Response to Recommendations from the Committee of Visitors (COV)
for the Office of Emerging Frontiers (EF)
September 2-4, 2009

Introduction

The Directorate for Biological Sciences (BIO) and Emerging Frontiers (EF) wishes to thank the members of the Committee of Visitors (COV) for their careful consideration of the three activities under review, Advancing Theory in Biology (ATB), Ecology of Infectious Disease (EID) and Microbial Genome Sequencing (MGS). The COV's thoughtful comments and recommendations are deeply appreciated.

Overall, the COV report was quite favorable. The COV noted that the merit review in these programs was generally of high quality, effective and maintained integrity, and recognized that the success of merit review is a consequence of the expertise and dedication of the BIO Program Directors. The COV also provided a very positive evaluation of the portfolio of awards in ATB, EID and MGS, and the programs' responsiveness to emerging research and education opportunities. Nonetheless, a number of valuable recommendations were provided to improve upon current practices and activities.

Major Recommendations of the Report

In their report, the COV identified two primary issues up front, provided a list of summary recommendations at the end, and included additional comments and recommendations throughout the report. This response is structured to address the primary issues and the summary recommendations first, and then to address additional specific comments and recommendations.

1. **The COV recommended that EF focus on two primary areas in the coming years: Generating Ideas, and Transitioning Ideas.**

Generating Ideas: The COV recommended that EF increase use of external sources to explore increased funding for emerging frontiers in biology.

Response. In considering the ways in which community input is used to identify emerging biological frontiers, the COV wrote: "The COV commends EF on the diversity of community workshops during which ideas are shared across the Directorate. ... The COV suggests that EF should make more clear when and how the use of external expertise is used to explore fully the nature of and the potential for funding the emerging frontiers in biology. The COV felt that EF should consider increasing the use of such expertise."

BIO appreciates, and agrees with, the COV's recommendation to consider a full range of potential scientific investments for targeted support and management in EF. The BIO Directorate consistently uses a wide range and variety of sources and mechanisms, both internal and external, to identify emerging research areas and potential research priorities. Mechanisms that involve the "broader external community" include support for workshops, symposia, and conferences involving investigators with relevant expertise; relevant National Research Council reports that are discussed widely within the BIO Directorate in the context of developing funding priorities; and the BIO Advisory Committee whose members represent the external community, and who regularly engage in discussions with BIO Directorate senior managers to identify scientific opportunities and advise BIO about priorities.

Transitioning Ideas: The concept of transitioning ideas and programs out of EF was addressed in many ways throughout the COV report. The COV provided the following specific recommendations related to transitioning:

- **Develop an explicit transition plan for each of the programs leaving EF.**
- **Develop metrics for the success of programs that transition into core after residence in EF.**

- **Consider the production of comprehensive syntheses that capture lessons learned at the frontiers as programs complete their tenure in EF.**
- **Set up 2012 COV to meet with the senior management team at the start and end of the COV to discuss program transitions out of EF.**
- **Provide for 2012 COV materials that track the fates of programs after transition from EF.**

Response. BIO agrees that planning for transitioning activities initiated in EF is very important. BIO has already begun to grapple with this issue, in considering how to transition activities supported through the Microbial Observatories and Microbial Processes and Interactions program (which ended in 2008), and through the Arabidopsis 2010 program (which is ending in 2010). In both cases, BIO is analyzing where within the core these activities are migrating, so that the resources associated with those programs can be directed appropriately. Going forward, BIO will continue to work toward establishing a systematic and proactive process for the transition of activities into other divisions for management, which will be discussed with future EF COVs. Materials about transitioned programs will be made available to the COV most relevant to the program under review. BIO Program Directors regularly monitor the progress and evolution of the science in all the programs for which they are responsible and communicate this progress through a variety of mechanisms such as NSF Highlights and BIO-wide Leading Edge presentations.

