

Understanding the Rules of Life: Microbiome Interactions and Mechanisms (URoL:MIM)

PROGRAM SOLICITATION NSF 21-534

REPLACES DOCUMENT(S): NSF 20-513



National Science Foundation

Full Proposal Deadline(s) (due by 5 p.m. submitter's local time):

February 23, 2021

IMPORTANT INFORMATION AND REVISION NOTES

The program name has been changed from "Understanding the Rules of Life: Microbiome Theory and Mechanisms (URoL:MTM)" to "Understanding the Rules of Life: Microbiome Interactions and Mechanisms (URoL:MIM)".

The two tracks of the previous solicitation have been combined into one supporting projects with budgets up to \$3,000,000 for a duration of up to 5 years.

Letters of Intent are no longer required.

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 20-1), which is effective for proposals submitted, or due, on or after June 1, 2020.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Understanding the Rules of Life: Microbiome Interactions and Mechanisms (URoL:MIM)

Synopsis of Program:

In 2016, the National Science Foundation (NSF) unveiled a set of "Big Ideas," 10 bold, long-term research and process ideas that identify areas for future investment at the frontiers of science and engineering (see https://www.nsf.gov/news/special_reports/big_ideas/index.jsp). The Big Ideas represent unique opportunities to position our Nation at the cutting edge of global science and engineering by bringing together diverse disciplinary perspectives to support convergence research. As such, when responding to this solicitation, even though proposals must be submitted to the Division of Emerging Frontiers in the Directorate for Biological Sciences (BIO/EF), once received, the proposals will be managed by a cross-disciplinary team of NSF Program Directors.

Understanding the Rules of Life (URoL): Predicting Phenotype is one of NSF's 10 Big Ideas (https://www.nsf.gov/news/special_reports/big_ideas) and is focused on predicting the set of observable characteristics (phenotypes) based on the genetic makeup of the individual and the nature of its environment. The Understanding the Rules of Life: Microbiome Interactions and Mechanisms (URoL:MIM) program is an integrative collaboration across several Directorates and Offices within the National Science Foundation. The objective of URoL:MIM is to understand interactions and mechanisms that govern the structure and function of microbiomes. By integrating the wide range of accumulated data and information on microbiome structure and function, new causal models of interactions and interdependencies across scales and systems can be generated. Elucidating these relationships will inform our understanding of the Rules of Life – the theoretical constructs and models that explain and predict the emergent characteristics of living systems, as seen in the robustness, resilience, and adaptability of the individual organisms, populations, and communities.

We define a microbiome as a collection of different microbes in a specific habitat. This may include non-host-associated microbiomes and host-associated microbiomes, such as those in humans and other organisms, where i) the microbiome impacts host physiology, behavior, development, and fitness; ii) the host influences the metabolic activity, dynamics and evolution of the microbiome, and iii) the environment (biological, chemical, physical, and social) influences and is influenced by both the host and the microbiome.

The URoL:MIM program invites integrated, interdisciplinary proposals that create new knowledge in multiple disciplines to develop causal frameworks with well-designed scientific and/or computational approaches to test hypotheses about the relationships within the microbiome, and among the microbiome, the host, and the environment. Projects may develop new computational, mathematical, or experimental tools, and models, to: i) explain function and interactions in natural, experimental, and model microbiomes; ii) elucidate the chemical and molecular mechanisms that underlie communication between the host and the microbiome and among the members of the microbiome; and/or iii) comparatively analyze characteristics of microbiomes to discover emergent properties that provide insight into the behavior of living systems.

Successful projects will contribute to a portfolio of research that identifies general principles ("rules") that underlie a wide spectrum of biological phenomena across different spatial, complexity (e.g., molecular, cellular, organismal, population), and/or temporal scales (from sub-second to geologic). URoL:MIM projects must be novel and innovative in more than one discipline (e.g., biology, chemistry, computer science, engineering, geology, mathematics, physics, social and behavioral sciences). They must also incorporate best practices regarding protocol documentation, sample selection, data collection and analysis, as well as data sharing and accessibility. URoL:MIM projects must provide workforce development and/or innovative undergraduate or graduate education opportunities that increase the pipeline for MIM in higher education and train the next generation of microbiome scientists. Projects should benefit society through engagement of the public and/or enhancement of K-12 STEM education.

URoL:MIM supports basic science research projects of different scales and scope. Projects may have a total budget of up to \$3,000,000 and an award duration of up to 5 years.

Cognizant Program Officer(s):

Please note that the following information is current at the time of publishing. See program website for any updates to the points of contact.

- Catalina Achim, MPS, telephone: (703) 292-2048, email: microbiome@nsf.gov
- Robert Mayes, EHR, telephone: (703) 292-7267, email: microbiome@nsf.gov
- Mamta Rawat, BIO, telephone: (703) 292-7265, email: microbiome@nsf.gov
- Karl J. Rockne, ENG, telephone: (703) 292-5356, email: microbiome@nsf.gov
- Christopher Sanford, telephone: (703) 292-7512, email: microbiome@nsf.gov
- Michael E. Sieracki, GEO, telephone: (703) 292-7585, email: microbiome@nsf.gov
- Sylvia J. Spengler, CISE, telephone: (703) 292-8930, email: microbiome@nsf.gov

Applicable Catalog of Federal Domestic Assistance (CFDA) Number(s):

- 47.041 --- Engineering
- 47.049 --- Mathematical and Physical Sciences
- 47.050 --- Geosciences
- 47.070 --- Computer and Information Science and Engineering
- 47.074 --- Biological Sciences
- 47.075 --- Social Behavioral and Economic Sciences
- 47.076 --- Education and Human Resources
- 47.079 --- Office of International Science and Engineering
- 47.083 --- Office of Integrative Activities (OIA)

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 4 to 8

Anticipated Funding Amount: \$12,000,000 to \$15,000,000 Contingent upon availability of funds.

