CORE QUESTIONS and REPORT TEMPLATE
for
FY 2007 NSF COMMITTEE OF VISITOR (COV) REVIEWS

Guidance to the COV: The COV report should provide a balanced assessment of NSF's performance in two primary areas: (A) the integrity and efficiency of the ***processes*** related to proposal review; and (B) the quality of the ***results*** of NSF's investments that appear over time. The COV also explores the relationships between award decisions and program/NSF-wide goals in order to determine the likelihood that the portfolio will lead to the desired results in the future. Discussions leading to answers for Part A of the Core Questions will require study of confidential material such as declined proposals and reviewer comments. *COV reports should not contain confidential material or specific information about declined proposals.* Discussions leading to answers for Part B of the Core Questions will involve study of non-confidential material such as results of NSF-funded projects. The reports generated by COVs are used in assessing agency progress in order to meet government-wide performance reporting requirements, and are made available to the public. Since material from COV reports is used in NSF performance reports, the COV report may be subject to an audit.

We encourage COV members to provide comments to NSF on how to improve in all areas, as well as suggestions for the COV process, format, and questions. For past COV reports, please see http://www.nsf.gov/od/oia/activities/cov/covs.jsp.

FY 2007 REPORT TEMPLATE FOR
NSF COMMITTEES OF VISITORS (COVs)

Date of COV: June 6-8, 2007
Program: Plant Genome Research Program (PGRP)
Division: Division of Biological Sciences (DBI)
Directorate: Directorate for Biological Sciences (BIO)
Number of actions reviewed by COV: 84 **Awards:** 18 **Declinations:** 66
Total number of actions within Program during period being reviewed by COV: 607 **Competitive Awards:** 108 **Competitive Declinations:** 386 **Other Actions:** 113
Manner in which reviewed actions were selected: The program selected a random jacket sample of 84 competitive awards and declines. For qualitative measures (such as recommendation completeness), this quota of 84 jackets is a sufficient sample to provide examples of the styles and procedures of all the program activities. There is a representative number of actions per fiscal year, proportionate to the total number of awards or declines, and including Small Grants for Exploratory Research (SGERs), conferences and workshops, Faculty Early Career Development (CAREER) proposals, and proposals submitted to all program solicitations covered by the review period. The COV will be able to access the sample jackets via the COV module on eJacket. In addition, eJacket contains a list of all 607 actions reviewed by the Program over the last three years, including supplements, proposals returned without review, and withdrawn proposals. The COV can request to see any proposal on this list during the meeting.

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

Briefly discuss and provide comments for *each* relevant aspect of the program's review process and management. Comments should be based on a review of proposal actions (awards, declinations, and withdrawals) that were *completed within the past three fiscal years*. Provide comments for *each* program being reviewed and for those questions that are relevant to the program under review. Quantitative information may be required for some questions. Constructive comments noting areas in need of improvement are encouraged.

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

Provide comments in the space below the question**.** Discuss areas of concern in the space provided.

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE [1]
1. Are the review methods (for example, panel, ad hoc, site visits) appropriate? Comments: The Committee of Visitors (COV) reviewed the 84 eJackets randomly selected by the PGRP to assess the quality and merit of the grant review process. It was the unanimous opinion of the COV that the PGRP is providing fair and equitable reviews for all proposals it receives. The process is sufficiently flexible to accommodate the wide range of proposals addressing fundamental questions of plant genome organization and function. During FY2004-FY2006, the PGRP used a combination of panels, ad hoc mail reviews and site visits for all proposals except the Small Grants for Exploratory Research (SGERs), conference and workshops, supplements and the Maize Genome Sequencing Program. Each proposal was accompanied by an electronic file (eJacket), documenting the review process including the reviewer's evaluation, (Reviewers file), the Panel Summary file, and the Review Analysis file. The COV found no proposal missing these files although the number of reviews and the length of the evaluations and analyses varied from proposal to proposal. The review methods described reflect a rigorous and fair process that should encourage investigators to submit creative proposals of the highest quality.	Yes
2. Are both merit review criteria addressed? a) In individual reviews? yes b) In panel summaries? yes c) In Program Officer review analyses? yes	Yes

[1] If "Not Applicable" please explain why in the "Comments" section.

Comments: The NSF does not have standard templates for panel summaries, Most of the reviewer analyses, however, consistently addressed broader impacts in terms of database development, data sharing and technology development. Fewer summaries included evaluations of outreach activities to the broader community of nonscientists.	
3. Do the individual reviews provide the rationale for the reviewer ratings (E, VG, G, F, and P)? Comments: The PGRP encourages reviewers to provide substantive comments on strengths and weaknesses of the proposal. Their evaluations, for the most part, made every effort to justify ratings based on NSF's established review criteria set forth in the Guide to Programs. Due to the confidential nature of the review process, however, rating rationales varied widely because reviewers do not (and should not) consult with each other on their reviews. No reviews in our sample provided an objective rationale for the "E" vs. "VG" rating, or more critically, the "VG" vs "G" rating. Few (if any) proposals receiving a "G" were awarded funding. Generally, however, rating rationales were based on how well the investigator complied with the importance and impact criteria of a proposal. Program officers use these rationales when selecting proposals for awards and declinations.	Yes
4. Do the panel summaries provide the rationale for the panel consensus (or reasons consensus was not reached)? Comments: In the ejackets we reviewed, panel summaries did not directly address the issue of consensus. This is because it is the practice of the panels to only report the lack of consensus. Therefore all the panel summaries reviewed by the COV had reached consensus on the funding decision.	Yes
5. Does the documentation in the jacket provide the rationale for the award/decline decision? (Note: Documentation in jacket usually includes context statement, individual reviews, panel summary (if applicable), site visit reports (if applicable), Program Officer analysis, and staff diary notes.) Comments: Yes, this is clear.	Yes
6. Does the documentation to the PI provide the rationale for the award/decline decision? (Note: Documentation to the PI usually includes the context statement, individual reviews, panel summary (if applicable), site visit reports (if applicable), and, if not otherwise provided in the panel summary, an explanation from the program officer (written or telephoned with diary note in jacket) of the basis for a declination.) Comments: In the jackets we reviewed, rationales for award/decline were clearly stated. For declined proposals, summaries tend to emphasize one or two key	Yes for awards; less complete for declines

problems and may not give PI full evaluation of all the weaknesses of the proposal. 7. Is the time to decision appropriate? Note: NSF Annual Performance Goal –Time to Decision: For 70 percent of proposals, the Division Director concurrence has been completed within six months of deadline or target date, or receipt date, whichever is later. Once the Division Director has concurred, applicants may be informed that their proposals have been declined or recommended for funding. The 70 percent goal recognizes that for some programs or some individual proposals, the time to decision is appropriately greater than six months. Comments: Assuming the PGRP has only one panel per year, the time to decision is appropriate. The time frame is affected, in large part, by the reviewer solicitation and response process.	

8. Additional comments on the quality and effectiveness of the program's use of merit review process: The PGRP

Comments: The COV was of the opinion that the NSF program staff had made a concerted effort to select a diverse group of scientists for the various panels.

A.2 Questions concerning the selection of reviewers. Provide comments in the space below the question. Discuss areas of concern in the space provided.