2. The list of summary recommendations included the recommendations addressed above, and the following additional recommendations:

- **Consider the appropriate balance between permanent and rotating program officers, especially for programs administered through or transitioned from EF.**

  Response. BIO appreciates the COV's recommendation. The Directorate has set a general goal of recruiting approximately 50% permanent Program Directors in each of the BIO Divisions, as a reasonable balance of permanent experienced scientific managers, and the need to continuously infuse the organization with the new ideas and perspectives that come from visiting members of the communities we serve. EF activities are managed by teams of Program Directors drawn from the divisions.

- **The COV is concerned about the workload of program officers. Program officers need to have time to think broadly and to continue active engagement in science.**

  Response. BIO shares the COV's concern about the workloads of the Program Directors. Workload is an important issue across all of NSF, which has made increasing staff FTE a high priority. In the meantime, EF will continue to experiment with novel management approaches aimed in part at reducing Program Director workload.

- **Continue to stress the importance of Broader Impacts in the evaluation of proposals, both for reviewers and for panelists. One suggestion is to add panelists with education expertise.**

  Response. BIO concurs with the need to continue to stress the importance of Broader Impacts during the review. Program Directors will be reminded to re-emphasize to panelists the need to address broader impacts more fully, both strengths and weaknesses, in their evaluation of proposals and in their panel summaries. Science Assistants will be trained to monitor the panel summaries more effectively, and to diplomatically yet firmly alert panelists and Program Directors about any summaries that do not adequately address broader impacts. EF will adopt a panel summary template that ensures that both review criteria are adequately addressed.

- **As an incubator, experiment with training postdoctoral fellows and graduate students to increase diversity and improve quality. ATB may be a good test ground for such an initiative.**

  Response. BIO appreciates the observation that as an incubator, EF could provide mechanisms to experiment with novel ways to train graduate students and postdocs, and to increase the participation of underrepresented groups. Program Directors who are developing program announcements for EF will be encouraged to incorporate novel training mechanisms for graduate students and postdocs, and to incorporate language emphasizing the goal of broadening participation.

- **As an incubator, partner with HRD to develop and promote inclusive workforce training models.**

  Response. BIO appreciates this recommendation, and will consult with EHR to identify and consider incorporation of inclusive training models as a means to increase participation of underrepresented groups in EF activities.

- **Review Analyses should clarify the basis for funding recommendations, especially for proposals with mixed ratings on panel and external reviews.**

  Response. BIO agrees that the Review Analysis must provide the rationale and justification for the Program Director's funding recommendation, which is grounded in the advice received through the individual reviews and panel discussions and ratings. Program Directors will be reminded that these documents must clearly articulate the specific rationale for a decline or funding recommendation.

- **Continue to refine the EF Mission Statement to capture the full range of its portfolio.**

  Response. BIO will work to clarify and further articulate the newly adopted mission statement of EF, specifically with regard to the innovative forms of peer review, and with regard to the inclusion of NEON in EF.

- **Train and reward Science Assistants to preview and edit panel summaries before they are submitted by the panelists to improve the quality of the summaries.**

  Response. BIO appreciates this recommendation. As noted above, Science Assistants will be trained to monitor the panel summaries more effectively, and to diplomatically yet firmly alert panelists and Program Directors about any summaries that do not adequately address broader impacts. EF will adopt a panel summary template that ensures that both review criteria are adequately addressed. The Directorate for Biological Sciences routinely recognizes excellent performance by providing incentive awards to strong performers; the Science Assistants in BIO have been recognized in this manner on numerous occasions.

- **Future self-studies should include a breakdown of outcomes by major program as well as the inclusion of useful metrics for comparison (e.g. rates of success and rates of submission).**

  Response. BIO appreciates the COV's feedback on the information provided, particularly the self-study material, the report template, and the flexibility of the agenda for its work. We also appreciate the COV's feedback concerning electronic access to the jackets to facilitate the work of the COV. BIO recognizes that the work of the COV would be greatly assisted by providing more program-specific data, and will endeavor to provide more disaggregated data to future COVs. BIO also appreciates the recommendation to include submission statistics associated with a range of variables relevant to the

report template (e.g., female investigators) as a means of aiding the COV's ability to be responsive to the template, and will make every effort to supply such information in future COVs.