Eligibility Information

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members. Special Instructions for International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus, and justify why the project activities cannot be performed at the US campus.
- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI: 1

An individual may appear as Principal Investigator (PI) co-PI, or Senior Personnel on only one proposal submitted in response to this

solicitation.

If an individual is listed as PI, co-PI, or Senior Personnel on more than one proposal to this solicitation, all proposals received after the first submission involving the individual will be returned without review.

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- **Letters of Intent:** Not required
- **Preliminary Proposal Submission:** Not required
- **Full Proposals:**
 - Full Proposals submitted via FastLane: *NSF Proposal and Award Policies and Procedures Guide* (PAPPG) guidelines apply. The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.
 - Full Proposals submitted via Research.gov: *NSF Proposal and Award Policies and Procedures Guide* (PAPPG) guidelines apply. The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.
 - Full Proposals submitted via Grants.gov: *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov* guidelines apply (Note: The *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide).

B. Budgetary Information

- **Cost Sharing Requirements:**

Inclusion of voluntary committed cost sharing is prohibited.
- **Indirect Cost (F&A) Limitations:**

Not Applicable
- **Other Budgetary Limitations:**

Other budgetary limitations apply. Please see the full text of this solicitation for further information.

C. Due Dates

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

February 23, 2021

Proposal Review Information Criteria

Merit Review Criteria:

National Science Board approved criteria. Additional merit review criteria apply. Please see the full text of this solicitation for further information.

Award Administration Information

Award Conditions:

Additional award conditions apply. Please see the full text of this solicitation for further information.

Reporting Requirements:

Standard NSF reporting requirements apply.

TABLE OF CONTENTS

Summary of Program Requirements

- I. [Introduction](#)
- II. [Program Description](#)
- III. [Award Information](#)
- IV. [Eligibility Information](#)
- V. [Proposal Preparation and Submission Instructions](#)
 - A. [Proposal Preparation Instructions](#)
 - B. [Budgetary Information](#)
 - C. [Due Dates](#)
 - D. [FastLane/Research.gov/Grants.gov Requirements](#)

- VI. **NSF Proposal Processing and Review Procedures**
 - A. Merit Review Principles and Criteria
 - B. Review and Selection Process
- VII. **Award Administration Information**
 - A. Notification of the Award
 - B. Award Conditions
 - C. Reporting Requirements
- VIII. **Agency Contacts**
- IX. **Other Information**

I. INTRODUCTION

It is now well-established that microbiomes are widespread on earth and play important roles in shaping the function of ecosystems. Microbiomes are living systems that are an essential part of organisms and provide additional genomes that contribute to the phenotype of the host organisms. Large scale projects such as the Human Microbiome Project and the Earth Microbiome Project have cataloged microbes and identified specific correlations among microbes, the host, and/or the environment. A grand challenge is to move beyond this descriptive, correlative research to establish explanatory and predictive relationships between and among the members of the microbiome, the host, and the environment. A conceptual framework of the microbiome that accounts for chemical, physical, physiological, structural, ecological, and evolutionary mechanisms underlying the function of microbiomes, and the interaction of the microbiome with the environment is necessary. In the case of host-associated microbiomes, understanding the host-microbiome association and the interactions among the microbiome, host, and the environment is needed. How these complex interactions give rise to emergent properties of/in host-associated and non-host-associated microbiomes is also of major importance. Understanding these mechanisms will have significant benefits to society, including increased agricultural production, bio-economic advances, improved human health and well-being, and stronger and more resilient protection from national security threats, among many others.

URoL:MIM is a cross-directorate program of the National Science Foundation that aims to foster the understanding of mechanistic relationships within and among the microbiome, the host (if any), and the environment. The URoL:MIM program portfolio will support projects that collectively cross levels of complexity (e.g., molecular, cellular, organismal, population), span spatial and temporal scales (from sub-second to geologic), and address interactions with taxa from anywhere within the tree of life, including humans.

The interdisciplinary focus of URoL:MIM requires the advancement of knowledge in more than one discipline. This includes development of novel experimental methods, comparative approaches integrating knowledge from different areas, predictive modeling, new mathematical, computational, and data science approaches, and integrated multi-disciplinary education and/or outreach activities that foster workforce development.

Investigators wishing to inquire about the suitability of potential projects for URoL:MIM are encouraged to email a one-page summary with rationale, specific research objectives, intellectual merit, and broader impacts to microbiome@nsf.gov.

II. PROGRAM DESCRIPTION

The URoL:MIM program defines a microbiome as a community of microorganisms with more than one type of organism, including bacteria, archaea, fungi, protists, and viruses that inhabit a particular habitat. The habitat can be a living host or a particular environment, broadly defined to include the biological, chemical, physical, and/or social state, settings, or conditions. The URoL:MIM Program is focused on the causal and mechanistic understanding of the structure and function of these microbiomes and the connections, interactions, and interdependencies within and among the microbiome, the host, and the environment (biological, chemical, physical, and social). The major objective of URoL:MIM is to develop an integrated understanding of how microbiome organisms communicate and interact with each other, with their hosts, and with their environments, across various spatial and temporal scales. This includes mechanisms underlying how the microbiome affects the phenotypes of organisms and their robustness, resilience, and adaptability. How the underlying relationships among the microbiomes, hosts, and physical, social, and built environments ultimately emerge as properties that affect phenotype of the microbiome, the host, or both is of interest.

