

Response of the Division of Materials Research to the 2019 Committee of Visitors (COV) Recommendations (including annual updates, as indicated)

The Division of Materials Research (DMR) in the Directorate for Mathematical and Physical Sciences (MPS) extends its sincere gratitude to the members of the 2019 COV for the considerable time and effort they invested in reviewing DMR and in compiling a thorough and detailed review of the Division's activities from FY 2015 to FY 2018. In particular, DMR recognizes the exceptional leadership and organizational skills of Professor Melissa Hines, who served as the Chair of the Committee, and who expertly and efficiently orchestrated the actual review and the completion of the report within a highly demanding time frame.

DMR appreciates the Committee's high praise for the integrity and efficacy of the processes, as well as for the significance of the scientific accomplishments of the Division. Community confidence and approval are points of pride for program officers and staff members alike. The considered Community guidance delivered as suggestions and recommendations in the COV report is highly appreciated. We hereby provide responses, as appropriate, and outline plans on how DMR will take relevant action and convert to the fullest extent possible the COV recommendations into practice. The DMR response to the COV will be updated annually to reflect progress made.

COV Key Recommendations and DMR Responses:

Recommendation 1: DMR should take the lead in increasing funding for and awareness of materials research as this funding is essential to US global economic competitiveness and to the ability of the US to confront challenges ranging from national security and energy independence to climate change and waste management.

DMR Response:

01/24/20: DMR agrees with the conclusion of the National Academies of Sciences, Engineering, and Medicine *Frontiers of Materials Research* decadal survey that is underlined in the COV report, namely that US global economic competitiveness requires that the US maintain a world-leading position in materials research. While DMR cannot on its own increase its funding level, or support lobbying efforts for the same, it can take further steps towards increasing awareness of materials research and its multifaceted impact. To that effect, the Divisional webpages will be updated, aiming to provide a more effective outlet for research highlights. In addition, a contractor will be hired to create a professionally designed and visible website for the Designing Materials to Revolutionize and Engineer out Future (DMREF) program, in the same vein as in those that have been created for the Materials Research Science and Engineering Centers (MRSEC) and the Partnerships for Research and Education in Materials (PREM) programs. A newly hired Science Analyst working in conjunction with an MPS-wide Communications Working Group will streamline the processing and increase the efficacy of highlighting and publicizing DMR research to as wide an audience as possible.

01/25/21: The DMR Divisional webpages are continually updated to include research highlights from DMR-funded research. The DMREF program now has a dedicated website (<https://dmref.org/>), which is in the process of being populated with professionally designed content and information regarding the program and existing DMREF teams. DMR's Science Analyst has become fully engaged in the collection, curation, and dissemination of DMR-funded research highlights in close collaboration with the MPS-wide Communications Working Group.

01/25/22: The DMREF webpage is now fully operational and has become an important portal for accessing information and resources about materials research, the Materials Genome Initiative, and the DMREF program itself. The collection and dissemination of highlights in the DMR Divisional webpages as well as throughout the Directorate continues unabated. Several instances of important DMR-supported research have enjoyed extremely high visibility on “The Discovery Files”, which airs on commercial radio stations across the country and online, as well as in over 177 countries worldwide via the American Forces Network.

Recommendation 2: Given the breadth and importance of materials research across NSF and to the economic vitality of the US, the COV recommends that a separate directorate encompassing materials research, materials chemistry, materials engineering, and materials (condensed matter) physics be established in NSF.

DMR Response:

01/24/20: DMR is a highly diverse division, with programs that have multiple and essential interdisciplinary connections that span other programs within MPS and more broadly within the Directorates for Engineering, Biological Sciences, and Computer and Information Science and Engineering. While the coherent conglomeration of materials-related research efforts under a new directorate would necessarily have to be part of an NSF-wide reorganization effort, some of the challenges identified and detailed in the COV report could be effectively addressed in the short and the intermediate terms by attaining staffing levels commensurate to the needs dictated by the complexity and the breadth of the relevant programmatic efforts. The latter considerations form a broader context for Recommendation 9, below, which suggests having at a minimum one permanent program officer per program. DMR will take the necessary steps to articulate these needs to the MPS Office of the Assistant Director in a request for more Full-Time Equivalents (FTEs).