- **The structure and process for the current COV is to review a traditional set of programs. Owing to transient programs and the EF residence in the office of the Assistant Director, the structure of and information provided to future COVs should be given careful consideration.**

  Response. BIO appreciates this recommendation, and will take this into account when considering the focus of future COV reviews of EF activities.

In addition to the summary recommendations noted above, the COV made a number of other comments and recommendations throughout their report, some of which were captured in the summary recommendations, and some of which were not. Comments and recommendations that are not captured in the summary recommendations are addressed below.

PART A. INTEGRITY AND EFFICIENCY OF THE PROGRAM'S PROCESSES AND MANAGEMENT

A.1 Questions about the quality and effectiveness of the program's use of merit review process.

Advancing Theory in Biology:

The COV noted that in the first year of ATB, reviews were not consistently informative, but were "detailed and informative" in the second year of the program.

Response. Owing to reasons of timing, the review process in the first year of ATB involved only panel review, where the range of expertise can be narrower compared to the range of expertise that can be applied to proposals through the combination of panel and ad hoc review. The Program Directors compensated well in the second year of the competition by employing both ad hoc and panel review, mitigating this problem.

Microbial Genome Sequencing:

As noted by the COV, this program has ended. Nonetheless, the concerns raised by the COV warrant a response, as they speak to best practices, thus each is addressed below.

The panel summaries for MGS proposals varied in quality with regard to providing sufficient information to the PIs about their proposals.

Response. BIO agrees with this concern. BIO will remind the Program Directors and the Science Assistants (who monitor panel summaries dynamically in the panels) to continue to emphasize the need to articulate the substance of the panel discussion in the summaries. BIO will redouble its efforts to focus on the importance of panel summary writing during panel instructions, and will develop the skills of the Science Assistants to communicate to the panelists when summaries could include more information.

The number of reviews received for MGS proposals was "quite variable."

Response. BIO appreciates the COV's concern related to this observation. With rare exceptions, all full proposals are brought to final action with a minimum of three reviews as required by NSF policy. BIO shares the COV's concern about the potential effect of variable numbers of reviews on the quality of review, and will continue to monitor the review process to ensure that proposals receive an adequate number of substantive reviews, that PIs receive expert advice and criticism based on a thorough review of their proposals, and that NSF staff continue to reach informed funding decisions based on a high quality merit review process.

The COV felt that the necessary documentation in the MGS jackets did not consistently indicate the rationale for an award or a decline recommendation. The COV cited explicitly the Review Analysis in this context, but based on the comments of the COV it is clear that the concerns focus on the lack of consistency in the panel summary as well as the review analysis to clearly indicate the rationale.

Response. BIO shares the COV's concerns. As noted above, EF will respond to the concerns of the COV with respect to panel summary consistency, and will closely examine review analyses to insure that these documents consistently and clearly articulate the specific rationale for a decline or funding recommendation.

Ecology of Infectious Diseases:
The COV noted for EID that, "In all years except 2008, dwell time was less than six months for >80% of proposals. In 2008, the number dropped to 57% with 14% dwelling for 9-12 months…The rapid increase in average dwell time suggests an anomalous circumstance."

Response. BIO appreciates the COV's comment and concern about dwell time for EID proposals. Because EF activities often involve multiple organizational stakeholders, within and outside NSF, EF will make every effort in the future to insure a dwell time average that meets NSF's target of coming to final action on 70% of proposals within six months.

A.2 Questions concerning the selection of reviewers.

The COV wondered whether the "…Broader Impacts component could have been better addressed if community members with expertise in education and outreach had been included in the panels."

Response. BIO appreciates the COV's careful examination of the qualifications of the reviewers selected for merit review of the proposals in these three programs. EF will continue to work with Program Directors to ensure the composition of panels has appropriate expertise scientifically as well as in the area of education and outreach based on the content of proposals that are submitted to the programs.

The COV noted that the programs under evaluation used reviewers balanced with respect to characteristics such as geography, type of institution and underrepresented groups, but also noted that 1) "Little or no representation from undergraduate institutions" in the ATB program should require some effort to effectively balance institutional type; and 2) participation by underrepresented groups is still a problem for the MGS program.