The URoL:MIM program includes participation from the Directorates for Biological Sciences (BIO), Computer and Information Science and Engineering (CISE), Education and Human Resources (EHR), Engineering (ENG), Geosciences (GEO), Mathematical and Physical Sciences (MPS), Social, Behavioral, and Economic Sciences (SBE), and the Office of Integrative Activities (OIA) at the National Science Foundation. The goal of the program is to foster crosscutting, interdisciplinary science that integrates perspectives and research approaches from multiple directorates and offices. Projects must give rise to novel science in more than one discipline.

The URoL:MIM strongly encourages research to i) identify causal relationships among members of the microbiome, and among the microbiome, host (if any), and the environment; ii) investigate how these relationships affect the robustness and adaptability of organisms and communities; and iii) determine how these interactions affect the observable characteristics of the environment and vice versa. Many basic research opportunities could lead to new understanding of the interactions between members of the microbiome, between microbiomes and the environment, between microbiomes and their hosts, and among microbiomes, hosts, and the environment. The projects considered by the program could address, but are not restricted to, the following topics:

- The development of innovative biological, chemical, physical, engineering, computational, mathematical/statistical, and social science approaches to understand the molecular mechanisms that underlie the communication among the microorganisms in a microbiome and between the microbiome and the host
- New combination of approaches, including biological, chemical, physical, engineering, computational, mathematical/statistical, and social science methods, to understand scale-invariant principles as well as temporal and spatial variation in microbiome structure and function
- Leveraging novel engineering, mathematical/statistical, and computational approaches to understand the ecology and evolution of microorganisms in microbiomes and the co-evolution of microorganisms, environment, and host
- The development of innovative data science and control theory approaches to understand functional redundancy and the role it may play in microbiome diversity and resiliency to changing environmental conditions
- New biological, chemical, physical, computational, engineering, and/or social networking approaches to understand and predict how a host's genetic

- composition, physiology, and/or behavior influence the genetics, physiology, and behavior of the microbiome and vice versa
- Novel socio-technical approaches to understand the nature and function of microbiome-brain-behavior relationships in humans and other species
- New models and cross-disciplinary approaches to understand, predict, and control how horizontal gene transfer affects the function and evolution of microbiomes and/or hosts
- The development of novel experimental model or synthetic microbiomes in defined and controlled environments to elucidate microbiome structure and function
- Comparative analysis of microbiomes using novel methods of analysis of existing microbiome, host and environmental data in order to develop novel models and elucidate relationships among the microbiome, the host, and the environment

The URoL:MIM program also strongly encourages inclusion of research in pedagogy, curriculum development, and broadening participation that accelerates the pace of microbiome science and workforce development, as a complement to the proposal's research on microbiome interactions and mechanisms. Research projects that stress workforce development, integrate training and outreach activities in their research plan, provide interdisciplinary training opportunities, develop novel teaching modules, and/or provide explicit plans to integrate primarily undergraduate institutions and broaden participation of under-represented groups in science are also encouraged.

Successful research is expected to develop causal frameworks and to employ experimental and/or computational approaches to increase our understanding of microbiomes. Successful projects are anticipated to have compelling validation and verification plans for the models or methods of analysis in the proposed research.

The Project Description must include clear statements on:

- How the research will lead to generalizable concepts that can be applied to systems beyond the microbiome of study.
- The use of interdisciplinary approaches that develop new science in more than one research discipline (e.g. biology, chemistry, physics, computer science, engineering, mathematics, social and behavioral sciences, education).
- Reproducibility and replicability of sample collection and preparation, experimental design, data analysis, model generation, and/or validation of mathematical and computational methods. Proposals must align with or advance community best practices to produce scientifically defensible results.
- Workforce development as part of the intellectual merit and/or broader impacts.

Investigators are encouraged to develop collaborations with researchers with complementary expertise to facilitate an interdisciplinary approach to address the overarching research question(s).

Proposals that fall within the purview of other federal granting agencies such as the National Institutes of Health (NIH), U.S. Department of Agriculture (USDA), Department of Energy (DOE), and others are discouraged.

Projects that would be supported normally through regular core programs of the participating NSF Directorates and Offices are also discouraged.

Proposals that are not responsive to this solicitation or that fall outside the purview of NSF will be returned without review, as described in the *Proposal & Award Policies & Procedures Guide* Introduction, A. About the National Science Foundation (https://www.nsf.gov/pubs/policydocs/pappg20_1/index.jsp#A):

"Research with disease-related goals, including work on the etiology, diagnosis, or treatment of physical or mental disease, abnormality, or malfunction in human beings or animals, is normally not supported. Animal models of such conditions or the development or testing of drugs or other procedures for their treatment also are not eligible for support.

However, research in bioengineering or information technology with diagnosis- or treatment-related goals that applies engineering or computer science principles to problems in biology and medicine while advancing engineering or computer science knowledge is eligible for support. Bioengineering and assistive information technology research to aid persons with disabilities also is eligible."

Research on microbiomes related to organism dysfunction in an ecological context will be considered.

URoL:MIM provides support for projects with a total budget (including indirect costs) of up to \$3,000,000 and award duration of up to 5 years. Projects are required to submit a Student Training Plan and Management Plan as part of Supplementary Documentation.

International collaborators are encouraged to seek support from their respective funding organizations. Funding guidelines for involving international collaborators allow the following expenses to be included in the NSF budget:

- Travel expenses for U.S. scientists and students participating in exchange visits integral to the project.
- Project-related expenses for international partners to engage in research activities while in the U.S. as project participants.
- Project-related expenses for U.S. participants to engage in research activities while abroad.

