Archived funding opportunity

This solicitation is archived.

NSF 24-508: Emerging Frontiers in Research and Innovation (EFRI-2024/25)

Biocomputing through EnGINeering Organoid Intelligence (BEGIN OI)

Program Solicitation

Document Information

Document History

- **Posted:** November 16, 2023
- **Replaces:** NSF 21-615

View the program page

National Science Foundation
Directorate for Engineering
Emerging Frontiers and Multidisciplinary Activities
Directorate for Biological Sciences
Directorate for Computer and Information Science and Engineering
Directorate for Mathematical and Physical Sciences
Directorate for Social, Behavioral and Economic Sciences

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

January 17, 2024

September 12, 2024

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

February 22, 2024

December 12, 2024

Table Of Contents

Important Information And Revision Notes

Please note that the FY 2024/25 EFRI solicitation differs from previous EFRI solicitations in not requiring submission of preliminary proposals. Consequently, the deadline for full proposal submission is significantly earlier than for past solicitations.

Emerging Frontiers in Research and Innovation (EFRI-2024/25) Biocomputing through EnGINeering Organoid Intelligence (BEGIN OI) participates in the NSF-U.S. Binational Science Foundation (BSF) lead agency opportunity. For details, please refer to NSF 20-094 (or future versions replacing it)

Proposals may optionally include requests for cloud computing resources through an external cloud access entity, https://cloudbank.org, supported by NSF's Enabling Access to Cloud Computing Resources for CISE Research and Education (Cloud Access) Program.

Any proposal submitted in response to this solicitation should be submitted in accordance with the *NSF Proposal &*

Award Policies & Procedures Guide (PAPPG) that is in effect for the relevant due date to which the proposal is being submitted. The NSF PAPPG is regularly revised and it is the responsibility of the proposer to ensure that the proposal meets the requirements specified in this solicitation and the applicable version of the PAPPG. Submitting a proposal prior to a specified deadline does not negate this requirement.

Summary Of Program Requirements

General Information

Program Title:

EMERGING FRONTIERS IN RESEARCH AND INNOVATION (EFRI): Biocomputing through EnGINeering Organoid Intelligence (BEGIN OI)

Synopsis of Program:

The Emerging Frontiers in Research and Innovation (EFRI) program of the NSF Directorate for Engineering (ENG) serves a critical role in helping ENG focus on important emerging areas in a timely manner. The EFRI Biocomputing through EnGINeering Organoid Intelligence (BEGIN OI) solicitation supports foundational and transformative research to advance the design, engineering, and fabrication of organoid systems that are capable of processing information dynamically while interfacing with non-living systems.

This solicitation will be coordinated with the Directorate for Biological Sciences (BIO), the Directorate for Computer and Information Science and Engineering (CISE), the Directorate for Mathematical and Physical Sciences, and the Directorate for Social, Behavioral, and Economic Sciences (SBE).

The EFRI program seeks proposals with potentially transformative ideas that represent an opportunity for a significant shift in fundamental engineering knowledge with strong potential for long term impact on national needs or a grand challenge. The proposals must also meet the detailed requirements delineated in this solicitation.

INFORMATIONAL WEBINAR: The Emerging Frontiers and Multidisciplinary Activities (EFMA) Office will host an informational webinar in November 2023 to discuss the EFRI FY 2024/25 solicitation and to answer questions. Details on how to join this webinar will be posted on the EFRI website and Solicitation Website.

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.

- Sohi Rastegar, Office Head, ENG/EFMA, telephone: (703) 292-8305, email: srastega@nsf.gov
- Alias Smith, ENG/EFMA, telephone: (703) 292-8367, email: alismith@nsf.gov
- BEGIN OI - Topic Lead, Steven W. Peretti, ENG/CBET, telephone: (703) 292 7029, email: speretti@nsf.gov
- BEGIN OI - Topic Lead, Svetlana Tatic-Lucic, ENG/ECCS, telephone: (703) 292-4627, email: staticlu@nsf.gov
- Edda Thiels, BIO/IOS, telephone: (703) 292-8421, email: ethiels@nsf.gov
- Kenneth C. Whang, CISE/IIS, telephone: (703) 292-5149, email: kwhang@nsf.gov