Response. BIO shares the COV's concern on this issue, and will remind Program Directors to make every effort to ensure that reviewers are balanced with respect to the characteristics listed above. EF will focus on efforts to recruit reviewers and panelists from primarily undergraduate institutions to the ATB program, and will redouble its efforts to include individuals from underrepresented minorities in the review process consistently.

A.3 Questions concerning the resulting portfolio of awards under review.

The COV called for more emphasis on theory having "application to the cellular or molecular level" in the ATB portfolio.

Response. BIO agrees with the assessment of the COV concerning this aspect of portfolio balance in ATB. The Program Directors managing this activity are aware of the issue, and will encourage applications concerning theory development in cellular and molecular biology as well as organismal biology in the follow-on solicitation for the program and during outreach efforts.

The COV found that the MGS portfolio did not have an appropriate balance of interdisciplinary and multidisciplinary awards, and recognized that this situation may be due to the program's exclusion of functional genomics projects. The COV, referring to MGS, noted that "It is striking that functional genomics is excluded from the program."

Response. BIO agrees that the COV has identified a principal reason for the lack of interdisciplinary and multidisciplinary projects, i.e., that the program was designed to focus on sequencing. The BIO Directorate has decided to end MGS, and to integrate this activity into the core programs as a way to stimulate the community to request sequencing of microbes when appropriate to address larger biological issues or questions, rather than focusing on sequencing alone. We believe the resulting

collective portfolio of microbial studies across BIO will have a much better balance of interdisciplinary and multidisciplinary projects.

The COV felt that the MGS portfolio did not have appropriate participation of underrepresented groups.

Response. BIO recognizes the challenges of increasing the participation of investigators from underrepresented groups and will make a concerted effort to publicize funding opportunities available to investigators from these groups.

The COV commented that "the future of the [MGS] program is an issue and of significant concern in the broader community.

Response. BIO notes that new technologies have resulted in dramatic reductions in the costs of genome sequencing, such that sequencing can be incorporated in regular, unsolicited requests to BIO's core programs. BIO will make every effort to continue to educate this community about opportunities to support their science through applications to the core programs in BIO.

The COV commented that the overall quality of awards in the three programs under review is appropriate and of high quality but considered the impacts of the awards in ATB to be "limited" with respect to education and broader impacts. Likewise the COV considered the "educational component" of MGS awards to be "weak," and the "integration of research and education" to be "missing or rarely apparent."

Response. BIO appreciates the COV's thorough analysis of the broader impacts of the awards portfolio. BIO will remind Program Directors of the importance of incorporating broader impacts in their portfolios, and encourage them to promote the full range of possible broader impacts in EF activities.

The COV noted that award size and duration appear to be appropriate for ATB, EID and MGS, and recommended "increasing the size of the award, but not the duration, to some extent, if it were to be used to fund education- and broader-impact related goals" in the ATB program.

Response. BIO will continue to encourage PIs to request budgets that fully support all of the aims of their projects, including those related to education and broader impacts activities.

The COV noted that the ATB and EID portfolios had an appropriate balance of innovative/potentially transformative projects, and that MGS had an appropriate balance considering selection of "organism, environmental niche, novel pathogens, etc.", but was not balanced appropriately "with respect to technology development per se."

Response. BIO appreciates the evaluation of the COV on this important issue. EF is gratified that portfolios of these programs include an appropriate number of projects with these qualities, and believes this is the result of concerted efforts by the Program Directors managing these activities to identify and recommend awards for riskier projects. Although the sample jackets for MGS awards may not have indicated the strength of the technical developments funded by this program, the portfolio includes projects that have included development of algorithms, data bases, approaches for single-cell sequencing, and making use of cloud computing.

The COV noted that the ATB portfolio included many investigators who had been trained in fields other than biology, and found "a definitive emphasis on funding theory that is strongly relevant to advancing biological understanding. Proposals that were too abstract or not applied to any specific empirical system did not get funded."

Response. BIO appreciates the COV's interest in this issue. ATB was established to address the need to develop theory as a means to encourage and advance our fundamental understanding of biology as a more unified discipline. ATB has therefore initially emphasized projects that support this goal rather than those focused on more abstract ideas in its portfolio. However, as ATB evolves, proposals focused on more abstract ideas that may advance our understanding of biological systems will be added to the awards portfolio.

