Reproducible Cells and Organoids via Directed-Differentiation Encoding (RECODE)

PROGRAM SOLICITATION
NSF 20-541

National Science Foundation

Directorate for Engineering
Division of Chemical, Bioengineering, Environmental and Transport Systems

Letter of Intent Due Date(s) ***(required)*** (due by 5 p.m. submitter's local time):

March 02, 2020

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

May 14, 2020

IMPORTANT INFORMATION AND REVISION NOTES

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:

Reproducible Cells and Organoids via Directed- Differentiation Encoding (RECODE)

Synopsis of Program:

The National Science Foundation (NSF) Division of Chemical, Bioengineering, Environmental and Transport Systems (CBET), seeks proposals that elucidate mechanisms of, and develop strategies to, direct the differentiation of undifferentiated cells into mature, functional cells or organoids. Projects responsive to this solicitation must aim to establish a robust and reproducible set of differentiation design rules, predictive models, real-time sensing, control, and quality assurance methods, and integrate them into a workable differentiation strategy. They must develop a fundamental understanding of how cells develop, including mechanisms, molecular machinery, dynamics, and cell-cell interactions, and use this understanding to manipulate cells purposefully. Investigators can choose any undifferentiated cell type, from any animal species, as a starting point and choose any appropriate functional product (cell, organoid, etc.) with real-world relevance. This solicitation parallels NSF's investment in *Understanding the Rules of Life (URoL): Predicting Phenotype*, NSF's Big Idea focused on predicting the set of observable characteristics (phenotype) of an organism based on its genetic makeup and the nature of its environment and applies it to understanding and accomplishing the intentional and guided differentiation of an undifferentiated cell into cells, organoids or tissues with predetermined activities and functions.

The process of differentiation involves a multiplex combination of signaling molecules, receptors, promoters, markers, and regulators that dynamically interact to direct cell development and behavior. While individual inducers of native differentiation have been identified and employed to create specialized cell types, we still cannot engineer stem cells to allow for synthetic induction of differentiation along a predetermined path that can be actively monitored and manipulated on-the-fly. Such control of differentiation will enable the realization of individualized medicine in areas such as regenerative medicine, cancer treatment with engineered killer cells, the development of functional cells and tissues to treat disease, environmental control and monitoring, adaptive sensing, as well as the scalable and reproducible application of 3D organoids in drug testing.

The convergence of many disciplines is necessary to answer the fundamental questions and devise the tools needed to realize truly deterministic cell induction and differentiation strategies. As such, investigators are encouraged to form interdisciplinary teams with expertise in developmental biology, stem cell biology, cell biology, engineering, synthetic and systems biology, computation, sensing, and physics. Proposals will not be responsive to this solicitation if they address only one aspect of the differentiation process or aim to create a functional living product without improving our understanding of the mechanisms that underlie developmental processes. Collaborative proposals, of a duration up to 4 years, with budgets between $1,000,000 to $1,500,000 **total** will be considered. Proposed budgets must be justified by project scope and need for complementary expertise. The solicitation will support teams of three or more

PI/co-PIs and senior personnel. Proposals with only one PI or one PI with one other senior personnel are not permitted. Reflecting the need for thoughtful collaboration and planning required for these projects, Letters of Intent are required to be submitted prior to submission of a full proposal.

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.

- Steven W. Peretti, telephone: (703) 292-7029, email: speretti@nsf.gov
- Aleksandr L. Simonian, telephone: (703) 292-2191, email: asimonia@nsf.gov
- Leon Esterowitz, telephone: (703) 292-7942, email: lesterow@nsf.gov
- Steven M. Zehnder, telephone: (703) 292-7014, email: szehnder@nsf.gov

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

- 47.041 --- Engineering

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 4 to 5

Anticipated Funding Amount: $5,000,000

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

Principal Investigators (PI) must be at the faculty level, tenured or tenure-track, as determined by the submitting organization.

If the proposal is submitted by a non-profit, non-academic organization, the lead PI must meet all of the following requirements: (1) the PI has a continuing appointment that is expected to last for the duration of a RECODE grant; (2) the appointment has substantial research responsibilities; and (3) the proposed project related to the PI's job responsibilities as well as to the mission of the department or organization. In addition, a minimum of two collaborating Senior Personnel (e.g. co-PIs, Collaborating PIs) must participate. At least one member of the project team (PI or co-PI) must have a full-time, tenured or tenure-track faculty appointment within a College/Department of Engineering.