- Vishal Sharma, CISE/CNS, telephone: (703) 292-8950, email: vsharma@nsf.gov
- Jordan M. Berg, ENG/CMMI, telephone: (703) 292-5365, email: jberg@nsf.gov
- Steven M. Zehnder, ENG/CBET, telephone: (703) 292-7014, email: szehnder@nsf.gov
- Krastan B. Blagoev, MPS/PHY, telephone: (703) 292-4666, email: kblagoev@nsf.gov
- Jason D. Borenstein, SBE/OAD, telephone: (703) 292-4207, email: jborenst@nsf.gov
- Dwight Kravitz, SBE/BCS, telephone: (703) 292-4502, email: dkravitz@nsf.gov

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

- 47.041 --- Engineering
- 47.049 --- Mathematical and Physical Sciences
- 47.070 --- Computer and Information Science and Engineering
- 47.074 --- Biological Sciences
- 47.075 --- Social Behavioral and Economic Sciences

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 15

(7-8 each in FY24 and FY25; 4-year awards)

Anticipated Funding Amount: $30,000,000

$15,000,000 per fiscal year; Pending 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 laboratories, professional societies and similar organizations located in the U.S. that are directly associated with educational or research activities.

Who May Serve as PI:

For proposals submitted by Institutions of Higher Education, the lead Principal Investigator (PI) must be full-time, tenured or tenure-track faculty. For proposals submitted by Non-Profit, Non-Academic Organizations, the lead PI must meet all of the following requirements: (1) the PI has a

continuing appointment that is expected to last the four years of an EFRI grant; (2) the appointment has substantial research responsibilities; and (3) the proposed project relates to the PI's job responsibilities as well as to the mission of the department or organization.

A minimum of one PI and two co-PIs must participate in each proposal. Either the PI or one of the co-PIs must have a full-time, tenured or tenure-track faculty appointment within a College/Department of Engineering.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

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

Individuals may participate as either PI or co-PI in only one proposal submitted to this solicitation in a single fiscal year. It is the responsibility of the submitting organization to ensure that the PI and all co-PIs are participating only in one proposal as either PI or co-PI and not in any others submitted in response to this solicitation in a single fiscal year.

If an individual is listed as PI or co-PI on more than one proposal in response to this solicitation in a single fiscal year, all proposals in excess of the limit for any person will be returned without review in the reverse order received, based on the proposal submission time stamp on the Cover Sheet.

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 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

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

  January 17, 2024

  September 12, 2024

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

  February 22, 2024

  December 12, 2024

Proposal Review Information Criteria
Merit Review Criteria:

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

Award Administration Information
Award Conditions:

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

Reporting Requirements:

Additional reporting requirements apply. Please see the full text of this solicitation for further information.

I. Introduction

The Office of Emerging Frontiers and Multidisciplinary Activities (EFMA) in the Directorate for Engineering provides funding opportunities for interdisciplinary teams of researchers to embark on rapidly advancing frontiers of fundamental engineering research. The Emerging Frontiers in Research and Innovation program (EFRI), the signature program of the EFMA Office, seeks proposals with potentially transformative ideas that represent an opportunity for a significant shift in fundamental engineering knowledge with strong potential for long-term impact on national needs or a grand challenge. For this solicitation, EFRI will consider proposals that aim to investigate emerging frontiers in one of the following research area: Biocomputing through EnGINeering Organoid Intelligence (BEGIN OI). Proposals must meet the detailed requirements delineated in this solicitation.

Biocomputing through EnGINeering Organoid Intelligence (BEGIN OI)

Artificial intelligence and machine learning (AI/ML) technologies are becoming a ubiquitous presence in our daily lives. AI/ML is revolutionizing how we integrate information, analyze data, and make decisions. Increasingly powerful computational capabilities and accumulation of large volumes of data afford the possibility for sophisticated decision-making, but current silicon-based computation may not scale for future societal needs. Despite the extraordinary potential of AI/ML technologies, they are currently unable to achieve the computing capabilities observed in biology with respect to adaptability, continuous learning, and efficiency.

