Organismal Response to Climate Change (ORCC)

Expanding Understanding and Improving Predictions of Life on a Warming Planet

PROGRAM SOLICITATION
NSF 22-513

REPLACES DOCUMENT(S):
NSF 20-044, NSF 21-034

National Science Foundation

Directorate for Biological Sciences
Division of Integrative Organismal Systems
Division of Environmental Biology

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

March 01, 2022

November 15, 2022

Third Tuesday in November, Annually Thereafter

IMPORTANT INFORMATION AND REVISION NOTES

This solicitation replaces the pair of Dear Colleague Letters (DCL) focused on **I**ntegrating **M**echanisms of **A**daptation with **G**enes **i**n **N**etworks and across **E**nvironments (**IMAGiNE**). DCL NSF 20-044 (***IMAGiNE: 2020: Organisms in a Dynamic Environment***) was issued to encourage submission of proposals that addressed how organism-environment interactions determine the emergence of **complex traits**. A second DCL NSF 21-034 (***IMAGiNE FG: Functional Genomics***) extended the **IMAGiNE** theme to encourage research on the organismal mechanisms, analytical frameworks, and biological theories that advance our understanding of the connection between an organism's genome and its phenotype. This solicitation replaces the two IMAGiNE DCLs and focuses on the synthetic integration of organismal mechanism and eco-evolutionary approaches and models in order to improve our understanding and ability to predict and manage organismal responses to changing climates.

Important Information

Innovating and migrating proposal preparation and submission capabilities from FastLane to Research.gov is part of the ongoing NSF information technology modernization efforts, as described in Important Notice No. 147. In support of these efforts, proposals submitted in response to this program solicitation must be prepared and submitted via Research.gov or via Grants.gov and may not be prepared or submitted via FastLane.

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 22-1), which is effective for proposals submitted, or due, on or after October 4, 2021.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Organismal Response to Climate Change (ORCC)
Expanding Understanding and Improving Predictions of Life on a Warming Planet

Synopsis of Program:

The world is currently undergoing unprecedented changes in global climates across all biomes, with effects on nearly every life-form. How organisms respond to these rapidly changing conditions will have large consequences for the distribution of species over space and time, the integrity and the composition of natural communities, the distribution and the yield of domesticated crops and animals, and the incidence and the severity of pathogen outbreaks. Consequences such as these are already having major impacts on the world's food security, the bioeconomy, and the ecosystem services provided by living systems to humans. Developing a comprehensive understanding of the mechanistic underpinnings of organismal response to climate change will improve our ability to predict and to mitigate maladaptive biological responses to rapidly changing environments and to facilitate organismal adaptation and persistence. Most climate change studies to date have lacked integration between the study of organismal mechanisms involved in the response to changing climates and eco-evolutionary approaches. This solicitation calls for proposals that integrate the study of genomic, physiological, structural, developmental, neural, or behavioral mechanisms of **o**rganismal **r**esponse to **c**limate **c**hange (ORCC) with eco-evolutionary approaches to better manage the effects of

a rapidly changing climate on earth's living systems. Specific areas of emphasis include but **are not limited to**: integrating physiology and genomics into the next generation of species distribution models; mechanistic understanding of plastic responses to climate change; functional genomics of organismal response to climate change; the role biological interactions play in organismal responses to climate change; and improving our ability to predict how organisms will respond to climate change and the consequences these responses will have across biological scales.

Proposals to the ORCC Solicitation are encouraged that build on NSF's investment in growing convergence research by developing integrative, cross-disciplinary approaches that examine the organismal mechanisms that underlie adaptive and maladaptive responses to environmental factors associated with climate change, how these responses affect fitness in changing and/or novel climates, and the genetic and evolutionary processes through which these traits originate, persist, and are transmitted across generations. Further, this solicitation encourages creative approaches to translate results of these investigations to better predict and manage effects of climate change on organisms across spatial and temporal scales and biological hierarchies. Proposals that do not bridge disciplinary components, that lack a specific focus on organismal responses to climate change, that do not relate mechanistic insights to eco-evolutionary consequences above the level of the individual, and that could normally be submitted to the "core" or special programs in IOS or DEB are not appropriate for submission to this solicitation. Please contact a cognizant program officer if you have questions about where your planned proposal fits.

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.

- Irwin Forseth, telephone: (703) 292-7862, email: iforseth@nsf.gov
- Theodore J. Morgan, telephone: (703) 292-7868, email: tmorgan@nsf.gov
- Courtney E. Jahn, telephone: (703) 292-7746, email: cjahn@nsf.gov
- Douglas K. Abbot, telephone: (703) 292-7820, email: dabbot@nsf.gov
- Christopher Balakrishnan, telephone: (703) 292-2331, email: cbalakri@nsf.gov

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

- 47.074 --- Biological Sciences

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 6 to 10

IOS anticipates making 6-10, depending on the availability of funds.