01/25/21: The 2020 DMR Staff Retreat held in September of 2020 had as one of its main subjects the organizational challenges that stem from DMR’s complexity and breadth of scope. As an outcome of the retreat, a series of recommendations were set forth, addressing the need to develop better connections and partnerships with other relevant NSF units (e.g., ENG, and CISE/OAC), as well as exploring a network management approach intended to optimize the flow of information from each unit and to better inform strategic decisions. Specific action on the latter involves the creation of thematic clusters of programs to be initiated and piloted in 2021.

01/25/22: The implementation of an open-window (no submission deadline) process for all the Topical Materials Research Programs took precedence in 2021, which completed the expansion of a highly successful pilot. A new NSF Directorate that focuses on Technology, Innovation, and Partnerships is being planned to be introduced in 2022. With materials and materials research being relevant for a broad swath of technological innovations, DMR anticipates developing a close working relationship and strong partnership with several arms of the new Directorate.

Recommendation 3: DMR should explore new mechanisms to promote the need for and impact of materials research on society and the economic well-being of the nation, potentially in partnership with other NSF divisions, NSF directorates and other Federal agencies. To this end, DMR should explore the feasibility of supporting an effort similar to the Computer Research Association, with a mission of uniting industries, academia and government to advance materials science to improve the lives and well-being of all.

DMR Response:

01/24/20: DMR concurs that conveying effectively the importance and impact of materials research on society and the well-being of the nation is an important undertaking. However, given the representational and lobbying restrictions that are in place, it is unclear to what extent a Government entity could spearhead an effort such as the Computer Research Association. It seems that Academia and Industry are the principal partners and drivers in the latter. Nevertheless, we will seek to find if, and to what extent, other parts of NSF have explored similar directions, and what can be done to foster and support such activities. Efforts to improve the communication and wide dissemination of the impact of previous funding of materials research are already underway at the divisional as well as at the directorate level, as outlined in the response to Recommendation 1 above. DMR will actively seek further opportunities to strengthen its outreach and community-engagement efforts.

01/25/21: With the usual outreach channels disrupted by the Covid-19 pandemic, DMR is reorganizing its outreach efforts. Besides virtual participation at national meetings of the various relevant societies (e.g., MRS, APS, ACS, NSBP, and SACNAS), DMR is planning semi-annual informational webinars aimed at broad participation and is exploring the establishment of virtual office hours for each program.

01/25/22: The DMR Division Director is the co-chair for the National Science and Technology Council (NSTC) subcommittee for the Materials Genome Initiative, representing all NSF divisions supporting the broad materials enterprise. A new national strategic plan was completed and published in December 2021. This was completed under DMR leadership involving a coordinated effort across multiple agencies in the federal government. DMR leads these efforts for NSF and is working with other federal agencies to respond to the recommendations in the new strategic plan recently approved by the Office of Science and Technology Policy (OSTP). DMR is also strongly engaged in the NSTC subcommittee for Leadership in Microelectronics. A strategic plan is currently being prepared by multiple federal agencies and OSTP in response to the CHIPS act. That strategic plan should be published this year and further emphasizes the importance of the materials enterprise in meeting this national need. Finally, DMR with its 9 divisional partners across NSF initiated a new National Academies of Science, Engineering, and Medicine (NASEM) study: Advising NSF on its Efforts to Achieve the Nation's Vision for the Materials Genome Initiative (DMREF). The study group has engaged academia, national labs, industry, and international researchers. All these efforts spearheaded by DMR have a national impact and demonstrate the importance of materials research to the national needs of the U.S.

Recommendation 4: DMR should take the lead in establishing partnerships with other government agencies (e.g., DOE, DOD, NIH) to develop new initiatives aimed at connecting discovery to translation while also providing creative approaches to funding the underlying materials research and development.