Cells and organs exhibit a high degree of responsive and adaptive behavior to develop and perform distinct functions. From building and self-organization to mediating homeostasis, biological components exhibit responsive capabilities, receiving inputs, processing, and generating outputs with a high degree of fidelity, throughput, and energy efficiency. Recent advances in understanding the biological mechanisms involved in development and learning and new computational and engineering tools lay the foundation to leverage the

capability of cells, tissues, and organoids for biological computing. These biocomputers would receive diverse and unexpected inputs and dynamically respond through communications that span multiple spatiotemporal scales and modalities - chemical, optical, mechanical, electrical, etc. Harnessing the mechanisms behind complex biological behavior is critical for the development of "smart" technologies that integrate custom 3D *in vitro*biological systems with engineered sensors and device interfaces to enable biological computing with superior power and data efficiency. The objective of EFRI Biocomputing through EnGINeering Organoid Intelligence (BEGIN OI) is to harness the novel discoveries and advancements in biological sciences, engineering, material sciences, and computer sciences toward designing 3D *in vitro* biological systems that are capable of information processing and actuation. This solicitation is interested in exploiting the concept of organoid intelligence (OI): the development of organ-like systems that problem-solve, learn, and adapt.

ENHANCING DIVERSITY IN ENGINEERING - THE BROADENING PARTICIPATION PLAN

The Directorate for Engineering (ENG) promotes diversity in all aspects of its programs. In keeping with ENG's priority to broaden the participation and inclusion of the full spectrum of diverse talents in Engineering, the Office of Emerging Frontiers and Multidisciplinary Activities (EFMA) is addressing the need to support diversity in all fields of Engineering by requiring all EFRI projects to include a Broadening Participation Plan as part of the EFRI 2024/2025 Solicitation. This requirement will not only promote diversity and inclusion in the human resources engaged in the EFRI program, but will also expand diversity of thought, ideas, impact and approaches brought together by EFRI research teams in defining and solving important research questions.

The Broadening Participation Plan must be described as part of the Broader Impacts of the proposal both in the Project Summary and in the Project Description. PIs are encouraged to focus on community building, innovative and inclusive engineering practices, advancing engineering talent, diversifying pathways to and through engineering, and addressing the equity, access, and inclusion related to the broader impact of the national and/or societal need or grand challenge addressed.

The EFMA Office encourages proposers to be creative in the planning of activities to attract and retain persons from the full spectrum of diverse talents to the fields of engineering and engineering research when developing their Broadening Participation Plans. The Plan may include, but is not limited to, any of the following menu of activities as appropriate for your project and the circumstances of your organization(s):

- RESEARCH EXPERIENCES FOR UNDERGRADUATES (REU) - A plan to apply for supplement(s) to engage undergraduate researchers, using *REU* supplement(s);
- RESEARCH EXPERIENCE AND MENTORING (EFRI-REM) - A plan to apply for post-award supplement(s) to enhance research goals through broadening the participation of emerging researchers on the EFRI research teams;
- MINORITY-SERVING INSTITUTIONS - Inclusion of faculty at minority-serving institutions (MSIs) as PI, co_PI, or senior personnel, and/or student researchers from MSIs in the research project;
- COMMUNITY COLLEGES - Engaging faculty and/or student researchers at community colleges in the research project;
- RESEARCH EXPERIENCES FOR TEACHERS (RET) - A plan to apply for post-award supplement(s) to engage teachers and/or Community College Faculty through the RET program;
- RESEARCH EXPERIENCES FOR HIGH SCHOOL STUDENTS - Providing research opportunities for members of the community at the high school level;
- RESEARCH EXPERIENCES FOR VETERANS - A plan to apply for post-award supplement(s) to engage veterans through the Research Experience and Mentoring (REM) or Veterans Research Supplement (VRS) programs;
- EXISTING INSTITUTIONAL PROGRAMS - Enhancing/collaborating with existing broadening participation at

your home organization and/or nearby organizations;

- MENTORING - Senior Personnel serving as role models and mentors for the emerging researcher population;
- K-12 OUTREACH - Outreach activities that will interest and attract K-12 students to engineering undergraduate programs.

II. Program Description

The EFRI Biocomputing through EnGINeering Organoid Intelligence (BEGIN OI) solicitation supports foundational and transformative research to advance the design, engineering, and fabrication of organoid systems that are capable of processing information dynamically while interfacing with non-living systems. EFRI BEGIN OI supports a broad interpretation of *in vitro* biological "intelligent systems" to include capture of real-world input, autonomous processing in an engineered biological construct, and generating an output that drives an engineered system. "Intelligence" and "learning" have unique meanings for different communities in biology, cognitive science, computer science, and engineering. The EFRI BEGIN OI solicitation asks investigators to define the bounds of "intelligence" and "learning" needed to achieve responsive and adaptive biological computing and control in engineered systems. In the context of this solicitation, the term "organoid" has broad meaning, capturing a range of designer three-dimensional cellular constructs, microphysiological systems, and engineered tissues. Projects may leverage organoids representative of any organ system or a consortium of organoids to achieve biological computing. Cells used to construct organoids need not be mammalian, for example deploying 3D plant cell- or biofilm-based constructs for biocomputing is allowable, and diversity of cell types is encouraged. The use of human-derived cells, including human induced pluripotent stem cells (iPSCs), is allowed. However, proposals that plan to leverage human embryonic stem cells or pursue human/non-human chimeric systems will not be supported and will be returned without review.