Anticipated Funding Amount: $10,000,000

Pending availability of funds, a minimum of $10,000,000 is anticipated to be available for awards in FY2022.

Eligibility Information

Who May Submit Proposals:

The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG), Chapter I.E. Unaffiliated individuals are not eligible to submit proposals in response to this solicitation.

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:

There are no restrictions or limits.

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 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:**

  Not Applicable

C. Due Dates

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

  March 01, 2022

  November 15, 2022

  Third Tuesday in November, Annually Thereafter

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:

Standard NSF award conditions apply.

Reporting Requirements:

Standard NSF reporting requirements apply.

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I. INTRODUCTION

Nearly every life-form across earth's terrestrial and aquatic biomes is experiencing rapid and dramatic changes in their biotic and abiotic environments. These dynamic conditions have resulted in many organisms experiencing conditions outside of their climatic tolerances, with effects on their growth, reproduction,

survival, and distribution. Studies over the last several decades have documented changes in the distribution, phenology, abundance, and rates of extinction of natural populations and species in response to changing climate, as well as changes in agricultural yields and ecosystem services supplied to human populations. Other studies have identified physiological and genetic mechanisms underlying organismal response to environmental stressors, but not always in the context of climate change. In response to the need to better understand the interaction between genetic and environmental variation in producing adaptive organismal phenotypes, the Division of Integrative Organismal Systems (IOS) established a thematic research focus in 2020 entitled **I**ntegrating **M**echanisms of **A**daptation with **G**enes **i**n **N**etworks and across **E**nvironments (**IMAGiNE**). A Dear Colleague Letter (DCL), DCL NSF 20-044 (***IMAGiNE: 2020: Organisms in a Dynamic Environment***) was issued that encouraged submission of proposals addressing how organism-environment interactions determine the emergence of complex traits. A second DCL NSF 21-034 (***IMAGiNE FG: Functional Genomics***) extended the **IMAGiNE** theme to encourage research on the organismal mechanisms, analytical frameworks, and biological theories that advance our understanding of the connection between an organism's genotype and its phenotype. This solicitation replaces those two DCLs and focuses the IMAGiNE theme on the synthetic integration of mechanistic and eco-evolutionary approaches and models to improve our understanding and ability to predict organismal responses to changing climates.

The Directorate for Biological Sciences is particularly interested in increasing the participation of underrepresented groups[1] in biological research and education, such as women, persons with disabilities, and underrepresented minorities, and of those from geographically underrepresented areas in science, technology, engineering, and mathematics (STEM). Proposals submitted in response to this solicitation are strongly encouraged to involve PIs, co-PIs, postdoctoral fellows, students, and other personnel who are members of these groups. Proposers are also strongly encouraged to consider involving veterans of the U.S. Armed Forces as part of NSF's broader effort to promote veteran involvement in STEM research and education[2].

[1] https://ncses.nsf.gov/pubs/nsf19304/digest/introduction

[2] https://www.nsf.gov/od/oia/activities/ceose/reports/2017-2018-ceose-biennial-report-508.pdf

II. PROGRAM DESCRIPTION

The goal of this solicitation is to invite mechanistic studies of **o**rganismal **r**esponse to **c**limate **c**hange (ORCC) as a **foundation** that, when integrated with research at other levels of organization, will lead to a deeper understanding and **better predictions** of the integrity, the resilience, and the adaptation of biological systems to climate change. Proposals are encouraged to include collaborative teams with an overarching goal of using approaches across biological disciplines to anticipate more accurately adaptive and maladaptive organismal responses to future and novel environmental conditions. All aspects of organismal response associated with global climate change are open for consideration, but proposals should integrate developmental, physiological, neural, behavioral, or genomic mechanisms of organismal response with eco-evolutionary approaches to be generalizable across temporal, geographic, and/or biological scales. Competitive proposals will describe how the incorporation of mechanistic insights at the organismal level can increase understanding of persistence, dynamics, resilience and/or resistance of organisms to climate change. Research catalyzed by this solicitation should also aim to translate the results in ways that address societal challenges arising from climate change, including but not limited to assisted migration, resource and agricultural systems management, food security, management of disease and pest outbreaks, conservation, and maintenance of ecosystem services. Proposals that lack a specific focus on mechanistic responses to climate change, do not bridge disciplinary components, and could normally be submitted to the "core" or special programs of IOS or DEB are not appropriate for submission to this solicitation. Please contact a cognizant program officer if you have questions about where your planned proposal fits.