III. AWARD INFORMATION

The Program estimates a Fiscal Year (FY) 2021 budget of \$12,000,000 to \$15,000,000 and expects to make 4-8 awards.

Estimated program budget, number of awards and average award size/duration are subject to the availability of funds.

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

Proposals may only be submitted by the following:

Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members. Special Instructions for International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus, and justify why the project activities cannot be performed at the US campus.

- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI: 1

An individual may appear as Principal Investigator (PI) co-PI, or Senior Personnel on only one proposal submitted in response to this solicitation.

If an individual is listed as PI, co-PI, or Senior Personnel on more than one proposal to this solicitation, all proposals received after the first submission involving the individual will be returned without review.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Full Proposal Preparation Instructions: Proposers may opt to submit proposals in response to this Program Solicitation via FastLane, Research.gov, or Grants.gov.

- Full proposals submitted via FastLane: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG). The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg. Paper copies of the PAPPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov. Proposers are reminded to identify this program solicitation number in the program solicitation block on the NSF Cover Sheet For Proposal to the National Science Foundation. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.
- Full Proposals submitted via Research.gov: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the *NSF Proposal and Award Policies and Procedures Guide* (PAPPG). The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg. Paper copies of the PAPPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov. The Prepare New Proposal setup will prompt you for the program solicitation number.
- Full proposals submitted via Grants.gov: Proposals submitted in response to this program solicitation via Grants.gov should be prepared and submitted in accordance with the *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov*. The complete text of the *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide). To obtain copies of the Application Guide and Application Forms Package, click on the Apply tab on the Grants.gov site, then click on the Apply Step 1: Download a Grant Application Package and Application Instructions link and enter the funding opportunity number, (the program solicitation number without the NSF prefix) and press the Download Package button. Paper copies of the Grants.gov Application Guide also may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov.

In determining which method to utilize in the electronic preparation and submission of the proposal, please note the following:

Collaborative Proposals. All collaborative proposals submitted as separate submissions from multiple organizations must be submitted via FastLane or Research.gov. PAPPG Chapter II.D.3 provides additional information on collaborative proposals.

See PAPPG Chapter II.C.2 for guidance on the required sections of a full research proposal submitted to NSF. Please note that the proposal preparation instructions provided in this program solicitation may deviate from the PAPPG instructions.

Special instructions for submitting to this Big Idea solicitation

FastLane Users: Proposers are reminded to identify the program solicitation number (located on the first page of this document) in the first block on the NSF Cover Sheet. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Please note that even though proposals must be submitted to BIO/EF, once received the proposals will be managed by a cross-disciplinary team of NSF Program Directors.

Research.gov Users: The Prepare New Proposal setup will prompt you for the program solicitation number (located on the first page of this document). Compliance with this requirement is critical to determining the relevant proposal processing guidelines. As stated previously, even though proposals must be submitted to BIO/EF, once received the proposals will be managed by a cross-disciplinary team of NSF Program Directors.

Grants.gov Users: The program solicitation number will be pre-populated by Grants.gov on the NSF Grant Application Cover Page, however you will need to locate the Division Code, Program Code, Division Name, and Program Name for the specific solicitation you are applying to by visiting <https://www.fastlane.nsf.gov/pgmannounce.jsp>. As stated previously, even though proposals must be submitted to BIO/EF, once received the proposals will be managed by a cross-disciplinary team of NSF Program Directors.

Proposal Preparation Instructions

The following information SUPPLEMENTS (not replaces) the guidelines provided in the NSF Proposal & Award Policies & Procedures Guide (PAPPG).

1. Cover Sheet

Proposal Title: Titles of proposals submitted to URoL:MIM should begin with MIM: followed by a substantive title.

When responding to this solicitation, even though proposals must be submitted to the Division of Emerging Frontiers in the Directorate for Biological Sciences (BIO/EF), once received, the proposals will be managed by a cross-disciplinary team of NSF Program Directors. Exception: Proposals led by PIs from Primarily Undergraduate Institutions should be submitted through the RUI/ROA solicitation (https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5518) by the deadline for the URoL:MTM program. In addition to the requirements of the RUI program, proposals should follow the guidance in this solicitation.

2. Project Description (up to 15 pages): For all proposals, the project description must include:

- A description of how the project integrates and advances knowledge in two or more diverse and complementary (i.e. interdisciplinary) disciplines to further a mechanistic and causal understanding of the structure and function of microbiomes, and the connections, interactions and interdependencies within and among the microbiome, the host, and the environment. The project description must address how the research leads to generalizable concepts that can be applied to systems beyond the microbiome of study. Reproducibility and replicability in sample and data collection, experimental design and methodology, and data analysis that align with community best practices must be included. Workforce development as part of the intellectual merit and/or broader impacts must be addressed.
- Results from Prior NSF Support
- Please note that per guidance in the PAPPG, the Project Description must contain, as a separate section within the narrative, a section labeled "Broader Impacts". PIs can decide where to include this section within the Project Description. Project Descriptions without this specifically labeled section will be returned without review.

3. Budget: Proposals Requiring Research Facilities: Budgets should include all costs charged to the project for platforms and facilities supporting the proposed research, except those facilities separately supported by NSF (e.g., research aircraft or field equipment). Principal investigators are responsible for filing the appropriate requests for major research platforms; a copy of the request must be attached as a Supplementary Document.