DMR Response:

01/24/20: DMR agrees that intra- and inter-agency partnerships are essential to further the impact and reach of the materials research it supports. Most recently, DMR has initiated a partnership with DOD/US Air Force on the development of advanced materials and of data-centric methods for materials discovery. Under an effort to accelerate the convergence of science and engineering communities that are working at the confluence of Synthetic Biology and Biomaterials, DMR is organizing a series of workshops that are expected to seed partnerships with FDA and NIH/NIBIB.

DMR will also host the 2020 Federal Interagency Materials Representatives (FIMaR) meeting, which will bring together program managers in materials research from a broad spectrum of relevant government agencies (DOD, DOE, FDA, NASA, NIH, NIST, NSF, and USDA). The meeting aims at fostering interagency communication and coordination, and it facilitates the establishment of partnerships. The

Interagency Polymer Meeting, which was introduced over two decades ago and is coordinated by NSF will follow immediately after FIMaR.

Another activity that will bring together all stakeholders involved in MGI, including all relevant federal government partners, is the upcoming 2020 MGI Principal Investigators meeting, which is a scheduled DMREF activity for the years between competitions.

01/25/21: During 2020, DMR led the addition of an Annex to the broad Memorandum of Understanding (MOU) between the National Science Foundation and the Air Force Research Laboratory (AFRL) for Collaboration in Science and Engineering Research. The Annex codified the participation of AFRL and the Air Force Office of Scientific Research in the 2021 Designing Materials to Revolutionize and Engineer our Future (DMREF) competition under the Material Genome Initiative (MGI), offering DMREF teams the opportunity to collaborate with activities sponsored by AFRL.

The 2020 MGI Principal Investigators meeting was postponed due to the Covid-19 pandemic. DMR is planning to hold a virtual version of the meeting in 2021.

DMR partnered with the Engineering Biology Research Consortium (EBRC) to create the “Engineering Biology & Materials Science” research roadmap, which assesses challenges and potential for innovation at the intersection of engineering biology and materials science. The research roadmap can be found here: <https://roadmap.ebrc.org/2021-roadmap-materials/>.

01/25/22: Following the success of the 2021 DMREF competition, which brought a record number of proposal submissions, the broadest partnership within NSF and with other federal agencies, as well as the highest to-date investment in the program, DMR is working to engage more federal partners in the preparation for the 2023 DMREF competition.

The 2020 MGI Principal Investigators meeting, which was regrettably postponed further in 2021 due to the Covid-19 pandemic, will be held virtually in the summer of 2022.

Recommendation 5: DMR should commission a study of the economic impact of the materials research workforce previously developed by the NSF and the future workforce needs in materials research, as this was not included in the Decadal Study.

DMR Response:

01/24/20: DMR has sponsored a study on the development of the next-generation workforce within the context of the Materials Genome Initiative, which is being executed by the Minerals, Metals & Materials Society (TMS). A report compiling perspectives on the subject from academia, industry, and government is in the final stages of completion. This report will inform the first steps towards forming a plan on how to comprehensively address the evaluation of the economic impact of the materials research workforce and its future needs, most likely through further engagement of the National Academies and relevant research societies.

01/25/21: The TMS study, entitled “Creating the Next-Generation Materials Genome Initiative Workforce” has been published, and it can be found here: <https://www.tms.org/portal/Publications/Studies/MGIworkforce/MGIworkforce.aspx>. A 2021 MGI strategic plan is being developed by the National Science and Technology Council Subcommittee for the National Materials Genome Initiative and calls for NSF to lead the participating agencies in developing an implementation plan. Active development is underway by DMR in collaboration with the NSF Division of Civil, Mechanical, and Manufacturing Innovation.

01/25/22: The 2021 MGI strategic plan has now been published and is available at: <https://www.mgi.gov/sites/default/files/documents/MGI-2021-Strategic-Plan.pdf>. We also note that NIST has already completed an economic study of MGI in 2015, which is called out in this strategic plan,

and exemplifies the importance of the materials enterprise to the economy
(<https://www.nist.gov/system/files/documents/2018/06/26/ffo-mgi-impact-analysis.pdf>.)