Areas of emphasis within this solicitation

We list below, but do not limit, areas of emphasis that may form the foci of proposals submitted to this solicitation. Proposals may be centered around any one or a combination of these areas, although other investigator-inspired topics may also be appropriate. Competitive projects are expected to develop causal frameworks and to employ experimental, theoretical, and/or computational approaches to increase understanding of organismal responses to climate change. Competitive proposals are anticipated to have strong plans for assessing success and impact of proposed activities. Additionally, competitive proposals should lead to generalizable concepts that can be applied to systems beyond the organism(s) under study.

Developing the next generation of species distribution models

Multiple species distribution models (SDM) have been developed to describe and predict species responses to future climates. However, SDMs that correlate climatic variables with current distributions to predict future distributions face challenges in accounting for proximal mechanisms organisms have evolved in response to climate variables, intra-specific variation in those mechanisms, local adaptation, gene flow, phenotypic plasticity, and the genetic potential for rapid evolutionary change. This area of emphasis encourages proposals to integrate and synthesize diverse mechanistic, physiological, genetic, genomic, and ecological data to develop predictive eco-evolutionary projections for populations and species in changing climates. These models may serve as tools to develop informed strategies for natural resource management, conservation, improved food security, management of pest or disease epidemics, and/or ecosystem services as climate changes.

Mechanistic understanding of plastic responses to climate change

All organisms express the capacity to produce different phenotypes in response to different environments. However, predicting how plasticity contributes to the organismal and population-level responses to environmental change, and the relative contributions of genetic and phenotypic variation in population persistence, remains an unsolved challenge. This area of emphasis calls for proposals that focus on mechanistic approaches that describe the proximate parts and processes that underlie phenotypic plasticity, with the goal of understanding general patterns of plasticity, their genetic basis, and their role in organismal response to climate change. These studies could be at any level of organismal analysis, such as biochemical, genomic, epigenomic, cellular, developmental, physiological, neural, or behavioral, and could encompass spatial, temporal, and phylogenetic variation in the phenotypic plasticity of organismal traits.

Functional genomics of organismal response to climate change

This area of emphasis calls for proposals that focus on functional genomic mechanisms of response to climate variables and how these scale-up to organismal level responses and beyond. An unsolved grand challenge in biology is determining the functional integration of genetic and environmental variation in producing organismal structures, functions, and, ultimately, fitness. Here, the focus should be to investigate functional genomic mechanisms using empirical field or controlled environment studies, analytical frameworks, artificial intelligence

approaches or biological theories to advance understanding of the connection between an organism's genotype and its phenotype in changing climates. These proposals may involve collaborators with expertise at other levels of organization to enable scaling across biological heirarchies or to bridge ecological and evolutionary approaches.

Improving predictive power in nature

The focus of this area of emphasis is to increase the ecological realism of studies and thereby improve understanding of organismal response to multiple, simultaneous environmental variables associated with climate change. The overall goal of such proposals should be more accurate predictions of biological responses to multiple stresses and the interactions among these stresses. Results are expected to improve risk assessment of how climate change threatens organisms, increase the accuracy of predictions of organismal range expansion or contraction, and improve prediction of potential impacts on food security, biodiversity, or ecosystem services. Proposals should go beyond predictions from a single trait or single environmental variable, and should integrate mechanistic information with ecological complexity across spatial, taxonomic, or temporal scales to achieve improved predictive power. Although these proposals must have organismal traits as their core focus, they should also involve ecological, genetic, and/or evolutionary components. These proposals may involve modeling and computational approaches to achieve the desired scaling-up.

Role of interactions in organismal response to climate change

Intra- and inter-specific interactions, such as those between mates, parents and offspring, competitors, predators and prey, hosts and parasites, or mutualists can result in both antagonistic and synergistic effects on organismal responses to climate change. Changes in interactions may disrupt entire biological systems and result in the formation of new species ranges, changes in phenology, or local extinction of populations in response to changing climate. Predicting how intra- and inter-species relationships will respond to climate change involves understanding not only each organism's response to the environment but also requires a fundamental understanding of the proximal mechanisms underlying cooperative or antagonistic interactions. Therefore, competitive proposals would focus on the mechanistic bases (biochemical, genetic, physiological, neural, or behavioral) behind the interactions and on how climate change-generated environmental variables affect these mechanisms and, ultimately, the outcome of the interactions.