Investigators at federal agencies and federally funded research and development centers (FFRDCs) may participate only as unpaid collaborators. FFRDC and federal agency scientists cannot serve as lead PI to be eligible for NSF funding. Non-NSF sponsored FFRDCs are required to provide a letter of support from their agency.

For cooperative projects involving U.S. and foreign organizations, support will only be provided for the U.S. portion. Researchers from a foreign organization cannot be PIs OR co-PIs, and must be listed as "non-funded Senior Personnel." Researchers from a foreign organization cannot be supported by subawards. A letter of collaboration from their organization is required.

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 investigator may only be a PI, Co-PI, or other Senior Personnel on one RECODE proposal. Please be advised that if an individual's name appears, in any of the above-mentioned capacities, on more than ONE proposal, all submittals after the first proposal (based on time-stamp) will be returned without review. No exceptions will be made.

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- **Letters of Intent:** Submission of Letters of Intent is required. Please see the full text of this solicitation for further information.
- **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 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

- **Letter of Intent Due Date(s) *(required)*** (due by 5 p.m. submitter's local time):

  March 02, 2020

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

  May 14, 2020

Proposal Review Information Criteria

Merit Review Criteria:

National Science Board approved criteria apply.

Award Administration Information

Award Conditions:

Standard NSF award conditions apply.

Reporting Requirements:

Standard NSF reporting requirements apply.

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I. INTRODUCTION

Stem cells offer tremendous potential for the alleviation and possible cure of many diseases caused by cellular or tissue malfunctions arising from trauma or genetic dysfunction. It is critical that differentiation be directed to a desired endpoint, whether that be a functioning differentiated cell, organoid, or tissue. The National Academies of Science, Engineering and Medicine, published a report in 2017 entitled “Navigating the Manufacturing Process and Ensuring the Quality of Regenerative Medicine Therapies: Proceedings of a Workshop”. This report indicated that reproducibility is a critical attribute when developing cell-based therapies, and that we currently do not have sufficient fundamental knowledge of cell activity to reliably produce cells with consistent efficacy. The report also highlighted the need to identify appropriate markers of efficacy and develop sensors capable of tracking those markers during manufacturing. While the focus of that workshop was manufacture of Chimeric Antigen Receptor (CAR) T cells specifically, the same requirements and gaps hold true for therapies involving induction of stem cells and are further complicated by the complexity inherent in the differentiation process. While individual researchers are beginning to address these issues for different stem cells and end points, there is not a connected community of researchers looking at the entire range of questions that would be necessary to answer to develop strategies to reproducibly generate stem cell derived products.

The Reproducible Cells and Organoids via Directed Differentiation Encoding (RECODE) solicitation seeks proposals that elucidate mechanisms and develop strategies for directed differentiation from undifferentiated cells to mature functional cells or organoids with specified activity. This solicitation parallels NSF’s investment in *Understanding the Rules of Life (URoL): Predicting Phenotype*, NSF’s Big Idea focused on predicting the set of observable characteristics (phenotype) of an organism based on its genetic makeup and the nature of its environment and applies it to understanding and accomplishing the intentional and guided differentiation of an undifferentiated cell into cells, organoids or tissues with predetermined activities and functions. This program is an integration and extension of the activities supported by the Engineering Biology and Health Cluster within CBET to involve cross-directorate programs that share an interest in understanding and directing cell differentiation mechanisms.

II. PROGRAM DESCRIPTION

The RECODE solicitation will support activities that substantially advance our capability to direct cell differentiation to a specific endpoint through the integration of synthetic biology, advanced sensing technologies, and cellular and tissue modeling. The proposed research should go well beyond that typically supported by a single core program in the Engineering Biology and Health cluster of CBET. A key objective of this solicitation is to encourage sustained collaboration among the diverse fields of engineering, biology, and physics necessary to develop a holistic differentiation control framework. To that end, proposed research submitted in response to this solicitation is expected to bridge the topics supported by the Division of Chemical, Biological, Environmental, and Transport Systems, Engineering Biology and Health programs. Proposals are expected to be submitted by multidisciplinary-teams of no less than three investigators.

To achieve the above goal, the RECODE solicitation will support projects that address several aspects of the directed differentiation process from a Design-Build-Test-Learn perspective. It is expected that such projects will, of necessity, leverage the expertise and tools relevant to the multiple facets of molecular sensing, signal cascades and regulations, synthetic biology, multi-scale modeling, and tissue or organoid formation. Understanding dynamics, sensing, and control at the reactor level, as well as addressing the social science aspects of designer organoids and cells may also be appropriate for specific projects. Successful proposals will indicate a holistic approach to the problem that exploits the strengths of an interdisciplinary team of researchers.