SELECTION OF REVIEWERS	YES , NO, DATA NOT AVAILABLE, or NOT APPLICABLE[2]
1. Did the program make use of reviewers having appropriate expertise and/or qualifications? Comments: In examination of the e-jacket records, the COV could see that considerable effort was expended in the selection of both ad-hoc reviewers and panel reviewers. Many of the proposals examined had between 5 and 8 ad-hoc reviews and no less than two and often three panel reviews. Other than the sense and knowledge of the COV, there are no empirical measures in the ejacket system of the level of expertise of a given reviewer, however based on the aggregate knowledge of the COV it was evident that strategies such as the use of previously funded grantees, use of citation or bibliographic databases, and knowledge of the research community on the part of the Program staff are all used in the selection of the reviewers, and that the selection is driven by the content of the proposal.	Yes
2. Did the program use reviewers balanced with respect to characteristics such as geography, type of institution, and underrepresented groups? Comments: The COV was of the opinion that the NSF program staff had made a concerted effort to select a diverse group of scientists for the various panels. Regarding geographic regions, California appeared to have the most number of reviewers, but this may be a reflection of the number of awards in that state and it population density. The number of states not represented varied between two and four for the years 2004-2006. The majority of panelists came from Ph.D. granting institutions, although in 2006, a moderate number of panelists were associated with business, state and local organizations. It was difficult to assess accurately the number of panelists from underrepresented groups or females because 80% chose not to self identify. For the folders selected for review, there appeared to be a significant number of female panelists.	Yes
3. Did the program recognize and resolve conflicts of interest when appropriate? Comments: In general, the NSF enterprise system denotes known conflicts when such have been self-identified by reviewers (ad-hoc or panelists) or when determined *a priori* by Program staff. The proposal submission process formally solicits conflict of interest (COI) data to aid Program staff in the	

[2] If "Not Applicable" please explain why in the "Comments" section.

avoidance of conflict in the reviewer selection process. For panelists in conflict with a given proposal under review, there is a well-established and consistently executed process for managing the conflict; such panelists usually leave the room while a proposal is being discussed, and the electronic review systems constrain access to the proposal and review data. COV examination of e-Jackets also affirmed that the handling of known conflicts is also documented in the text of the Review Analysis or in diary notes added to the proposal record.	

4. Additional comments on reviewer selection:

One concern noted was the somewhat low return rate on ad-hoc reviews. Our estimate suggested that only about 25% of requested reviews were returned. A (very) rough calculation suggests that the average number of requested ad hoc reviews was of the order of 5 per proposal, or roughly 400 for the selected set of 84 proposals examined by the COV. If only 100 were returned, that represents 300 transactions the Program staff spent time on managing that yielded no result. The COV discussed both among themselves and with Program staff their observations and came to some recommendations. These recommendations are discussed in Section C.3 below.

A.3 Questions concerning the resulting portfolio of awards under review. Provide comments in the space below the question. Discuss areas of concern in the space provided.

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE[3], OR DATA NOT AVAILABLE
1. Overall quality of the research and/or education projects supported by the program. Comments: The COV has come to their assessment after a thorough review of ejackets, program information, research highlights, and news releases. The quality of the funded proposals in PGRP is very high, and of great relevance. A notable feature in many proposals was the use of the databases resulting from PGRP funding as a backbone for addressing questions about a wider range of important plant species. The high impact multidisciplinary research such as the genome sequencing and annotation projects, and genome-wide pathway analyses that are funded by the PGRP has laid the foundation for an abundance of potential applications related to agriculture, natural resources, the environment, health, and plant-based industries. Educational programs such as PlantGDB, a web site bringing together a collection of teaching and outreach resources, serves to foster and secure an active, innovative research community in the future that will be critical for food security, energy production, and other plant industries.	Appropriate
2. Does the program portfolio promote the integration of research and education? Comments: Yes, all NSF awards seek to integrate research and education; this is emphasized in the program solicitations for all PGRP activities. An example from the review of ejackets is the award funding for an outreach project as part of Gramene (Stein 0321685) that provides opportunities for high school students to participate in and make significant contributions to research in genomics and bioinformatics. Other examples are discussed in section B.2.	Appropriate
3. Are awards appropriate in size and duration for the scope of the projects? Comments: For NSF BIO programs, the average award size is appropriate for the scope of the proposed research, which is often multi-institutional with multiple PIs. For resource projects, a strong correlation exists between the size of the award and the size of the request. In addition, the duration of resource-generating projects are longer than projects that make use of the resources or apply technology and methods developed under the resource-generating projects.	Appropriate

[3] If "Not Appropriate" please explain why in the "Comments" section.

4. Does the program portfolio have an appropriate balance of: • Innovative/potentially transformational projects? Comments: The COV recognizes the importance of supporting high risk, high-reward research that will enable rapid advancement in areas of intense scientific interest. The COV believes that an appropriate balance exists and that the merit review process for award selection is rigorous. The research funded by Small Grants for Exploratory Research (SGERs) is inherently more risky, but is believed to enable rapid and innovative advances in a particular area of science consistent with the PGRP mission. PGRP portfolio includes 6 SGERs per year. One SGER that exemplifies the value of innovative projects employed MPSS signatures to successfully demonstrate that the technology can uniquely identify more than 95% of all genes in Arabidopsis. In addition to stimulating research projects on the functions of the new genes, the signature collection is proving to be a valuable resource for genome annotation. The project is now applying the MPSS technology to develop a comparable resource for the rice genome.	Appropriate
5. Does the program portfolio have an appropriate balance of: • Inter- and Multi- disciplinary projects? Comments: The number of inter- and multi-disciplinary awards over the period of this review is slightly more than half the number of the uni-disciplinary awards (18 vs 34). As the field expands and investigators become more accustomed to team research, the number of multidisciplinary and intercollegiate awards is expected to increase.	Appropriate
6. Does the program portfolio have an appropriate balance considering, for example, award size, single and multiple investigator awards, or other characteristics as appropriate for the program? Comments: Neither the PGRP nor NSF has targets for the number of individuals, groups, or centers a program should support. However, due to the multidisciplinary nature of the work, the PGRP makes the majority of its awards to projects with multiple PIs (approximately 80% of the total between 2004 and 2006). Through the 20 or so Virtual Centers such as those that support the genome sequencing efforts in rice, Medicago, and maize, the PGRP is providing the infrastructure to bring together groups of scientists to tackle large problems that could not be undertaken by individual researchers. International collaboration and coordination is built into the management plan for such projects. Virtual Centers also develop community services and tools that impact basic research across the biology community. Examples of these tools include microarrays and chips for expression studies, and tagged mutant lines.	Appropriate
7. Does the program portfolio have an appropriate balance of: • Awards to new investigators? Comments: When new research niches open up, new investigators who are in the process of formulating their career goals, will be disproportionately attracted.	Appropriate

Given the expansion of the field of plant genomics over the last several years, it would be expected that the number of new investigators entering the field would be high. This is borne out by the fact that the number of new investigators associated with the 65 awards over the review period make up about half of the total number of investigators (109 vs 226).	
8. Does the program portfolio have an appropriate balance of: • Geographical distribution of Principal Investigators? Comments: Yes, geographical distribution of its principal investigators is critical to ensure that the PGRP is serving the needs of the entire scientific community. Review of the COV module shows that of the 65 new regular competition awards, there were 207 unique investigators in 38 states. There was a seemingly high proportion of PI's funded in CA and NY and this likely reflects the occurrence of virtual centers in these states. In any given fiscal year, a large portion of program funds may be mortgaged as continuing grant increments (CGIs). During FY2004-FY2006, the distribution of program funds for new awards and CGIs was spread across investigators at 89 primary and subaward institutions in 44 states.	Appropriate
9. Does the program portfolio have an appropriate balance of: • Institutional types? Comments: As expected, the majority of program awards are to research intensive PhD granting institutions (76). Nevertheless, 14 awards were made to non-research intensive institutions, where they play an important role in supporting faculty members who are active in research, and who bring to the attention of students, the benefits of research and the rewards of research careers.	Appropriate
10. Does the program portfolio have an appropriate balance: • Across disciplines and sub-disciplines of the activity? Comments: Upon review of the eJackets, the COV concluded that the PGRP's portfolio contains an appropriate level of cross-disciplinary research. In fact, projects funded by PGRP are inherently multidisciplinary where linkages between disciplines and sub-disciplines are critical. The following list highlights the breadth of disciplines and sub-disciplines represented in the award portfolio: bioinformatics, data curation or database management, chemistry, mathematics/statistics, QTL studies, molecular biology, evolutionary biology, biochemistry, metabolite chemistry, cytogenetics, cell biology, developmental biology, physiology, comparative genomics, proteomics, genetics and plant interactions with associated organisms such as microbes, nematodes, insects and viruses.	Appropriate
11. Does the program portfolio have appropriate participation of underrepresented groups? Comments: An important goal for the future success of the scientific enterprise in	Appropriate