Realizing the vision and goals of this solicitation will require a convergent research approach that engages engineers, biologists, computer scientists, social scientists, ethicists, and others with complementary expertise to tackle challenging problems relevant to engineering smart systems driven by organoid intelligence. Integrating social scientists, ethicists, and educators in the interdisciplinary teams will be critical for addressing the associated ethical, legal, and social implications of using living systems as building blocks for bio-enabled computing. Inclusion of appropriate expertise from the Social, Behavioral, and Economic Sciences within project leadership is required. EFRI BEGIN OI projects are also envisioned as ideal platforms for innovative educational and workforce development programs, such as curriculum development and outreach activities to broaden participation of the full spectrum of diverse talents in STEM.

Research Threads:

To harness the power of biocomputing, holistic frameworks, driven by real-world applications, are needed that combine experimental, theoretical, computational, and engineering approaches while considering the ethical challenges throughout the project life cycle. With that in mind, **addressing all three of the following Threads** is critical to making significant advances in biocomputing and is required of each proposal submitted in response to this solicitation.

Research Thread 1: Biocomputing Theory and Modelling

The objective of this thread is to devise a strategy to employ organoid intelligence towards achieving biocomputing capabilities: theorizing and modeling how 3D, engineered, biology-integrated systems can express learning, memory, and signal processing. Incorporation of principles derived from experimental and theoretical studies of biological development, structure, and function are expected to be the foundation for the proposed project. Designing such engineered systems would require new computational models that describe the ability for storage and retrieval of information in a robust, stable, timely, and secure fashion, and for processing dynamic

inputs and generating adaptive outputs. Likewise, strategies to effectively interpret the complex biological outputs into meaningful signals are expected. Projects may incorporate computational approaches, including AI/ML methods, that enable novel signal processing, statistical analyses, and computation to translate inputs to the system and interpret biological responses to generate meaningful outputs.

Research Thread 2: Biology-Integrated Culture Maintenance and Hardware Systems

The objective of this thread is to physically realize the proposed biocomputing framework through design of custom organoid systems, engineering of platforms for maintenance and sensing, and integration to create organoid-based biological controllers. Teams are encouraged to develop organoids with designer physical architectures that reach beyond mimicking the structure and function of mature organs. Maintenance of the 3D organoid within the platform will require new engineering advances that enable long-term viability, as well as stable retention of tailored biological complexity and desired function *in vitro*. Integrated organoid/device platforms will encompass novel hardware strategies that allow for the sensing of dynamic inputs, monitoring of organoid response, and the delivery of output signals, each of which can span many forms of stimuli - chemical, electrical, optical, photonic, mechanical, etc. Sensing may be achieved with living (sensory organoids) or non-living components.

Research Thread 3: Ethical, Legal, and Social Implications (ELSI)

The objective of this thread is to investigate ELSI issues raised by the proposed research project. Development of engineered living systems – especially in the context of systems capable of displaying aspects of intelligence – is interwoven with ethical, legal, and social implications that are to be recognized and addressed within the proposed project. Proposals must include a plan within the project description that describes the project's ELSI research activities. The plan should identify ELSI research questions that complement the development in Threads 1 and 2. ELSI scholars must be integrated as active collaborators within the research team, helping shape research directions during the lifecycle of the project.

EFRI BEGIN OI proposals must include an ethical justification for the proposed project's focus and approach in addition to addressing Research Thread 3. The justification must include the rationale for why specific cell line(s) were selected for the research and how risks associated with cell line selection will be mitigated.

Meaningful evaluation of performance and validation are required for all three Research Threads. Teams are required to formulate quantifiable metrics that align with each of the proposed activities. These metrics should reflect considerations for advantages and disadvantages of the proposed system for technological applications and conditions, as well as the ELSI implications regarding the project's implementation.