4. Special Information and Supplementary Documentation:

A. Data Management Plan (up to two pages): Each proposal must include, as a supplementary document, a data management section with the specific details of data standards, accessibility, electronic dissemination, and preservation. Of particular importance (where applicable) are: plans for data collection and analysis; plans for dissemination of data and archiving; details of collaborative efforts; information about necessary permits; and information about access to resources that are not immediately under the investigator's control (e.g., museum collections, research sites, computing facilities). Further information about Data Management Plans can be found in the [PAPPG](#). Proposals that do not comply with this requirement will not be accepted or will be returned without review. Data management plans should follow community best practices.

B. Student Training Plan (up to two pages): The URoL:MTM Program seeks to build a diverse, interdisciplinary, globally engaged, scientific workforce capable of transforming and communicating our understanding of the mechanisms that underlie structure and function of microbiomes (including host-associated microbiomes), the interactions within the microbiome and with the environment and/or host, and the resultant, robustness, and adaptability of organisms, populations, and communities.

Each proposal that requests funding to support undergraduate and/or graduate students should include, as a supplementary document, a description of the training activities that will be provided for such individuals. Training should promote intellectual and methodological cross-fertilization and encourage a systems/integrative perspective towards a mechanistic and causal understanding of the microbiome. The goal of the Student Training Plan is to prepare students to develop broad hypotheses and to become well versed in all aspects of interdisciplinary microbiome research. This may be accomplished, for example, through lab rotations among PI institutions, cross-training plans, and/or integrative training workshops. NSF believes that student research experiences have their greatest impact in situations that lead the participants from a relatively dependent status to an independent status as their competence warrants. A training plan should be included that explains the approach, depth and breadth of instruction. The training plan must not exceed two pages. Proposers should describe specifically how the proposed training plan will enhance the future workforce for the field of interdisciplinary microbiome research and how trainees will be better able to engage in emerging research areas employing newly developing methods and tools. Only one Student Training Plan should be submitted for each project, even if it is a collaborative project.

C. Project Management Plan and Role of Project Personnel (up to two pages): Each proposal must include a detailed management plan describing the role and expertise of each investigator, what each person brings to the project leadership team, reporting relationships, means of communication and interaction among the members of the project team, oversight and accountability mechanisms, metrics to evaluate the success of the project.

D. Letters of Collaboration: If the project involves collaborative arrangements of significance, these arrangements should be documented through letters of collaboration. Letters of collaboration should be limited to stating the intent to collaborate and should not contain endorsements or evaluation of the proposed project. Letters of collaboration should follow the single-sentence format: "If the proposal submitted by Dr. [insert the full name of the Principal Investigator] entitled [insert the proposal title] is selected for funding by the NSF, it is my intent to collaborate and/or commit resources as detailed in the Project Description or the Facilities, Equipment or Other Resources section of the proposal." Requests for letters of collaboration should be made by the PI well in advance of the proposal submission deadline, because they must be included at the time of submission. *Please note that letters of recommendation for the PI or other letters of support for the project are not permitted.*

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

Other Budgetary Limitations:

URoL:MIM supports projects with a total budget (including indirect costs) of up to \$3,000,000 and award duration of up to 5 years.

C. Due Dates

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

February 23, 2021

D. FastLane/Research.gov/Grants.gov Requirements

For Proposals Submitted Via FastLane or Research.gov:

To prepare and submit a proposal via FastLane, see detailed technical instructions available at: <https://www.fastlane.nsf.gov/a1/newstan.htm>. To prepare and submit a proposal via Research.gov, see detailed technical instructions available at: https://www.research.gov/research-portal/appmanager/base/desktop?_nfpb=true&_pageLabel=research_node_display&_nodePath=/researchGov/Service/Desktop/ProposalPreparationandSubmission.html. For FastLane or Research.gov user support, call the FastLane and Research.gov Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov or rgov@nsf.gov. The FastLane and Research.gov Help Desk answers general technical questions related to the use of the FastLane and Research.gov systems. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

For Proposals Submitted Via Grants.gov:

Before using Grants.gov for the first time, each organization must register to create an institutional profile. Once registered, the applicant's organization can then apply for any federal grant on the Grants.gov website. Comprehensive information about using Grants.gov is available on the Grants.gov Applicant Resources webpage: <https://www.grants.gov/web/grants/applicants.html>. In addition, the NSF Grants.gov Application Guide (see link in Section V.A) provides instructions regarding the technical preparation of proposals via Grants.gov. For Grants.gov user support, contact the Grants.gov Contact Center at 1-800-518-4726 or by email: support@grants.gov. The Grants.gov Contact Center answers general technical questions related to the use of Grants.gov. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this solicitation.

Submitting the Proposal: Once all documents have been completed, the Authorized Organizational Representative (AOR) must submit the application to Grants.gov and verify the desired funding opportunity and agency to which the application is submitted. The AOR must then sign and submit the application to Grants.gov. The completed application will be transferred to the NSF FastLane system for further processing.

Proposers that submitted via FastLane or Research.gov may use Research.gov to verify the status of their submission to NSF. For proposers that submitted via Grants.gov, until an application has been received and validated by NSF, the Authorized Organizational Representative may check the status of an application on Grants.gov. After proposers have received an e-mail notification from NSF, Research.gov should be used to check the status of an application.