Recommendation 6: NSF should develop a data-driven understanding of how exposure to an environment of research excellence influences student persistence in STEM and assess how efforts to increase diversity are working.

DMR Response:

01/24/20: Prior existing reports point to a positive correlation between student exposure to research excellence and persistence in STEM. An NSF-commissioned Follow-up Study of Integrative Graduate Education and Research Traineeship (IGERT) Program Graduates found that an overwhelming majority of IGERT graduates reported that the IGERT experience positively contributed to their ability to complete their PhDs; a majority moved on to postdoctoral appointments or became employed in positions involving research duties. DMR's Assessment Working Group is concentrating its current efforts towards identifying methodologies for the assessment of investment broader impacts.

01/25/21: The DMR Assessment Working Group has conducted a pilot assessment of the DMR Partnerships in Research and Engineering in Materials (PREM) program. Limitations in the availability of relevant data and regulation-imposed restrictions in the type of data that can be collected hinder a comprehensive approach. DMR has partnered with NSF's Evaluation and Assessment Capability Section to explore formal avenues for expanding relevant data collection as well as to participate in a pilot aimed at tracking student educational outcomes.

01/25/22 This assessment undertaking remains a highly challenging one that has proven to be beyond the capabilities of and resources available to the Division.

Recommendation 7: DMR should creatively find new mechanisms for funding much needed materials research infrastructure, both experimental and computational, for individual investigators.

DMR Response:

01/24/20: DMR has considerable investments in large-, mid- and small-scale materials-research infrastructure. At the small scale (up to \$4M), the NSF-wide Major Research Instrumentation (MRI) program is the primary mechanism for supporting materials-research instruments at the present time. Over the last several years, a considerable 15% of the centralized MRI funds were used to fund MRI proposals that were reviewed in DMR. In addition, DMR has added at least \$1M per year to fund additional meritorious MRI proposals, a practice that will be continued.

DMR is generally aware of the need for increasing support for instrumentation at the individual investigator level. Discussions are on-going on how to best develop a sustainable portfolio for instrumentation at that level that is in harmony with the overall DMR portfolio. The considerations include convening a workshop or a blue-ribbon panel to document critical needs for tools in materials research.

In FY19, DMR successfully participated in the Mid-scale Research Instrumentation:1 competition, resulting in an award supporting the acquisition, implementation, and commissioning of a world-class neutron spin echo spectrometer for the nation.

(https://www.nsf.gov/awardsearch/showAward?AWD_ID=1935956&HistoricalAwards=false)

01/25/21: In FY20, DMR continued the practice of funding additional meritorious MRI proposals. Owing to budgetary limitations, it is unclear whether it will be feasible to sustain this practice in FY2021.

In FY20, DMR successfully participated in the Mid-Scale Research Instrumentation:2 competition, resulting in an award supporting a first-of-its-kind x-ray facility for new science at the high-magnetic-field frontier (https://www.nsf.gov/awardsearch/showAward?AWD_ID=1946998).

01/25/22: In FY21, DMR continued the practice of funding additional meritorious MRI proposals. In addition, DMR has charged a working group comprising program directors from DMR and other interested NSF Divisions to develop plans for, to manage, and to coordinate activities related to DMR's future investment in instrumentation in response to the 2021 Materials Genome Initiative Strategic Plan. Plans include engaging with stakeholders across federal agencies and private foundations.

Recommendation 8: The current division of program areas along specific classes of materials — the topical materials research programs (TMRP) — is working well, and the COV does not recommend a restructuring of the topical areas.

DMR Response:

01/24/20: DMR appreciates the Committee's recognition of the robustness of the Division's distribution of materials research in the Topical Materials Research Programs.

01/25/21: As a result of a Divisional retreat charged with addressing issues stemming from DMR's organizational complexity, and specifically the challenge of collecting, integrating, and communicating information from each unit to DMR management and to better inform strategic decisions DMR is spearheading the creation of thematic clusters of programs to be initiated and piloted in 2021. No actual restructuring of the topical areas is envisioned.