the US is to facilitate and encourage the participation of members of groups that are traditionally not well represented in the sciences. On average, the success rate of applications with minority involvement is similar to that of all investigators, which in the last year was ~20%. Similarly, in the most recent year, the success rate of applications from minority serving institutions was 25%. However, there was a great difference in 2006 in the number of applications from all investigators (216) and from those with minority involvement (24) and those from minority serving institutions (8). It is clear that the pipeline of minority scientists needs to be dramatically expanded. NSF should obviously continue its outreach to institutions serving minority populations, especially land-grant colleges in the south that have more of a focus on agricultural research.	
12. Is the program relevant to national priorities, agency mission, relevant fields and other constituent needs? Include citations of relevant external reports. Comments: COV review of the PGRP annual reports for FY2004-2006 affirms the relevancy of the awards and the PGRP in general to its broad constituency groups. National Priorities: The National Science and Technology Council (NSTC), a cabinet-level council, is the principal means for the President to coordinate science, space, and technology to, in turn, coordinate the diverse parts of the Federal research and development enterprise. An important part of the NSTC is the establishment of clear national goals for Federal science and technology investments in areas ranging from information technologies and health research to improving transportation systems and strengthening fundamental research. The NSTC Committee on Science's Interagency Working Group on Plant Genomes is responsible for coordination of the National Plant Genome Initiative (NPGI). The ultimate goal of the NPGI is to understand the structure and function of all plant genes at levels from the molecular to the organismal and to interactions within ecosystems. The new knowledge and insights gained from plant genomics will lead to unexpected discoveries and conceptual advances in our understanding of the biology of plants. With a focus on plants of economic importance and plant processes of potential economic value, the NPGI will impact applied research related to agriculture, natural resources, the environment, health, and plant-based industries. Please refer to cited examples in later sections of this document.	Appropriate
13. Additional comments on the quality of the projects or the balance of the portfolio: The overall quality of the projects and the balance in the portfolio is generally excellent. The COV encourages review of the rest of this document for specific supporting evidence.	

A.4 Management of the program under review. Please comment on:

1. Management of the program.

Comments: The PGRP is making good use of the many electronic management tools in all aspects of its operations. This includes the eJacket and FastLane systems. These electronic systems not only help NSF staff to manage their work, they make it easier for the PIs to monitor the status of their applications and the reviewers to return their comments. For example, the improvements for tracking and management in FastLane make it easier for PIs to be reminded for updates prior to a panel meeting, to see reviewers' comments for past submissions, and for grantees to submit timely annual and final project reports.

As with the previous COV, this COV was impressed by the extensive interactions the Program staff has with the PIs. This level of coordinated management is unusual but appears to have been instrumental in helping the PGRP become the premier national and international funding program for plant genome research.

2. Responsiveness of the program to emerging research and education opportunities.

Comments: The PGRP has attempted to develop a balance of multidisciplinary projects, individual investigator and high-risk projects. This is highly appropriate given that the proportion of multidisciplinary projects is likely to increase and access to new research datasets enables new and innovative research strategies. It is critical for the program to continue to emphasize multidisciplinary proposals, despite the challenges posed by obtaining reviewers who can comment on both integrative science and multiple scientific approaches without conflicts of interest. The bioinformatics component of these multidisciplinary projects should be integrated into the research plan as a creative and scholarly contribution, rather than as a service function.

The integration of research, education and global interactions should continue to be important goals for all future grants. As evidenced by the eJackets, some PIs and reviewers are still having problems understanding the meaning of the Broadening Participation section of an NSF grant proposal. Future RFP from the PGRP should direct prospective PIs to the NSF Grant Proposal Guide and the PGRP website. This site contains links to the: (1) Plant Genomics Research Outreach Portal (PGROP), which gives examples of outreach activities such as student training and activities, public outreach, journalist information, tools for use and resources available from plant genome projects, (2) the PRG awards list where the abstracts for all awards can be found with a statement about their outreach activities, and (3) the NPGI-Plant Genome Reports which highlight teaching, training, teacher training, and workshops that are part of the program. This brochure is distributed at every meeting, every visit from prospective PIs, every panel, and every outreach activity the PGRP participates in. We also gave you copies of this, as well as putting it on the COV module in the documents.

3. Program planning and prioritization process (internal and external) that guided the development of the portfolio.

Comments: The PGRP benefits from the coordination of the Interagency Working Group on Plant Genomes (IWG) through the NPGI. This group currently includes as members the National Science Foundation (NSF), Department of Agriculture (USDA), Department of Energy (DOE), National Institutes of Health (NIH), the Agency for International Development (USAID), and Forest Service

(USFS). Each agency participates in accordance with its specific mission. Internally, the PGRP has relied on new opportunities identified in the NPGI annual progress reports, the congressional intent, the mission of the NSF Directorate for Biological Sciences, and inputs from the community (through workshop reports, white papers, and comments from individual and consortia of investigators).

As a result of its careful planning and prioritization, the PGRP has played a lead role in many of the objectives of the National Plant Genome Initiative. For example, the PGRP facilitated the large-scale sequencing projects with the USDA and DOE. It also coordinated long-range data/resource curation and management programs with the USDA and supported research collaboration between scientists from developing countries in collaboration with the USAID. Moreover, the PGRP was critical in developing the foundational knowledge base on which the major biofuels programs (now supported by DOE, USDA and British Petroleum) are being built.

Overall, the PGRP has made, and continues to make excellent use of both external and internal resources to guide its planning and prioritization. The COV finds that the NSF is leading the way for other programs at the national level.

The NPGI's long-range plan for 2003-2008 included the following objectives:

- Continued Elucidation of Genome Structure and Organization
- Functional Genomics – Understanding the Biological Role of Plant Genome Sequences, Including Gene Sequences, Regulatory Sequences, and Repeated Sequences
- Translational Plant Genomics – Application of Genomics Tools
- Education, Training and Outreach
- Consideration of Broader Impacts

Based on a review of the PGRP award portfolio, the COV believes that the PGRP has effectively moved its portfolio towards meeting the NPGI's long-range plan for 2003-2008 objectives and the overall objectives of the NSF. Moreover, the program addresses important needs of the plant research community and the COV believes that the PGRP has been essential in advancing the forefront of this important area of research. Plant resources serve a unique place in our national needs as the ultimate source of food, fuel and materials on which society depends. To keep pace with the many pressures of our growing population and climate change, it is essential that we continue to dedicate resources to develop the strongest foundation for plant genome research that we possibly can. In addition, many findings from PGRP-funded projects have fundamental implications for all biology research. The COV was pleased to see that the PGRP has not only met its prior objectives but has done so at such a high level while being responsive to the research community.

4. Responsiveness of the program to previous COV comments and recommendations.

Comments: The PGRP has been very responsive to the previous COV report. For example, at the recommendation of the last COV, the PGRP held a number of workshops on data management that led to the development of the Plant Science Cyberinfrastructure Collaborative Program. This program will provide the foundation for full-scale development of systems biology among other things. The PGRP also produced an educational video to convey the importance of plants and genome research to middle and high school students. This video was viewed by the COV and was found to be of the highest quality in terms of production and intellectual content. As suggested by the previous COV, the PGRP created opportunities for scientists from developing countries to participate in plant genome research collaborations.

Issues with the reviewer base are still apparent from the relatively low level of responsiveness on the part of scientists who are asked to provide ad hoc reviews but the COV was pleased to see increased diversity of women in the review pool compared to the start of the program.

Integration of the Arabidopsis 2010 project into PGRP for 2008 is a concern for the COV. The COV would favor integration only if the 2010 funding, which currently resides in the BIO base, is added to the PGRP or retained in the base programs in the division of biology. The rationale for this recommendation can be found in Section D.4 below.

The COV was pleased to see that the PGRP has added another permanent position to the staff as recommended by the previous COV. With the high level of interaction between the Program staff and the PIs, the addition of the new permanent line will enhance the overall management of the PGRP portfolio. It is also notable that the PGRP established overlap with its rotators to help with institutional memory.

The PGRP also instituted efforts to have all researchers use standard data exchange formats and standards for community-wide annotations, etc.

