningful for physical infrastructure. That is, physical infrastructure need only meet local needs. CI must meet both local and global requirements. This puts a burden on the community and on the funding agencies to collect and assess requirements, integrate local requirements into community needs, and then devise and recommend community guidelines for interoperable cyberinfrastructure.
  - Most examples of physical infrastructure have a useful life measured in decades. Cyberinfrastructure components typically have a useful life measured in years, usually five or less. This requirement for a high rate of replacement puts a significant burden on funding agencies and on recipient organizations.
- The need for CI interoperability creates a new requirement for interagency coordination in this area.
  - Imagine it is ten years in the future and there now exists a fully functional, widely deployed cyberinfrastructure for all ecological research. And also imagine there is a separate fully functional, widely deployed cyberinfrastructure for all genetics research, and yet another one for all physics research, and yet another one for all medical research, and …
  - The existence of multiple, different, non-interoperable cyberinfrastructures for different fields of science would be a disaster, not an accomplishment.
  - Meeting this need for global interoperation across all cyberinfrastructure for all sciences will require substantial coordination across all NSF directorates and across all federal agencies that support science.
- NSF is the natural agency to play a leadership role in the development of interagency coordination for cyberinfrastructure.
  - Achieving the CI of the future requires considerable computer science research and development, not just technology deployment. NSF is the ONLY agency with the expertise to support research in CS and research in a wide range of scientific and engineering disciplines.
  - NSF's success in shepherding the conversion of ARPANET to NSFNET to the commercial internet shows that it has the ability to operate across agencies and to deliver incredibly valuable infrastructure for science, the nation, and the world. Indeed, one would be hard-pressed to find an example of a federal agency making a more valuable contribution to global infrastructure than the NSFNET to commercial internet transition managed by NSF.
- Appropriate scales of implementation for this plan (lessons from industry):
  - Data from business and industry show that the successful deployment of information technology can transform the competitive landscape and the levels of productivity across entire industries. When IT is first widely and successfully deployed in an industry, substantial changes often occur in industry leadership

    and competitive advantage. After this transformation occurs, the level of IT spending in the industry increases significantly and soon having an appropriately robust information infrastructure becomes a requirement for existence in the field. (e.g., Would anybody fly on an airline that could not offer computer-based reservations; can a shipping company compete without being able to offer computerized shipment tracking?)
    - Post IT transformation, the level of IT spending in some industries (e.g., high finance) exceeds 10% of gross revenues. Others like transportation have overall IT budgets around 5% of revenues. Some high-turnover businesses (like discount retailing) show IT budgets close in the 2-4% range of annual revenues.
    - If US publicly funded biomedical research is to have a cyberinfrastructure as effective and as transforming as that possessed by, say, UPS or Wal-Mart, the national (not just NSF) budget for cyberinfrastructure will need to be billions of dollars.
    - The magnitude of potential applications will be enormous so management of the plan must be at a comparable scale (e.g. a new cyber directorate with billions of dollars in budget, following the 5% model of many businesses).
    - Still, BIO needs to decide what issues can be tackled on the BIO scale (considering that the larger monetary and technical issues are best handled on an NSF scale). At the same time, NSF as a whole and the federal research funding agencies as a community should be developing plans for supporting a truly transformative cyberinfrastructure for biology in particular and for science in general.
- Accessibility problems and the need for even the most basic infrastructure within some institutions.
- Insufficient interoperability among disciplines and institutions as the rate-limiting factor for many other biologists.
- The need for workshops to bring together PIs from the CS community who are working on solutions relevant to cyberinfrastructure with PIs from the biology community who are using CI. Examples of projects of interest are Internet 2 Middleware initiative, Shibboleth, GridShib, etc.
- The need for regular workshops / meeting at which those responsible for deploying and managing bio-cyberinfrastructure at their institution can interact with colleagues with similar responsibilities at peer institutions.

APPROVED

/S/ Susan Stafford *11/17/05*

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Susan Stafford, Chair Date

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