VI. NSF PROPOSAL PROCESSING AND REVIEW PROCEDURES

Proposals received by NSF are assigned to the appropriate NSF program for acknowledgement and, if they meet NSF requirements, for review. All proposals are carefully reviewed by a scientist, engineer, or educator serving as an NSF Program Officer, and usually by three to ten other persons outside NSF either as *ad hoc* reviewers, panelists, or both, who are experts in the particular fields represented by the proposal. These reviewers are selected by Program Officers charged with oversight of the review process. Proposers are invited to suggest names of persons they believe are especially well qualified to review the proposal and/or persons they would prefer not review the proposal. These suggestions may serve as one source in the reviewer selection process at the Program Officer's discretion. Submission of such names, however, is optional. Care is taken to ensure that reviewers have no conflicts of interest with the proposal. In addition, Program Officers may obtain comments from site visits before recommending final action on proposals. Senior NSF staff further review recommendations for awards. A flowchart that depicts the entire NSF proposal and award process (and associated timeline) is included in PAPPG Exhibit III-1.

A comprehensive description of the Foundation's merit review process is available on the NSF website at: https://www.nsf.gov/bfa/dias/policy/merit_review/.

Proposers should also be aware of core strategies that are essential to the fulfillment of NSF's mission, as articulated in *Building the Future: Investing in Discovery and Innovation - NSF Strategic Plan for Fiscal Years (FY) 2018 – 2022*. These strategies are integrated in the program planning and implementation process, of which proposal review is one part. NSF's mission is particularly well-implemented through the integration of research and education and broadening participation in NSF programs, projects, and activities.

One of the strategic objectives in support of NSF's mission is to foster integration of research and education through the programs, projects, and activities it supports at academic and research institutions. These institutions must recruit, train, and prepare a diverse STEM workforce to advance the frontiers of science and participate in the U.S. technology-based economy. NSF's contribution to the national innovation ecosystem is to provide cutting-edge research under the guidance of the Nation's most creative scientists and engineers. NSF also supports development of a strong science, technology, engineering, and mathematics (STEM) workforce by investing in building the knowledge that informs improvements in STEM teaching and learning.

NSF's mission calls for the broadening of opportunities and expanding participation of groups, institutions, and geographic regions that are underrepresented in STEM disciplines, which is essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.

A. Merit Review Principles and Criteria

The National Science Foundation strives to invest in a robust and diverse portfolio of projects that creates new knowledge and enables breakthroughs in understanding across all areas of science and engineering research and education. To identify which projects to support, NSF relies on a merit review process that incorporates consideration of both the technical aspects of a proposed project and its potential to contribute more broadly to advancing NSF's mission "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF makes

every effort to conduct a fair, competitive, transparent merit review process for the selection of projects.

1. Merit Review Principles

These principles are to be given due diligence by PIs and organizations when preparing proposals and managing projects, by reviewers when reading and evaluating proposals, and by NSF program staff when determining whether or not to recommend proposals for funding and while overseeing awards. Given that NSF is the primary federal agency charged with nurturing and supporting excellence in basic research and education, the following three principles apply:

- All NSF projects should be of the highest quality and have the potential to advance, if not transform, the frontiers of knowledge.
- NSF projects, in the aggregate, should contribute more broadly to achieving societal goals. These "Broader Impacts" may be accomplished through the research itself, through activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. The project activities may be based on previously established and/or innovative methods and approaches, but in either case must be well justified.
- Meaningful assessment and evaluation of NSF funded projects should be based on appropriate metrics, keeping in mind the likely correlation between the effect of broader impacts and the resources provided to implement projects. If the size of the activity is limited, evaluation of that activity in isolation is not likely to be meaningful. Thus, assessing the effectiveness of these activities may best be done at a higher, more aggregated, level than the individual project.

With respect to the third principle, even if assessment of Broader Impacts outcomes for particular projects is done at an aggregated level, PIs are expected to be accountable for carrying out the activities described in the funded project. Thus, individual projects should include clearly stated goals, specific descriptions of the activities that the PI intends to do, and a plan in place to document the outputs of those activities.

These three merit review principles provide the basis for the merit review criteria, as well as a context within which the users of the criteria can better understand their intent.

2. Merit Review Criteria

All NSF proposals are evaluated through use of the two National Science Board approved merit review criteria. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

The two merit review criteria are listed below. **Both** criteria are to be given **full consideration** during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. Therefore, proposers must fully address both criteria. (PAPPG Chapter II.C.2.d(i). contains additional information for use by proposers in development of the Project Description section of the proposal). Reviewers are strongly encouraged to review the criteria, including PAPPG Chapter II.C.2.d(i), prior to the review of a proposal.

When evaluating NSF proposals, reviewers will be asked to consider what the proposers want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. These issues apply both to the technical aspects of the proposal and the way in which the project may make broader contributions. To that end, reviewers will be asked to evaluate all proposals against two criteria:

- **Intellectual Merit:** The Intellectual Merit criterion encompasses the potential to advance knowledge; and
- **Broader Impacts:** The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

The following elements should be considered in the review for both criteria:

1. What is the potential for the proposed activity to
 - a. Advance knowledge and understanding within its own field or across different fields (Intellectual Merit); and
 - b. Benefit society or advance desired societal outcomes (Broader Impacts)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?
3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or organization to conduct the proposed activities?
5. Are there adequate resources available to the PI (either at the home organization or through collaborations) to carry out the proposed activities?

Broader impacts may be accomplished through the research itself, through the activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. NSF values the advancement of scientific knowledge and activities that contribute to achievement of societally relevant outcomes. Such outcomes include, but are not limited to: full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education.

Proposers are reminded that reviewers will also be asked to review the Data Management Plan and the Postdoctoral Researcher Mentoring Plan, as appropriate.