The COV noted that the balance of geographical distribution of PIs in ATB, EID and MGS was appropriate, but noted that the ATB portfolio included "five awards ... made to schools in California, with two awards going to one school."

Response. BIO will continue to work with the Program Directors to insure that they fully consider the issue of geographic distribution of the awards in ATB in subsequent years.

The COV reviewed the portfolios of ATB, EID and MGS to address whether they have an appropriate balance of institutional types. The COV commented for ATB that "The portfolio is weighted towards large research universities...There is no representation from undergraduate-only institutions ... Proposals from these schools should be encouraged." Similarly, the COV noted for MGS that "In particular, four-year and historically under represented institutions have limited participation in the selection of proposals provided."

Response. BIO recognizes the challenges of increasing participation of investigators from both primarily undergraduate institutions and minority-serving institutions and will continue to emphasize outreach efforts to these investigators.

A.4 Management of the program under review.

Concerning the management of the MGS program, the COV writes: "Evidence of conflicting views between program officers reveals weak support for the program. The basis for funding decisions is not always clear... we observe no concept of the need for, broader impact, or future directions and evolution of a program where technological progress has been so striking. Thus, there is clearly a need for an independent, critical assessment of the program and its potential." These sentiments are reiterated elsewhere in this section, as noted: "There are clearly major weaknesses in this program as relates to the planning and prioritization process, especially in later years, and it is clear that no path forward is contemplated or identified...The COV considers it especially critical that NSF seek independent, critical review and assessment of this program (e.g., NSB, NRC)."

Response. BIO appreciates the COV's input on the MGS program. The use of functional genomics and other approaches to larger biological questions, many of which can and should be addressed most effectively using microbes, are commonly used by researchers who apply for funding to BIO's core programs. As noted above, because technological advances have dramatically lowered the cost of sequencing, this activity can be integrated into the core programs across BIO where sequencing of microbes can be supported when appropriate to address larger biological issues or questions.

The COV commented on the following issues concerning the management of the EID program: The cross-directorate partnership "appears weakened by funding imbalance and uncertainty. There is some evidence of inadequate communication among program officers."

Response. BIO appreciates these comments and will monitor these issues as the EID program transitions from management in EF to management in the Division of Environmental Biology (DEB). EF will also

work to ensure that communication among members of the Program Director Working Groups for EF-managed activities is satisfactory

PART B. RESULTS OF NSF INVESTMENTS

B.1 OUTCOME GOAL for Discovery: "*Foster research that will advance the frontier of knowledge, emphasizing areas of greatest opportunity and potential benefit and establishing the nation as a global leader in fundamental and transformational science and engineering.*"

The COV identified significant discovery outcomes for all three programs. They further commented that MGS has produced successful technical outcomes but has been less successful with respect to educational outcomes.

Response. BIO appreciates this assessment of the MGS program, and anticipates that by integrating this activity into the core programs, thus linking sequencing to larger conceptual issues in biology, will stimulate student interest and involvement thereby increasing the educational opportunities and outcomes in the portfolio.

B.2 OUTCOME GOAL for Learning: "*Cultivate a world-class, broadly inclusive science and engineering workforce, and expand the scientific literacy of all citizens.*"

The COV identified potential and real learning outcomes for all three programs. They also noted that for the MGS program, "the lack of adequate inclusion of underrepresented minorities continues to remain a problem that has escaped solution."

Response. Increasing the participation of underrepresented minorities remains an essential goal of NSF and BIO is committed to this goal. EF will make a concerted effort to publicize the funding opportunities available to investigators from these groups. EF will encourage participation of investigators from underrepresented minorities during outreach efforts to professional society meetings, outreach trips to minority serving institutions, and other relevant groups.

B.3 OUTCOME GOAL for Research Infrastructure: "*Build the nation's research capability through critical investments in advanced instrumentation, facilities, cyberinfrastructure and experimental tools.*"

The COV identified potential and real infrastructure outcomes for all three programs. No specific recommendations were articulated on this issue by the COV.