Topics that reside clearly within the boundaries of a single NSF core program are outside of the scope of this solicitation. Specifically, projects centered around the exploration of individual stages/mechanisms of differentiation in isolation or production of engineered cells, tissues, organ-on-a-chip systems, or organoids without developing an understanding of differentiation rules are not responsive to this solicitation. While such projects may have value, they are more appropriately supported by core programs in CBET and other Divisions at NSF.

III. AWARD INFORMATION

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 4 to 5

Anticipated Funding Amount: $5,000,000

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:

Principal Investigators (PI) must be at the faculty level, tenured or tenure-track, as determined by the submitting organization.

If the proposal is submitted by a non-profit, non-academic organization, the lead PI must meet all of the following requirements: (1) the PI has a continuing appointment that is expected to last for the duration of a RECODE grant; (2) the appointment has substantial research responsibilities; and (3) the proposed project related to the PI's job responsibilities as well as to the mission of the department or organization. In addition, a minimum of two collaborating Senior Personnel (e.g. co-PIs, Collaborating PIs) must participate. At least one member of the project team (PI or co-PI) must have a full-time, tenured or tenure-track faculty appointment within a College/Department of Engineering.

Investigators at federal agencies and federally funded research and development centers (FFRDCs) may participate only as unpaid collaborators. FFRDC and federal agency scientists cannot serve as lead PI to be eligible for NSF funding. Non-NSF sponsored FFRDCs are required to provide a letter of support from their agency.

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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 investigator may only be a PI, Co-PI, or other Senior Personnel on one RECODE proposal. Please be advised that if an individual's name appears, in any of the above-mentioned capacities, on more than ONE proposal, all submittals after the first proposal (based on time-stamp) will be returned without review. No exceptions will be made.

Additional Eligibility Info:

The solicitation will support teams of three or more PI/Co-PIs and senior personnel. Proposals with only one PI or one PI with one other senior personnel are not permitted. Personnel are strongly encouraged to have complimentary expertise in engineering, computation, life science, and physical sciences.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Letters of Intent *(required)*:

A one-page Letter of Intent is required. The letter should be submitted via FastLane no later than the deadline date specified in this solicitation. The subject heading of the letter should include a brief title of the proposal and the name of the lead organization. Each letter must include the following:

The Title - Title of the RECODE proposal. The title must begin with the words "RECODE:" .

The Team - List names, departments, organizational affiliation, and expertise of the Principal Investigator and Co Principal Investigators/Other Senior Personnel.

The Synopsis - Brief description of the specific goals and aims of the proposal (maximum 250 words).

These letters of intent are not used as pre-approval mechanisms for the submission of a full proposal and no feedback is provided to submitters. However, letters of intent are required for all submitted full proposals to this solicitation. The letters of intent are used to assess the overall response to the solicitation. They help NSF anticipate review requirements for full proposals. For more information on letters of intent, please review the NSF Proposal & Award Policies & Procedures Guide (PAPPG).

Letter of Intent Preparation Instructions:

When submitting a Letter of Intent through FastLane in response to this Program Solicitation please note the conditions outlined below:

- Submission by an Authorized Organizational Representative (AOR) is required when submitting Letters of Intent.

- A Minimum of 2 and Maximum of 4 Other Senior Project Personnel are permitted
- Submission of multiple Letters of Intent is not permitted

Full Proposal Preparation Instructions: Proposers may opt to submit proposals in response to this Program Solicitation via FastLane 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 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 the NSF FastLane system. 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.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

C. Due Dates

- **Letter of Intent Due Date(s)** ***(required)*** (due by 5 p.m. submitter's local time):

  March 02, 2020

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

  May 14, 2020

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.

B. Review and Selection Process

Proposals submitted in response to this program solicitation will be reviewed by 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:

- Steven W. Peretti, telephone: (703) 292-7029, email: speretti@nsf.gov
- Aleksandr L. Simonian, telephone: (703) 292-2191, email: asimonia@nsf.gov
- Leon Esterowitz, telephone: (703) 292-7942, email: lesterow@nsf.gov
- Steven M. Zehnder, telephone: (703) 292-7014, email: szehnder@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) 292-7827
- **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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Reports Clearance Officer
Office of the General Counsel
National Science Foundation
Alexandria, VA 22314