5. Additional comments on program management: The COV is pleased to see that the PGRP regularly promotes the results of their grantees with appropriate news releases. The initiation of the grantees annual meeting for exchange of data also is highly relevant.

PART B. RESULTS OF NSF INVESTMENTS

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The NSF mission is to:

- promote the progress of science;
- advance national health, prosperity, and welfare; and
- secure the national defense.

To fulfill this mission, NSF has identified four strategic outcome goals: Discovery, Learning, Research Infrastructure, and Stewardship. The COV should look carefully at and comment on (1) noteworthy achievements based on NSF awards; (2) ways in which funded projects have collectively affected progress toward NSF's mission and strategic outcome goals; and (3) expectations for future performance based on the current set of awards.

NSF investments produce results that appear over time. Consequently, the COV review may include consideration of significant impacts and advances that have developed since the previous COV review and are demonstrably linked to NSF investments, regardless of when the investments were made.

To assist the COV, NSF staff will provide award "highlights" as well as information about the program and its award portfolio as it relates to the three outcome goals of Discovery, Learning, and Research Infrastructure. The COV is not asked to review accomplishments under Stewardship, as that goal is represented by several annual performance goals and measures that are monitored by internal working groups that report to NSF senior management.

Please provide comments on the activity as it relates to NSF's Strategic Outcome Goals. Provide examples of outcomes ("highlights") as appropriate. Examples should reference the NSF award number, the Principal Investigator(s) names, and their institutions.

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."*

Comments: The ultimate goal of the PGRP (which are the same as the National Plant Genome Initiative) is to contribute to a better understanding of the structure and function of plant genes important to agriculture, environment, energy and health. Within the context of the NSF's mission, the overall goal of the PGRP is to support research on the structure, organization and function of plant genomes, and to accelerate the acquisition and utilization of new knowledge and innovative technologies that will lead to a complete understanding of fundamental biological processes in plants. To this end, the PGRP has chosen to focus on a broad array of plant genomes that are important to promoting global food security, human health and an abundant source of fuel and energy. The COV believes that this strategy is the best one for ensuring that the fruits of plant genome research are translated into tangible societal benefits in a timely manner.

Since its inception in 1997, the PGRP has made great strides in accomplishing its goals and objectives. In October 1997, the rice and Arabidopsis genome projects had just begun and only 25% of the Arabidopsis genome had been sequenced. Today, the rice, Arabidopsis and poplar genomes are complete and sequencing programs on Medicago, tomato, grape, Maize, soybean, potato and Brachypodium have been started. The dbEST/NCBI databases now hold over 8.5 million

ESTs and detailed and integrated genome maps of the major crop plants are available to the scientific community and the public. As a result of the PGRP, there is an abundant source of biological resources (full length cDNAs, molecular markers and mutant collections being shared by researchers around the country and the world). Powerful new genomic tools have been developed such as TILLING, RNAi, MPSS and informatic algorithms, and these tools are now being used to facilitate the next generation of large-scale-coordinated plant genome projects such those currently underway for maize, wheat, soybean, Medicago, barley, Rosaceae, Solanaceae and conifers. Perhaps as important as the information gained on a diverse collection of important plant genomes is the new trend toward using a systems biology approach that is expected to contribute to new conceptual frameworks for biology in general. This approach, which has been fostered by the PGRP, promises to produce the integration and synergies needed to predict and control biological process for the acquisition of knowledge and the betterment of humankind.

Implementation of the long term strategic vision laid out by National Plant Genome Initiative (NPGI) requires the ground breaking discoveries and resources that can only be provided by programs like the PGRP. Progress made to date has clearly laid the conceptual and technological foundation essential for advancement into new and critical areas of research, such as biomass production, yield and processor quality for the Biofuels Initiative (supported by the DOE, USDA and BP) as well as yield and growth stability as a result of environmental stress (as part of a Future Global Climate change initiative). Fundamental knowledge of plant genomes, gene structure and function, and our ability to apply that knowledge using new research tools are essential to making progress in the biofuels area and well as all other areas were varietal crop improvement will be critical to global food security, energy and nutritional quality.

A specific area the COV believes should be of critical importance to the PGRP is the role it will play in supporting the development of plant genome discoveries and tools that will establish the nation as a global leader in environmental stress tolerance research. Climate change predictions, increasing population sizes and the reduction in arable land make it abundantly clear that the ability of crops to tolerate environmental change will be essential to our ability to meet our food, and energy demands in the future. Global climate change caused by elevated 'greenhouse' gasses is predicted to increase the frequency of hot, semi-arid environments and the prevalence of heat and water stress. Oxidative stress from UV, photo-inhibition and air pollutants are associated stress factors that will reduce plant productivity. Drought is the primary cause of low plant productivity worldwide and water availability is an increasingly contentious issue: there is not enough renewable freshwater at the right place and time to serve human needs. Plant responses to salinity thus need study as another consequence of reduced water availability and water reuse. Agriculture, specifically, is estimated to account for 70% of the freshwater consumption globally and brings into question the sustainability of the irrigated agriculture upon which food security depends. In addition, climate change impact to the ecosystem is leading to declining biodiversity at a time when its value is increasingly being realized. Genome-based approaches such as genome-wide analyses of environmental stress adaptation pathways are very critical and continue to be an important opportunity for NSF. Having the PGRP part of the overall PGI is essential to provide the focus needed to accelerate our gains in this crucial area of research. The evolutionary basis of plant adaptation would have broad impact beyond the plant community both through the contribution to knowledge of conserved stress-response pathways and through the understanding of the contextual interactions of plants with other communities of organisms that rely on each other for survival. A key feature to highlight is our ability to further utilize and leverage the wealth of plant biodiversity; genetic and allelic variation that will push the forefront in stress tolerance and general biological research. Although the PGRP has already established the foundation of genomics knowledge for the new initiatives in biofuels, the COV feels further exploration and expansion on global change issues is important and consistent with the goals and objectives of the PGRP.

The COV will highlight specific research programs funded by PGRP that demonstrates concrete outcomes that have successfully fostered research in advancing the frontier of knowledge and in establishing the nation as a global leader in fundamental and transformational science. The COV would like to first emphasize how Plant Genomics has improved the status of the Plant Science Community in general.

We would like to emphasize how plant genomics (and PGRP specifically) has informed general principles of biology in pioneering ways and is serving as a model for other programs.

1. Structure-function relationships at the genome level: The Arabidopsis Genome Project was used to test strategies and technologies for Human Genome Sequencing Project and published the first description of the genome structure of a multi-cellular organism. Tools for genome and comparative genome analysis were co-developed in plants and animal models.

2. Epigenetics: PGRP research led to identification of some of the molecular bases of epigenetic markers and mapping them onto the genome. PGRP is currently leading the way in the development of the tools and analyses for investigating the role of epigenetics. For example, the recently developed whole genome arrays for Arabidopsis have demonstrated how DNA methylation of the genome is impacting gene expression patterns.

3. Signal transduction: Signaling pathways related to growth regulator perception and light signaling have contributed to our knowledge base on ligand-receptor interactions and novel ways cells perceive and transduce signals from their contextual environment. New common themes or guiding principles developed around whole organism perception and response to environmental cues are exemplified by genome analyses of the regulation of circadian rhythms.

4. Regulation of gene expression: PGRP research has led to the discovery of new mechanisms for regulation of gene expression, for example protein turnover, and expression regulation by small RNAs.

The COV has reviewed the specific outcomes in the Discovery area as a way to evaluate the ability of the program to meet the objectives described above. The tools generated by PGRP-funded research have produced a rapidly expanding landscape of new research opportunities. This research is quickly leading to translational research that is, or will be, of tremendous economic and social importance. A number of scientific breakthroughs have come about through PGRP-funded projects. Some highlights, of which there are many, include:

Plant cell walls, which constitute the bulk of plant biomass, have been tremendously difficult to study using standard biochemical and physiological approaches. Years of research led to many ideas but relatively little understanding of the molecular mechanisms of cell wall formation. Genome approaches have now opened doors to a revolution in our understanding of the plant cell wall. In work being lead by Dr. Keegstra (9975815 & 0211797) genomics has allowed them to identify genes that encode enzymes involved in cell wall synthesis. In conjunction with a specific cell expression system, the researchers are discovering how the enzymes function. In another project being led by Dr. Hahn at the University of Georgia (0421683), researchers are developing a molecular tool kit for identification and characterization of a large variety of cell wall components. These and other genome-based studies focused on understanding plant cell walls are highly relevant to improving our ability to live sustainability on Earth since for example, this knowledge is critical for developing effective methods for converting cell wall material to biofuels.