Additional Solicitation Specific Review Criteria

In addition to the standard NSF review criteria described above, proposals submitted in response to this solicitation will be assessed on how strongly they meet the following criteria:

- The potential of the research to lead to generalizable concepts that can be applied to systems beyond the microbiome of study
- The use of interdisciplinary approaches that develop new science in more than one research discipline (e.g. biology, chemistry, physics, computer science, engineering, mathematics, social and behavioral sciences, education)
- Reproducibility and replicability of sample collection and preparation, experimental design, data analysis, model generation, and/or validation of mathematical and computational methods. Proposals must align with or advance community best practices to produce scientifically defensible results
- Workforce development as part of the intellectual merit and/or broader impacts

B. Review and Selection Process

Proposals submitted in response to this program solicitation will be reviewed by Ad hoc Review and/or Panel Review.

Reviewers will be asked to evaluate proposals using two National Science Board approved merit review criteria and, if applicable, additional program specific criteria. A summary rating and accompanying narrative will generally be completed and submitted by each reviewer and/or panel. The Program Officer assigned to manage the proposal's review will consider the advice of reviewers and will formulate a recommendation.

After scientific, technical and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the cognizant Division Director whether the proposal should be declined or recommended for award. NSF strives to be able to tell applicants whether their proposals have been declined or recommended for funding within six months. Large or particularly complex proposals or proposals from new awardees may require additional review and processing time. The time interval begins on the deadline or target date, or receipt date, whichever is later. The interval ends when the Division Director acts upon the Program Officer's recommendation.

After programmatic approval has been obtained, the proposals recommended for funding will be forwarded to the Division of Grants and Agreements for review of business, financial, and policy implications. After an administrative review has occurred, Grants and Agreements Officers perform the processing and issuance of a grant or other agreement. Proposers are cautioned that only a Grants and Agreements Officer may make commitments, obligations or awards on behalf of NSF or authorize the expenditure of funds. No commitment on the part of NSF should be inferred from technical or budgetary discussions with a NSF Program Officer. A Principal Investigator or organization that makes financial or personnel commitments in the absence of a grant or cooperative agreement signed by the NSF Grants and Agreements Officer does so at their own risk.

Once an award or declination decision has been made, Principal Investigators are provided feedback about their proposals. In all cases, reviews are treated as confidential documents. Verbatim copies of reviews, excluding the names of the reviewers or any reviewer-identifying information, are sent to the Principal Investigator/Project Director by the Program Officer. In addition, the proposer will receive an explanation of the decision to award or decline funding.

VII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

Notification of the award is made to *the submitting organization* by a Grants Officer in the Division of Grants and Agreements. Organizations whose proposals are declined will be advised as promptly as possible by the cognizant NSF Program administering the program. Verbatim copies of reviews, not including the identity of the reviewer, will be provided automatically to the Principal Investigator. (See Section VI.B. for additional information on the review process.)

B. Award Conditions

An NSF award consists of: (1) the award notice, which includes any special provisions applicable to the award and any numbered amendments thereto; (2) the budget, which indicates the amounts, by categories of expense, on which NSF has based its support (or otherwise communicates any specific approvals or disapprovals of proposed expenditures); (3) the proposal referenced in the award notice; (4) the applicable award conditions, such as Grant General Conditions (GC-1)*; or Research Terms and Conditions* and (5) any announcement or other NSF issuance that may be incorporated by reference in the award notice. Cooperative agreements also are administered in accordance with NSF Cooperative Agreement Financial and Administrative Terms and Conditions (CA-FATC) and the applicable Programmatic Terms and Conditions. NSF awards are electronically signed by an NSF Grants and Agreements Officer and transmitted electronically to the organization via e-mail.

*These documents may be accessed electronically on NSF's Website at https://www.nsf.gov/awards/managing/award_conditions.jsp?org=NSF. Paper copies may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov.

More comprehensive information on NSF Award Conditions and other important information on the administration of NSF awards is contained in the NSF *Proposal & Award Policies & Procedures Guide* (PAPPG) Chapter VII, available electronically on the NSF Website at https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.

Special Award Conditions:

Grantees will be required to include appropriate acknowledgment of NSF support under the Understanding the Rules of Life in any publication (including World Wide Web pages) of any material based on or developed under the project, in the following terms:

"This material is based upon work supported by the National Science Foundation Understanding the Rules of Life Big Idea under Grant No. (Grantee enters NSF grant number.)"

Grantees also will be required to orally acknowledge NSF support using the language specified above during all news media interviews, including popular media such as radio, television and news magazines.

C. Reporting Requirements

For all multi-year grants (including both standard and continuing grants), the Principal Investigator must submit an annual project report to the cognizant Program Officer no later than 90 days prior to the end of the current budget period. (Some programs or awards require submission of more frequent project reports). No later than 120 days following expiration of a grant, the PI also is required to submit a final project report, and a project outcomes report for the general public.

Failure to provide the required annual or final project reports, or the project outcomes report, will delay NSF review and processing of any future funding increments as well as any pending proposals for all identified PIs and co-PIs on a given award. PIs should examine the formats of the required reports in advance to assure availability of required data.

PIs are required to use NSF's electronic project-reporting system, available through Research.gov, for preparation and submission of annual and final project reports. Such reports provide information on accomplishments, project participants (individual and organizational), publications, and other specific products and impacts of the project. Submission of the report via Research.gov constitutes certification by the PI that the contents of the report are accurate and complete. The project outcomes report also must be prepared and submitted using Research.gov. This report serves as a brief summary, prepared specifically for the public, of the nature and outcomes of the project. This report will be posted on the NSF website exactly as it is submitted by the PI.

More comprehensive information on NSF Reporting Requirements and other important information on the administration of NSF awards is contained in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) Chapter VII, available electronically on the NSF Website at https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.

VIII. AGENCY CONTACTS

Please note that the program contact information is current at the time of publishing. See program website for any updates to the points of contact.