01/25/22: In view of other priorities, which primarily include easing workload demands and the anticipated engagement with the new NSF Directorate, DMR prioritized the implementation of an open-window (no submission deadline) process for all the Topical Materials Research Programs, capitalizing on the success of a limited pilot. The topical areas remained intact.

Recommendation 9: Every DMR program should have at least one permanent (non-rotating, non-temporary assignment) program officer to maintain institutional memory and to enable long-term, reasoned evolution of the program.

DMR Response:

01/24/20: The breadth and depth of DMR's multifaceted engagement with the communities it serves and within NSF generates a very substantial workload for all of its programs. In addition, preserving institutional memory and adequate responsiveness of each program to shifting priorities and new opportunities imposes considerable additional demands of time and effort on program officers. Recommendations to address staffing demands have been key parts of numerous past COV reports, as well as of the present one. In the recent past and in response to MPS making a compelling case, the office of the Director has generously provided FTEs that have alleviated some of the workload burden and concerns. DMR and MPS will continue advocating for the provision of additional staff to address unmet staffing needs. DMR agrees that one permanent program officer per program is a minimum requirement.

01/25/21: Following 2020 recruitment efforts, the Electronic and Photonic Materials program acquired a permanent program officer. A search for a permanent program officer for the Biomaterials program is ongoing in early 2021. Plans to convert the single program officer position associated with the Metals and Metallic Nanostructures program from a rotator to a permanent type of appointment are being developed.

01/25/22: In 2021, as a result of successful recruitment efforts, a permanent program officer was hired for the Biomaterials program. Barring unforeseen difficulties, DMR anticipates hiring a permanent program director for the Metals and Metallic Nanostructures program in late 2022 or early 2023.

Recommendation 10: DMR, MPS, and NSF should work to stabilize the US supply of helium at a national level and the efficient use of helium by researchers, as an uninterrupted supply of helium is crucial to scientific research, economic advances, and health infrastructure.

DMR Response:

01/24/20: DMR will continue to provide opportunities for obtaining supplemental support for the acquisition of infrastructure that enables Helium conservation by capture and reliquefaction.

Recommendation 11: The MRSEC program should not introduce a sunset provision but should introduce a network model, in which several institutions can collaborate to support two or more IRGs, as a separate track within the MRSEC program.

DMR Response:

01/24/20: The MRSEC sunset provision was only brought up as a possibility for consideration and has not been introduced into policy. Considering the arguments presented in the COV report, we agree it should not be a priority. DMR will explore the creation of a subcommittee within the MPS Advisory Committee with an aim of comprehensively evaluating the MRSEC program.

01/25/21 A plan is being developed to comprehensively evaluate the MRSEC program via a National Academy of Sciences & Engineering study, intended to follow a similar commissioned study of the DMREF program that is underway.

01/25/22 Planning for the NASEM study continues, slightly delayed by programmatic and other priorities.

Recommendation 12: The centers programs are exemplars within DMR and MPS; however, the time from pre-proposal to proposal to site review to decision has lengthened over the years. It is taxing for PIs and institutions to sustain efforts for well over 12 months from pre-proposal to decision. The COV recommends that efforts be made to either shrink the evaluation time or to possibly provide development support as ENG does for the ERCs.

DMR Response:

01/24/20: DMR appreciates the importance of a timely evaluation for proposals, in general. At the same time, DMR is obligated to follow established procedures and rules that govern the thorough and considered review and evaluation of Center proposals. A rather firm timeline and attendant process are especially important considering the complexity of the Center proposals and the fact that established Centers participate in the competition along with neophytes. DMR program directors are working diligently and efficiently to minimize any delays. DMR will consult with ENG colleagues to evaluate possible benefits and limitations of planning grants and their appropriateness for DMR centers. We note that the consideration of Engineering Research Centers is an involved process that includes National Science Board review, which is not required for DMR Centers.