Nearly all aspects of plant growth and development are under hormone control. The hormone auxin, discovered nearly 100 years ago, is arguably the most critical regulator of plant growth but how it works has remained a mystery until recently. In a series of groundbreaking discoveries, Dr. Estelle at Indiana University (0077769) used a variety of genetic approaches to dissect the molecular mode

of action of auxin. This work led to the discovery of the auxin receptor and the detailed mechanisms by which it regulates gene expression. Moreover, this work revealed that similar mechanisms are at work in all eukaryotic organisms, including humans. This work could not have been done without the application of a vast array of the new tools that have come from the overall PGRP.

Plant productivity depends to a large extent on plant form and function (ability to respond to their environment in productive ways). For example, plants with more vertical leaves and branches allow more plants to be grown in a given area, thus increasing yield. Projects funded by the PRGP are leading to numerous discoveries about the genes that regulate plant structure. For example, a project lead by Dr. Hake at the University of California-Berkeley (0110189) has lead to the discovery of several genes that control the development of corn ears. Dr. Doebley (University of Wisconsin-Madison) and colleagues have been comparing corn and teosinte to try and understand how domestication led to modern corn. By using comparative genome approaches that have become available (by PGRP-funded research), they have been able to identify genes that regulate the amount of branching as well as the number and size of corn ears (0321467). This work is providing a summary of the genes that were impacted during the domestication of corn from teosinte. Moreover, this project should ultimately identify key gene targets for further modification of corn agronomics.

In another approach, Dr. Sheen at the Massachusetts General Hospital has been using genome approaches to discover the molecular mechanisms that impact stress tolerance, and specifically, cold tolerance in corn (0077692). This work has been translated into a practical application that could yield frost-tolerant corn, and could result in improved yield through increased early stand establishment as well as greatly expand the range where corn can be grown.

Other PRGP projects are focused on interactions between plants and their pathogens. For example, Dr. Bird at North Carolina State University (0077503) is doing pioneering work on the genomic analysis of nematode-plant interactions. This work is providing insight into how a common pathway may be used by different beneficial and harmful organisms to interact with a plant. This finding could have implications for development of new methods for pest control. In a study of the functional genomics of interactions of tomato and a Pseudomonas pathogen, Dr. Collmer at Cornell University (0077622) has sequenced the pathogen genome which is significantly impacting the whole community for developing new research efforts towards understanding how pathogens attack plants. At Yale University, Dr. Dinesh-Kumar is leading a PGRP project (0077510) to develop vectors for virus-induced plant gene silencing. This gene silencing tool can be used in many different plants and is enabling major discoveries to be made in plant biology. It is notable that this project was risky and the investigator was a new assistant professor when he received the award. It is unlikely that this work would have been funded without the PGRP. At Ohio State University, Dr. Kamoun is heading a project on potato blight (0211659) that is leading to the development of plants with improved disease resistance. Potato blight is a devastating disease (think Ireland) that is a major deterrent to potato production. In addition to the obvious relevance of these genome projects to plant/pathogen interactions, these projects are also contributing to better understanding of how human pathogens work.

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

Comments: The Plant Genome Research Program continues to provide ways to expand the scientific literacy of all citizens in understanding basic life processes in plants and how knowledge of these processes is crucial for the development of improved crops. Plant genomics research is

providing the fundamental knowledge and resources that are enabling numerous crop improvement strategies that will result in efficiency and productive gains for US growers, new and emerging markets for nutritional quality/supplements. Cultivating research in this critical area is also increasing the caliber of students entering the plant sciences and is increasing the quality of researchers trained in this area, which will ultimately drive US competitiveness and improve global food security and stability.

The PGRP through its grants continues its commitment to train the next generation of scientists by involving school age students, their teachers and college students in research at the cutting edge of plant sciences by offering wonderful subject matter for science education at all levels. The COV would like to highlight specific programs and impacts:

A workshop, held at the Plant and Animal Genome Meeting, San Diego, CA, in January 2004, supported by PGRP, highlighted many examples of how plant genomics researchers deliver their research information.

Web resources were developed to encompass the worldwide community as shown by the work of Ralph Dean, North Carolina State University and Barbara Baker, University of California-Berkeley. PI Volker Brendel, Iowa State University; (0110254) created the Plant Genome Research Outreach Portal (http://www.plantgdb.org/outreach) for students at all levels and their teachers. This is a centralized clearinghouse for genomic tools and activities related to the plant genome. A novel approach exemplified by an “Ask Dr. Carolyn” page allows students and teachers to submit questions about plant genomics that are not included on the website.

Plant Genome project at Iowa State University led by Dr. Jonathan Wendel is involved in a summer outreach course for teachers in the community to foster their interest and help develop their expertise in the sciences. This experience empowers teachers to transmit a passion for science, using plants as model organisms. Research team visits to elementary schools with a high percentage of underserved minority students brings the excitement of genomics into their classrooms (0211700 Jonathan Wendel Iowa State University). Additionally, as a result of another award (DBI-0211842), Dr. Henry Nguyen of the University of Missouri-Columbia has organized the MU Plant Genomic Research Experiences for Teachers (MUPGRET). This program is based on workshops (classroom and laboratory components) where teachers also have the opportunity to earn graduate credit from University of Missouri, and kits are provided to teachers for use in the classroom. To date, MUPGRET has trained 71 total Missouri teachers (urban and rural) with an estimated impact on more than 30,000 students in the next four years (see, http://rootgenomics.missouri.edu/prgc/RET/index.html.

Another outreach program developed by scientists at ChromDB, the database for chromatin-related proteins in plants, has brought bioinformatics to high school classrooms to augment textbooks that introduce genetics and genomics. Researchers at the University of Arizona (0421679 Carolyn Napoli University of Arizona) host high school teachers in summer internships to train them in laboratory techniques, including DNA purification and interpretation of DNA sequencing data. A “Bioinformatics in the Classroom" manual with labs and lessons pass on these experiences to students is prepared. Teachers and students who participated in the workshop submit *bona fide* sequences to GenBank. By targeting school districts that serve underrepresented students and rural communities varied communities are being contacted. Such partnerships give teachers unique opportunities, and expose students to plant genomics and bioinformatics while enhancing skills in data analysis and computational biology. Further, it builds strong foundations and fosters innovation to improve K-12 teaching, learning and evaluation in science and mathematics.

High school students have direct participation in plant genomics through a class in rice genome annotation organized by The Cold Spring Harbor Laboratory Dolan DNA Learning Center as part of

the PRGP awarded grant, Gramene-A platform for comparative cereal genomics (0321685). To target the college age student, PRGP researcher, Rod Wing, from the University of Arizona distributed a pamphlet at the University football stadium with information of how the genome of the rice that we eat is modified from wild grasses (Wing, Oryza Map Alignment Project, 2005 0321678).

The PGRP has also produced an excellent educational video on plant genomics that will be distributed to middle and high schools throughout the country.

PGRP participates in the NSF-sponsored website for broadcast of plant genome highlights so that these are globally available. For instance, the award announcement of $32 million through NSF, USDA, and DOE in November 2005 to sequence the corn genome was announced to share with the public that the research would increase corn yields and the development of disease-resistant varieties. The US economy is boosted by the export of approximately 2 billion bushels of corn annually and corn is a major grain crop in many other countries. News releases aimed at the citizen are coordinated in collaboration with OLPA for country and global release: these releases also provide information to the policy makers to aid in budget decisions.

The COV concludes that pathway for new researchers in plant genomics is encouraged because of the involvement of undergraduates and graduates in the PGRP supported programs.