PART C. OTHER TOPICS

C.1. Please comment on any program areas in need of improvement or gaps (if any) within program areas.

"The COV recognizes that the goals of EF, more than those of other divisions in the agency, need to be flexible and responsive to changes in the agency as well as in the scientific community. That said, the COV encourages the Division to cultivate a stable mission for EF."

Response. BIO appreciates the COV's support of EF's new mission statement, and agrees with the COV's recommendation that this virtual division needs to cultivate a stable mission. It is the intention of BIO's senior management to keep EF focused on term-limited funding opportunities, which require EF management as well as targeted investment.

The COV noted that for ATB, "In the first year of the program, there were several proposals that were declined, in part because reviewers did not consider mathematical models or simulations to necessarily be theory. We think a brief description of exactly what theory is and what it isn't would be useful to investigators who plan to submit proposals."

Response. BIO agrees with this recommendation by the COV, and will work with the ATB Program Directors to develop clarifying language on this point.

For MGS the COV wrote: "There is clearly a need for an independent, unbiased, critical review of the program and its future trajectory, which should examine the role of NSF in overall national priorities in the areas of microbial genomics and metagenomics, and thus an appropriate future role for NSF in these critically important areas. In addition, the broader impacts (criterion two) need attention from the perspective of program review and stewardship."

Response. BIO respectfully disagrees with this recommendation from the COV. MGS has enjoyed long-term funding, which has led to many important outcomes (as indicated by the review of the program by this COV). BIO believes that the substantial and continuing decline in sequencing costs presents an opportunity to integrate this activity into the core programs of BIO, and to tie the technical capacity to sequence microbes to overarching questions of importance to biology, many of which can best be approached through the study of microbial systems. On the issue of broader impacts, linking sequencing requests to larger conceptual issues in biology will help attract student interest to these studies and therefore educational opportunities and outcomes should grow as part of this portfolio.

C.4. Please provide comments on any other issues the COV feels are relevant.

Regarding the EID program, the COV wrote: "The COV … is concerned about the fate of this program, given its notable successes. … One concern of the COV is that the budget for the EID program has remained constant while the costs associated with proposals in it have increased, resulting in the granting of fewer awards. The COV recommends that EF and/or NSF seriously consider how to increase the budget for EID."

Response. BIO acknowledges the COV's concern, but notes that the EID budget maintains a substantial presence within the context of the overall BIO budget portfolio, which is balanced across the entire spectrum of biology.

C.5. NSF would appreciate your comments on how to improve the COV review process, format and report template.

The COV wrote: "… some significant data gaps in project jackets limited the COV from formulating adequate responses to numerous template questions … It would have been useful to have summaries of the numbers of publications from past awards for longer-running programs like EID and MGS." And: "It was hard to analyze outcomes over a full portfolio, because the only summaries were in the individual annual project reports. One helpful addition would be a listing of publications associated with each funded grant, summarized in a single document." And: "… it was not easy to see the relation between the broader impacts proposed by the portfolio of projects and what was actually accomplished."

Response. BIO appreciates the COV's desire to have such information available to evaluate impacts of the investments made in these programs. Unfortunately the present Project Reports System in use across the Foundation lacks the capacity to aggregate this kind of information in an automated fashion. BIO will consider this recommendation for future COVs in the context of the capability (and possible limitations) of available IT resources.

The COV found the presentation by the Division Director at the opening of the meeting to be extremely helpful, providing the history and the context for the development and growth of EF. The staff was helpful, flexible, and responsive to the needs of the COV. The program officers presented useful summaries of the programs and were responsive to questions from the COV. They noted that "The preparation of the report during the COV meeting was technically challenging. The staff is to be commended for rapidly setting up a wiki site and providing memory sticks to ease collaboration."

Response. EF appreciates the recognition by the COV that the information provided by NSF staff was responsive and useful in their review of these three programs as well as the EF mission statement. Likewise EF is pleased that the COV found the Wiki useful for the collaborative writing of their report. The Wiki was another innovation achieved by the administrative staff assigned to assist with the COV.