Types of Proposals Accepted by this Solicitation

Research proposals focused on incorporating mechanistic insights **at the organismal level to** increase understanding and the ability to accurately predict persistence, dynamics, resilience, and resistance of organisms to climate change. Competitive proposals should include explanations for how the findings obtained with the particular study system are generalizable to other systems and relevant to societal concerns generated by climate change, such as conservation, biodiversity, resource management, food security, disease and pest outbreaks, or maintenance of ecosystem services. Leveraging publicly available data generated by continental-scale environmental monitoring platforms such as, but not limited to, the National Ecological Observatory Network (NEON) and the Ocean Observatories Initiative (OOI) is encouraged.

Research Coordination Network (RCN) proposals to build collaborative networks of scientists in diverse disciplines to coordinate, expand, and synthesize research on the causal bases of genetic, developmental, neural, physiological, behavioral, or ecological responses to climate change. Highest priority will be given to RCNs that bring together researchers bridging experimental, ecological, computational, and '-omic' expertise from diverse experimental systems. Competitive proposals would include experts in applied fields, such as agriculture, forestry, conservation, and natural resource management. Please note that RCN proposals must be submitted by the deadline specified in this solicitation. Proposers should contact a program officer prior to submission to discuss their ideas. For general guidance about preparing RCN proposals, please consult the RCN program page.

Workshop and Conference proposals that bring together teams of scientists bridging experimental, ecological, computational, and '-omic' expertise to address research bottlenecks in climate change studies. For example, conference topics might include: What types of resources, including computational expertise and cyber-infrastructure, will the research community need to best incorporate organismal mechanisms into predictive models of the response of living systems to climate change? What metrics should be used to determine the most critical species/habitats/ecosystems for research? How will future research efforts in this area ensure that individuals and groups who are under-represented in the biological sciences are included? In what ways will recruitment, training, and mentoring of early-career individuals aid in the development of integrative approaches to climate change research in the future? Conference activities and any resulting outcomes reports should be designed to advance integrative, synthetic research that incorporates mechanistic studies of organismal response to climate change and aims to improve the ability to foresee and prepare for adaptive and maladaptive responses of biological systems to climate change. Please note that conference proposals may be submitted anytime during the year and reviewed accordingly. Proposers should contact a program officer prior to submission to discuss their ideas. For general guidance about conferences, follow the PAPPG guidance for preparing Conference Proposals (PAPPG II.E.9).

III. AWARD INFORMATION

Anticipated Type of Award: Continuing Grant or Standard Grant

Estimated Number of Awards: 6 to 10

IOS anticipates making 6-10, depending on the availability of funds.

Anticipated Funding Amount: $10,000,000

Pending availability of funds, a minimum of $10,000,000 is anticipated to be available for awards in FY2022.

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:

The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG), Chapter I.E. Unaffiliated individuals are not eligible to submit proposals in response to this solicitation.

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:

There are no restrictions or limits.

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 Research.gov or Grants.gov.

- 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 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.

Proposal titles should be prefaced by "ORCC:" for ease of identification. Proposals for RCNs should be prepared and submitted consistent with the guidelines in the RCN solicitation, with the proposal title prefaced with "RCN: ORCC:". Researchers are strongly encouraged to consult with ORCC Program Officers as they are developing their proposals.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

C. Due Dates

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

  March 01, 2022

  November 15, 2022

  Third Tuesday in November, Annually Thereafter

D. Research.gov/Grants.gov Requirements

For Proposals Submitted Via Research.gov:

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 Research.gov user support, call the Research.gov Help Desk at 1-800-673-6188 or e-mail rgov@nsf.gov. The Research.gov Help Desk answers general technical questions related to the use of the Research.gov system. 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 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 other underrepresented groups 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 two NSB-approved merit review criteria, reviewers will be asked to evaluate the following solicitation-specific criteria:

1. Does the proposal describe an **overarching question** that is addressed through integrative, hypothesis-driven research aimed at expanding knowledge and understanding of the mechanisms of response of organisms to climate change and improving predictions of life on a changing planet?

2. Does the proposal describe how mechanistic insights at the organismal level can be integrated with eco-evolutionary approaches to produce **synergistic** (i.e., greater than the sum of the individual parts) research outcomes and lead to novel, unexpected, or major advances in understanding of biological responses to climate change?

3. Do the broader impacts describe a **plan or a predictive framework** for how the research outcomes can be used to address societal challenges in dealing with climate change?

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.

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:

- Irwin Forseth, telephone: (703) 292-7862, email: iforseth@nsf.gov
- Theodore J. Morgan, telephone: (703) 292-7868, email: tmorgan@nsf.gov

Courtney E. Jahn, telephone: (703) 292-7746, email: cjahn@nsf.gov
- Douglas K. Abbot, telephone: (703) 292-7820, email: dabbot@nsf.gov
- Christopher Balakrishnan, telephone: (703) 292-2331, email: cbalakri@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 (FASED) 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:

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