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

Comments: In the previous COV review, attention was drawn to the need to develop a greater set of bioinformatics resources for the research community and the COV at that time reported that the PGRP had "made a good first step" in this arena. That previous COV also provided recommendations focused on making long term preservation and management of the data a priority for the program; these recommendations included:

- Promote use of existing standards (e.g., GO ontologies, Plant Genome Ontology, etc) in community-wide annotation.
- Promote use of standard data exchange formats (e.g., MIAME for microarray) in data submission.
- Promote and encourage submission of strictly bioinformatics proposals as long as database and tool development is relevant to the program.
- Strongly encourage participation from the bioinformatics community that develops general purpose and advanced form of bioinformatics tools as long as the relevancy to the program is demonstrated.
- Consider creating a community wide bioinformatics core center to provide a neutral venue for the various plant genome communities. Use cooperative agreement as a way of enforcing data submission to the database core. Utilizing supplement mechanism could be another mechanism for encouraging data submission.
- Institute an ongoing series of planning workshops addressing, for instance, bioinformatics and database issues that will respond to needs of researchers working on functional expression networks

The PGRP'S response to these recommendations was to embrace and accept the rationale and general specifics of the recommendations. Amongst the outcomes noted in the current COV review that demonstrate proactive execution of these recommendations are:

- Addition of a bioinformatics program officer to the PGRP team in 2005 and the stated intent

to add a second member in 2007 and beyond; this brings important subject matter expertise directly into the PGRP management team.

- Commissioning of a needs assessment focused on developing a strategy for long-lived data collections (workshop report reviewed as part of COV document set).

- A workshop and report on the development of a core cyberinfrastructure for plant science, which specifically recommended the creation of a cyberinfrastructure center.

- Translation of the recommendations above into the Plant Science Cyberinfrastructure Collaborative program (note, though a 2007 program, the COV is acknowledging that this is an outcome of planning and deliberations in part conducted within the review period).

- Institution of the Tools and Resources for Plant Genome Research program.

- Continued emphasis on open availability of and access to resources and products (data, software, materials, collections) from the PGRP resource through program management practices and award conditions, in particular the strong level of hands-on attention paid to these issues by Program staff as most evidenced through our interviews with same.

Much of the deliberations over this review period have led to a translation of the recommendations generated from activities described above into the Plant Science Cyberinfrastructure Collaborative program (PSCIC). The goal of this program is to create a new type of organization – a cyberinfrastructure collaborative for plant science – that will enable new conceptual advances through integrative, computational thinking. The Collaborative will be fluid and dynamic, utilizing new computer, computational science, and cyberinfrastructure solutions to address an evolving array of grand challenge questions in plant science. The Collaborative will be community driven, involving plant biologists, computer and information scientists, and experts from other disciplines working in integrated teams. In particular, the PSCIC was designed to address the recommendations made in the Plant Cyberinfrastructure Workshop Report, and the white paper on Plant Science Database needs.

One topic examined by the COV was the degree of integration of the PGRP staff in the overall planning and management of the Plant Cyberinfrastructure program. Though handled as a separate program within BIO, and managed by a dedicated program officer, the PGRP is a key stakeholder and with respect to this process serves as an important representative of and advocate for the needs of the plant genome research community in this program. Our initial impressions from discussions with the PGRP staff were that there is less integration and overlap than we would have expected, not least because of an inadvertent conflict of interest with the primary bioinformatics subject matter expert in the PGRP. The COV recommends that BIO institute a management mechanism to ensure closer integration of PGRP and PSCIC activities.

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

The COV found the PGRP to be well managed and effective in its solicitation, review and funding of meritorious proposals on a wide range of topics dealing with plant genome research and related technologies. After careful review of materials provided, the COV did find some aspects of the program could be strengthened. These include:

1) The inclusion in its future planning, plant genome research that takes into account the effects of global climate change (e.g., temperature effects, altered quality of light due to changes in ozone layer, water and salinity problems). Examining those adaptive mechanisms from a whole genome basis could play an important role in ensuring global food security, energy sufficiency and a sustainable world. The National Genome Research Initiative has identified these issues as being of national importance.

2) Historically, the PGRP has focused on plant systems of economic importance to the US. The COV believes that the PGRP should expand its focus to plants important to human health and crop plants important to developing countries.

3) More emphasis should be placed on supporting comparative genomics to increase understanding of plant biodiversity and its impact on global biodiversity, particularly the diversity of plant-pest, plant-pathogen, plant-beneficial microbe and plant-pollinator interactions.

4) The PGRP should encourage research proposals that involve systems approaches to integrating genetics, genomics and bioinformatics to unravel the biology of plants. By encouraging the concept of "systems genomics" the PGRP will be contributing to the development of unifying theory for all life forms. The analysis of diverse plant genomes supports this goal.

5) The PGRP should establish a process to ensure that it stays current on emergent technologies needed for the rapid and efficient analysis of plant genomes. This process may include establishing industrial liaisons in the area of genomic technology. For instance, NIH supports three cooperative centers for sequencing and they use an outside advisory group to provide advice to the staff regarding sequencing center operations and productivity. The PGRP should require its grantees to use the most cost effective technologies when appropriate. For example, since sequencing costs per base will decrease as new and more efficient technologies come online, the PGRP should require PIs to transition from older to newer technologies when possible.

6) The COV believes it is critical for the PGRP to disseminate the fruits of plant genome research in forms that are interactive, easy to understand and easy to use by the scientific community and the public. The COV recommends that PGRP explore collaborations with NSF-sponsored visualization centers to develop high-dimensional visualization and graphics tools for genomic data. Great progress is being made in generating visual representations of complex meteorological, geological and mathematical datasets. Some examples include work being done at the IDAV Visualization and Graphics Group at UC Davis (http://graphics.idav.ucdavis.edu/), the UNAVCO/GEON Cyberinfrastructure Research for the Geosciences (http://www.geongrid.org/workshops/geonvis2005/Links.html), the Charlotte Visualization Center at the University of North Carolina (http://www.viscenter.uncc.edu/) and the SIO Visualization Center at the Scripps Institution of Oceanography (http://siovizcenter.ucsd.edu/topo/b4.php).

7) FastLane and eJackets are important new improvements in how the NSF and PGRP manage the application, review and award process. Of course, like any newly developed software there will be bugs that can only be identified when users test it. NSF should pilot new software more fully before implementing it through all its programs.

8) Rotators and new employees have a steep learning curve and must pick up all the knowledge to do the job as a program staffer on-the job. The COV recommends that NSF be systematic in assigning rotators and new employees to mentors and that perhaps their workload for the first round be such that it more effectively facilitates acquisition of the necessary skills for the tasks at hand.

9) The PGRP should encourage greater industry-academic interactions. Industry often has strategies and technologies that could be beneficial to the academic plant genome researcher.

PGRP should explore the potential for closer industry collaboration and the leveraging of industry funds for mutually beneficial projects.

10) We are anticipating an explosion of data in metagenomics and this information must be rapidly disseminated to the scientific community in a useful/usable format. The PGRP should consider innovative ways of disseminating this information.

11) The PGRP is encouraged to expand funding opportunities to small colleges and universities, particularly those institutions with a track record for education outreach and training.

12) The NSF should develop programs to educate universities to the value of collaborative research (i.e., tenure committees give preference to individual grants) and facilitate the transition of established scientists from other disciplines into the plant sciences. Junior faculty should be encouraged to engage in multidiscipline research as an example of showing creative contribution in large projects.

C.2. Please provide comments as appropriate on the program's performance in meeting program-specific goals and objectives that are not covered by the above questions.

Comments: See Sections B1 and C1 above.

C.3. Please identify agency-wide issues that should be addressed by NSF to help improve the program's performance.