General inquiries regarding this program should be made to:

- Catalina Achim, MPS, telephone: (703) 292-2048, email: microbiome@nsf.gov
- Robert Mayes, EHR, telephone: (703) 292-7267, email: microbiome@nsf.gov
- Mamta Rawat, BIO, telephone: (703) 292-7265, email: microbiome@nsf.gov
- Karl J. Rockne, ENG, telephone: (703) 292-5356, email: microbiome@nsf.gov
- Christopher Sanford, telephone: (703) 292-7512, email: microbiome@nsf.gov
- Michael E. Sieracki, GEO, telephone: (703) 292-7585, email: microbiome@nsf.gov
- Sylvia J. Spengler, CISE, telephone: (703) 292-8930, email: microbiome@nsf.gov

For questions related to the use of FastLane or Research.gov, contact:

- FastLane and Research.gov Help Desk: 1-800-673-6188
- FastLane Help Desk e-mail: fastlane@nsf.gov
- Research.gov Help Desk e-mail: rgov@nsf.gov.

For questions relating to Grants.gov contact:

- Grants.gov Contact Center: If the Authorized Organizational Representatives (AOR) has not received a confirmation message from Grants.gov within 48 hours of submission of application, please contact via telephone: 1-800-518-4726; e-mail: support@grants.gov.

IX. OTHER INFORMATION

The NSF website provides the most comprehensive source of information on NSF Directorates (including contact information), programs and funding opportunities. Use of this website by potential proposers is strongly encouraged. In addition, "NSF Update" is an information-delivery system designed to keep potential proposers and other interested parties apprised of new NSF funding opportunities and publications, important changes in proposal and award policies and procedures, and upcoming NSF [Grants Conferences](#). Subscribers are informed through e-mail or the user's Web browser each time new publications are issued that match their identified interests. "NSF Update" also is available on [NSF's website](#).

Grants.gov provides an additional electronic capability to search for Federal government-wide grant opportunities. NSF funding opportunities may be accessed via this mechanism. Further information on Grants.gov may be obtained at <https://www.grants.gov>.

ABOUT THE NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) is an independent Federal agency created by the National Science Foundation Act of 1950, as amended (42 USC 1861-75). The Act states the purpose of the NSF is "to promote the progress of science; [and] to advance the national health, prosperity, and welfare by supporting research and education in all fields of science and engineering."

NSF funds research and education in most fields of science and engineering. It does this through grants and cooperative agreements to more than 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations and other research organizations throughout the US. The Foundation accounts for about one-fourth of Federal support to academic institutions for basic research.

NSF receives approximately 55,000 proposals each year for research, education and training projects, of which approximately 11,000 are funded. In addition, the Foundation receives several thousand applications for graduate and postdoctoral fellowships. The agency operates no laboratories itself but does support National Research Centers, user facilities, certain oceanographic vessels and Arctic and Antarctic research stations. The Foundation also supports cooperative research between universities and industry, US participation in international scientific and engineering efforts, and educational activities at every academic level.

Facilitation Awards for Scientists and Engineers with Disabilities (FASSED) provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See the *NSF Proposal & Award Policies & Procedures Guide* Chapter II.E.6 for instructions regarding preparation of these types of proposals.

The National Science Foundation has Telephonic Device for the Deaf (TDD) and Federal Information Relay Service (FIRS) capabilities that enable individuals with hearing impairments to communicate with the Foundation about NSF programs, employment or general information. TDD may be accessed at (703) 292-

5090 and (800) 281-8749, FIRS at (800) 877-8339.

The National Science Foundation Information Center may be reached at (703) 292-5111.

The National Science Foundation promotes and advances scientific progress in the United States by competitively awarding grants and cooperative agreements for research and education in the sciences, mathematics, and engineering.

To get the latest information about program deadlines, to download copies of NSF publications, and to access abstracts of awards, visit the NSF Website at <https://www.nsf.gov>

- **Location:** 2415 Eisenhower Avenue, Alexandria, VA 22314
- **For General Information** (NSF Information Center): (703) 292-5111
- **TDD (for the hearing-impaired):** (703) 292-5090
- **To Order Publications or Forms:**
 - Send an e-mail to: nsfpubs@nsf.gov
 - or telephone: (703) 292-8134
- **To Locate NSF Employees:** (703) 292-5111

PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by awardees will be used for program evaluation and reporting within the Executive Branch and to Congress. The information requested may be disclosed to qualified reviewers and staff assistants as part of the proposal review process; to proposer institutions/grantees to provide or obtain data regarding the proposal review process, award decisions, or the administration of awards; to government contractors, experts, volunteers and researchers and educators as necessary to complete assigned work; to other government agencies or other entities needing information regarding applicants or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See [System of Record Notices, NSF-50](#), "Principal Investigator/Proposal File and Associated Records," and [NSF-51](#), "Reviewer/Proposal File and Associated Records." Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

An agency may not conduct or sponsor, and a person is not required to respond to, an information collection unless it displays a valid Office of Management and Budget (OMB) control number. The OMB control number for this collection is 3145-0058. Public reporting burden for this collection of information is estimated to average 120 hours per response, including the time for reviewing instructions. Send comments regarding the burden estimate and any other aspect of this collection of information, including suggestions for reducing this burden, to:

Suzanne H. Plimpton
Reports Clearance Officer
Office of the General Counsel
National Science Foundation
Alexandria, VA 22314

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National Science Foundation, 2415 Eisenhower Avenue, Alexandria, Virginia 22314, USA
Tel: (703) 292-5111, FIRS: (800) 877-8339 | TDD: (703) 292-5090 or (800) 281-8749

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