1) Soliciting Grant Reviews and Staff Workload: The methods used for identifying and solicitation of ad hoc reviewers for PGRP grant proposals were developed in an era when grant proposals were fewer, smaller and less complex. While these methods may work well for single investigator awards, finding ad hoc reviewers for a program that supports numerous multi-investigator projects is difficult. Many potential reviewers find themselves in conflict because they are associated in some way with the proposal under review. The PRGP is often frustrated with the low (approximately 25%) positive response rate from potential ad hoc reviewers. For the 84 eJackets examined by the COV, over 400 reviews were solicited but only 100 reviews were provided. It was interesting to learn that extensive use of email communication and the imposition of spam filters at many academic institutions have exacerbated this problem by blocking NSF solicitations to potential reviewers. The COV believes that the current process creates an excessive workload on PGRP staff and we believe that new ways of engaging reviewers should be considered. For example, instead of increasing the number of solicitations to obtain the needed number of reviews based on a 25% to 30% success rate, the PGRP should explore ways of increasing positive responses for the solicitations. Are there financial or non-financial incentives that could be used to increase the recruitment rate of ad hoc reviewers?

Regarding reducing staff workload and increasing the efficiency of the grant review process, the COV wonders if the PGRP could impose a limit on the number of resubmissions on a given topic. The COV believes that three submissions may be a reasonable limit because the research topic and attendant technologies are likely to have changed significantly over a three to four year period. Can the PGRP program officers use a triage process to eliminate unfundable proposals before ad hoc reviews are solicited? While these suggestions may not be strictly in the tradition of NSF grant review process, we suggest that the PGRP be used as a pilot program for new reviewer solicitation methods and a process to reduce the number of less meritorious applications that are submitted to panelists and ad hoc reviewers for evaluation.

2) Grant Management and Project Sustainability and Continuity: The COV is concerned about the consequences of terminating large, multi-investigator, multiyear grants projects. Although termination of projects, regardless of project size, is a necessary component of any competitive grant program, the COV believes that after making substantial investments in such projects, an orderly phase-out mechanism should be available for large projects. This would help ensure the orderly transfer and archiving of information and biological materials as well as ensure that project personnel are out-placed into appropriate positions. PIs should be required to include reasonable phase-out procedures in their proposals. In this way, the PGRP will have some additional protection in its investment in research and training of a highly skilled workforce. Perhaps this concern could be addressed with more frequent site visit reviews of large multiyear awards so that PIs can be apprised early of concerns about progress and how that may affect any potential project renewals? Could the PGRP use one-year extensions to assist PIs with the orderly phase-out process? The COV believes that this is an issue of program sustainability and that a new agency-wide policy may be required to address this concern.

C4. Please provide comments on any other issues the COV feels are relevant.

COV Review Process: The COV had some suggestions on how to streamline the COV review process. These suggestions are as follows:

- breaking the COV committee into smaller groups to meet with different groups of program directors/officers
- continue to update and streamline the COV review template to reduce redundancies and ambiguities in the questions and terms
- provide a block at the beginning of the template for an Executive Summary
- provide more clarification in the READ ME document of what is expected of COV members at the meeting
- schedule the meeting with the Assistant Director earlier in the review process

Part D. Program Level Questions

PGRP would like COV advice about several questions related specifically to the program.

D.1 What new opportunities in plant genomics should the Program address?

D.1.1. Global Climate Change-Challenges and Opportunities: Global trends are such that the COV anticipates a need for continued and increased climate change research to underpin future national and international policy decisions to mitigate the effects of environmental challenges to the health of our planet. We already see efforts to increase research and development on biological systems as alternatives to traditional fossil fuel resources, most notably from plant or microbial sources. The COV believes that by virtue of the investments made to date, the PGRP is scientifically and strategically poised to continue serving as the foundation for such important national missions. The COV could well envision that the increased national emphasis food and energy sustainability could naturally be reflected in the missions of the PGRP. For example, the community ecologies of plants, insects (and indeed microbes) may well represent a highly sensitive sentinel for the effects (both improvements and erosion) of climate warming or disruption in the ozone layer. Further, as plant-based resources become key components of our energy supply, more research will be needed to develop a deeper understanding of how plants capture and sequester carbon into biomass. How we protect such resources (from the effects of pathogens, for example) will also take on added importance. Finally, analogous to tree growth rings, the genomes of plants shed light on the history of past responses to significant shifts in environmental conditions. The COV sees opportunities for

the PGRP to take on a leadership role in addressing of these issues on the part of the scientific community.

In advance of an increased federal emphasis on both climate change and bioenergy research, the COV recommends that the NSF make early seed investments in the PGRP so that it can more quickly respond to research initiatives and proposals that bridge existing PGRP research and resources with these areas. Furthermore, over time and with careful consideration and input from the research communities, a plan should be developed to evolve and position this program to contribute to these (and perhaps other) national missions yet to emerge consistent with NSF's overall research and education missions in basic research.

D.2. How best should the Program manage *in silico* resources?

As has been recognized elsewhere in the report (see Section B3), there has been a considerable degree of planning and input gathering from the bioinformatics, genomics, and plant science communities. Much of this input and the resulting recommendations are now reflected in the recently announced PSCIC. Once the PSCIC is funded the opportunity exists to pull together a detailed business management plan for all PGRP (and perhaps even the NPGI) activities that integrates the various components together, centered on the PSCIC initiative. We recommend that the PGRP take the lead for the NPGI in drafting a program-wide business plan for the management of *in silico* resources.

D.3 What are the most effective approaches for ensuring that scientists at all levels are equipped with appropriate skills to participate in multidisciplinary, collaborative, and integrative research?

The COV concluded that the PGRP is working hard to include scientists at all levels into funded projects and to equip them with appropriate skills. However, more effort should be made to ensure inter-operability between projects and to disseminate genomic information that is user-friendly. Examine the long-term career paths of postdoctoral and research professors to understand their integration and roles in the field. The PGRP should be aware of the challenges related to young genome researchers in securing tenure when they have been part of a large plant genome project. The project PIs should be encouraged to develop effective mentoring programs to aid in the career development of their staff.

D.4 Continued funding of PGR from BIO.

D.4.1. After reviewing the evidence of the program's success, and realizing its potential to continue to inform core areas of biological inquiry in the future, the COV recommends continued funding for the PGRP for the foreseeable future. We envision that the progress of this initiative will be similar to that of the Human Genome Project, which seeded, facilitated and transformed human biology, as well as impacting numerous other fields of study both applied and basic. Like the Human Genome Project, the COV believes the PGRP should continue to receive support from BIO as the PRGP transitions from a sequencing focus to a focus on integrated biological systems. The rationale for this recommended is provided below.

In order to address basic questions of plant biology, as well as the practical application of genomic research to global issues of food security, human health and energy sustainability, a greater diversity of plant genomes will still be required. The COV believes that plant genomics holds a keystone position in biology. Plant genome databases are essential resources with obvious application to agriculture and industry, and represent an invaluable step towards the eventual integration of all life sciences by providing unifying principles for all of biology. PGRP funded research is also driving rapid progress in fields that impact all of biology. Plants and the organisms that feed on them make up over half of all species on Earth, so understanding global patterns of

biodiversity depends upon our knowledge of plant diversity, evolution, and ecology. The diversity of plant-feeding organisms is largely a function of plant diversity, which represents a critical resource for agriculture, medicine, and world health. Plant genomes hold information about the history of the planet that can help forecast its future. Comparative plant genomics (which requires sequences from diverse species) are critical to reconstructing the history of terrestrial life, and to testing broader evolutionary models. Plant genomics can also reveal how plants have responded historically to pests and pathogens (and other organisms) and to past climates. To understand the genomics of any organism (e.g., human or corn), it is essential to have the ability to conduct very robust comparative genome analyses across as many genomes as possible in order to decipher how any given genome works. Analysis of plant genomes will also reveal more fundamental information about deep evolution and the role of lateral gene transfer in eukaryotic lineages. Because plants contain the chloroplast endosymbiont in addition to mitochondria, research on plant genomics will help reveal how the nuclear genome interacts with organellar genomes. This will lead to more integrated areas such as systems biology at all levels of organization, from molecules to ecosystems.

The COV was unanimous in its opinion that the NSF should retain its leadership role at the core of the Interagency Working Group on Plant Genomes. NSF has been, and should continue to be the leader in providing the basic knowledge and resources driving the rapid fundamental changes that have so remarkably influenced the field of plant science. The foundation of knowledge coming from NSF-funded plant genome research is enabling tremendous breakthroughs by academic scientists and training of the biology workforce of tomorrow. Moreover, the basic science supported by NSF is establishing the foundation of knowledge that is enabling other agencies that have more focused and applied missions to move forward. For example, the biofuels thrust at the DOE and many of the crop improvement programs at the USDA are dependent on the basic knowledge that NSF creates. The COV recommends continued funding until the Interagency Working Group determines that there is sufficient knowledge of plant genomics to address the needs of the nation (e.g., food, water quality and energy security).

The basis for the COV's recommendation for continued funding of the PGRP is that within the BIO Directive, the PGRP is a meritorious and impactful program. The PGRP's unique focus on genomics, its integration and coordination with the National Plant Genome Initiative, and coordination with international programs are a model in the world scientific community. This COV emphasizes that, among other things, genomics knowledge is essential for us to understand the mechanisms of plant survival and adaptation that will enable plants to adequately perform under global environmental change. Continued collaboration with the Interagency Working Group is needed for the nation to remain the world leader in plant genomics research and for the long-term plans of the National Plant Genome Initiative to be met. The COV advocates the continued use of input from workshops and external review groups (such as the NAS) to help refine the outcomes and goals for the future as the genomic technologies continue to accelerate in their refinement and productivity.

The COV recommends continued funding for the PGRP until such time that the quality and creativity of proposals to the PGRP are seen to become derivative or redundant in their goals or show limited scope and prospects for new discoveries. Other reasons for reconsidering funding could include reduced quality and impact of publications (e.g., number of PRGP-funded papers and impact factors). The COV does not expect this situation to occur anytime soon, however. Indeed, the COV anticipates the need for PGRP funding to increase for the foreseeable future.

NSF is recognized as the home of basic science within the US and globally. Global interest and development of plant genomics has been instigated through the findings that were funded through the PGRP at NSF. The program is manageable because it is under one umbrella and the dissemination of information is maximized by the clear focus of the program. The success of the

program is enhanced by the high degree of interaction of the Program officers and directors with the researchers. The availability of funding for large-scale multi-investigator projects is also unique to this program within BIO. The COV feels it is a successful operative model and has fostered synergy between groups that previously had not interacted. These projects have also fostered migration of scientists from other disciplines who are bringing their unique perspectives into plant research.

Maintenance of the PGRP program is required to affirm global leadership in education of graduates and postdoctoral researchers in food and agriculture. Moreover, the broader impacts supported by the PGRP are playing critical roles to encourage diversity and the next generation of scientists.

Finally, we would like to address the American Competitive Initiative and its relationship to funding of this program and others based in the Biological Sciences Directorate. Although the perception exists that the recent doubling of the NIH budget has taken care of our competitiveness in the life sciences area, this perception underestimates the role of fundamental research into biological systems has for the future. Despite recent strides in biomedical research, most biological problems do not fall within the area of biomedicine. It is by unlocking the codes that control how the genome accomplishes the development and functioning throughout life of a diversity of animals and plants on the planet, that we will gain the knowledge and tools needed to ensure sustainability of life on the planet. The US is just as vulnerable to losing its edge in life sciences as it is in other sciences. Indeed with the urgent need to attack problems related to global climate changes, the studies that will come from the PGRP, and from biology as a whole, will be key to understanding responses of organisms and communities of organisms to such changes. During this time of increased funding for the sciences to meet the challenges ahead, it is critical that Biological Sciences funding be on a par with the other sciences. Fluctuations in availability of funding exert a negative effect on the growth of a field, not only due to the shortage of available funds for research, but more importantly because prospective as well as current students and postdocs read this as a signal not to enter such a field, since funding is needed for a successful science career. This most damaging effect of unstable funding can cripple the development of an area of science for decades, an outcome that is directly at odds with the aims of the American Competitive Initiative.

D.4.2. Plant Genomes and Beyond: In spite of popular belief, genome analysis is more than sequencing, counting, mapping and measuring the expression of genes in a massively parallel fashion, although these are necessary steps and obvious outcomes of genomic research. Rather, the rationale for genome analysis is to reveal those processes and mechanisms that explain how phenotypes are derived from genotypes, regardless of the species, and how these processes are modulated by the environment. In this regard, genomics is an essential component of systems biology in that it facilitates the transformation of genetic information (i.e., gene structure, function, regulation and transmission) into a holistic description of pathways and networks and their interactions with environmental signals. By supporting infrastructure and comparative genomic research on a range of information-rich and economically important plants, the PGRP is laying the groundwork for an integrated biology based on unifying principles and theories from all life forms. Some of these unifying principles may come from unexpected places like small RNAs found within the vast stretches of noncoding, repetitive DNA in plant genomes. It may also involve as yet-to-be elucidated epigenetic control of genetic regulatory modules and interaction networks that link cellular metabolism and physiology to extracellular biotic and abiotic signals. Research supported by the PGRP is at the forefront in these areas. The COV believes that from these unifying principles will come solutions to society's most vexing problems. Additionally, the PGRP provides an excellent portal to bring the value of scientific research to the public and to promote the NSF's mission to better combine research and education. For these reasons, the COV recommends continued funding of the PGRP.

D.5 Evidence for improving status of plant science in US colleges and universities.

Studies on the plant genome have raised the profile and increased awareness of plant science to that of animal sciences. The status of faculty and researchers in plants sciences has been enhanced at major research universities and institutes, and their numbers have increased. Plant sciences are not only recruiting new investigators to the field, but also established scientists from other disciplines. To cite an example from the eJackets, a project on the relationship between naturally occurring genetic and phenotypic variation in loblolly pine (*Pinus taeda*) has brought into the research community a highly respected evolutionary geneticist Charley Langley, whose work until now has focused primarily on Drosophila. Another example is the major role played by Steven Henikoff, a HHMI expert in chromatin molecular genetics, and a new member of the NAS in developing novel approaches that have broad applicability with PGRP funding. His research developed the new technique of TILLING which has become a widely used tool by plant and animal genomics researchers alike.

The COV feels that hard data to document the impact of the PGRP is available and urges the PGRP to establish mechanisms to enhance the return of such information from their awardees. COV discussed possible indicators such as:

Quality and number of applicants for tenure track positions in the plant field
Numbers of students applying for graduate training, and the numbers graduating
Laboratory space devoted to plant research in research universities and institutes
Transition of established scientists from another area into plant sciences

On March 1, 2007, an ad hoc committee of the National Academies of Science initiated a study of the National Plant Genome Initiative (NPGI). The objectives of the study are to:

- review the accomplishments of NPGI to date;
- assess the contribution of NPGI to science, research infrastructure, education of the next generation scientists, and international research collaboration;
- discuss the broad impacts of NPGI to fundamental advances in biological sciences;
- assess the contributions of NPGI to the application of scientific knowledge including technological innovation and economic competitiveness; and
- recommend future research directions and objectives for NPGI.

The study (sponsored by the Interagency Working Group on Plant Genomes) is expected to be completed in May of 2008. The COV believes that this study will provide valuable and detailed information on the impact of plant genome research on American colleges and universities, and on the economy.

DIVERSITY DOCUMENT

Committee of Visitors for the
Division of Biological Infrastructure
Directorate for Biological Sciences
National Science Foundation

June 29, 2007

This document describes the diversity, independence, and balance represented by members of the COV, and the resolution of real or apparent conflicts of interest.

The 2007 Committee of Visitors for the Division of Biological Infrastructure was composed of 11 members, including Dr. Barbara Wakimoto, who represented the BIO Advisory Committee Six of the members are female, and three members are from an underrepresented minority. Members currently work in eight different states, including California, Washington, Alaska, Illinois, Virginia, Pennsylvania, North Carolina and the District of Columbia. Nine members are from academic institutions, one is from a national lab, and one is from government.

All files presented to the committee were first scrutinized for possible conflicts with committee members. All conflicts were identified so that committee members would be aware of which files they could not review. Committee members were advised about confidentiality and conflicts of interest both prior to arriving at NSF and at the inception of the meeting. Conflicts issues during the meeting were considered and adjudicated by the division conflicts official.

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