Cloud Computing Resources

Proposals may request cloud computing resources to use public clouds such as Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure, and IBM Cloud. Cloud computing resources described in proposals may be obtained through CloudBank (CloudBank.org), an external cloud access entity supported by NSF's Enabling Access to Cloud Computing Resources for CISE Research and Education (Cloud Access). Program.

Proposers requesting cloud computing resources through CloudBank should describe the request in a Supplementary Document no longer than two pages with (a) anticipated annual and total costs for accessing the desired cloud computing resources, based on pricing currently available from the public cloud computing providers; and (b) a technical description of, and justification for, the requested cloud computing resources. The NSF Budget should not include these costs for accessing public cloud computing resources via CloudBank.org. Proposers should include "CloudAccess" (one word without space) at the end of the Overview section as a key word (before the section on Intellectual Merit) of the Project Summary page if incorporating such a request into the proposal. Proposers may contact CloudBank.org (see https://www.cloudbank.org/faq) for consultation on determining the budget estimate for using cloud computing resources.

III. Award Information

The anticipated budget for this program solicitation is $15,000,000 in FY 2024 and $15,000,000 in FY25, pending the availability of funds. Each award will be funded as a Standard Grant or Continuing Grant. The anticipated number of awards for in each fiscal year is 7-8 awards. Each project team may receive support of up to a total of $2,000,000 spread over four years. It is not expected that all awards will receive the maximum amount; the size of awards will depend upon the type of research program proposed.

If a proposal involves multiple organizations, it must be submitted as a single proposal with subawards: separately submitted collaborative proposals are not permitted.

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 laboratories, professional societies and similar organizations located in the U.S. that are directly associated with educational or research activities.

Who May Serve as PI:

For proposals submitted by Institutions of Higher Education, the lead Principal Investigator (PI) must be full-time, tenured or tenure-track faculty. For proposals submitted by Non-Profit, Non-Academic Organizations, the lead PI must meet all of the following requirements: (1) the PI has a continuing appointment that is expected to last the four years of an EFRI grant; (2) the appointment has substantial research responsibilities; and (3) the proposed project relates to the PI's job responsibilities as well as to the mission of the department or organization.

A minimum of one PI and two co-PIs must participate in each proposal. Either the PI or one of the co-PIs must have a full-time, tenured or tenure-track faculty appointment within a College/Department of Engineering.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

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

Individuals may participate as either PI or co-PI in only one proposal submitted to this solicitation in a single fiscal year. It is the responsibility of the submitting organization to ensure that the PI and all co-PIs are participating only in one proposal as either PI or co-PI and not in any others submitted in response to this solicitation in a single fiscal year.

If an individual is listed as PI or co-PI on more than one proposal in response to this solicitation in a single fiscal year, all proposals in excess of the limit for any person will be returned without review in the reverse order received, based on the proposal submission time stamp on the Cover Sheet.

Additional Eligibility Info:

As part of NSF's interest in broadening participation, we encourage proposals from Minority-Serving Institutions (e.g., Historically Black Colleges and Universities (HBCUs), Hispanic-Serving Institutions (HSIs), and Tribal Colleges and Universities (TCUs).

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 Research.gov no later than the 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:

1. THE TITLE - Title of the EFRI proposal, preceded by the words "**EFRI BEGIN OI**:" .
2. THE TEAM - Names, departmental and organizational affiliation, and expertise of the Principal Investigator and at least two co-Principal Investigators.
3. THE SYNOPSIS (GOALS) - Brief description of the specific goals of the proposal (maximum of 250 words).

These letters of intent are not used as pre-approval mechanisms for the submission of full proposals and no feedback is provided to the submitters, *however letters of intent are required for all submitted full proposals to this solicitation.* The letters of intent are not reviewed but 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 PAPPG.

Letter of Intent Preparation Instructions:

When submitting a Letter of Intent through Research.gov 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
- A Minimum of 0 and Maximum of 4

  Other Participating Organizations 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 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.

See PAPPG Chapter II.D.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 Set-Up: Select "Prepare New Full Proposal" in Research.gov. Search for and select this solicitation title in Step One of the Full Proposal wizard. In the proposal details section, select "Single proposal (with or without subawards). Separately submitted collaborative proposals will be returned without review.

Title of Proposed Project: The title for the proposed EFRI project must begin with "**EFRI BEGIN OI:"**. The title must state clearly and succinctly the major emerging frontier in research and innovation that is the focus for the project.

Project Summary (one-page limit): The Project Summary consists of an overview, a statement on the intellectual merit of the proposed activity, and a statement on the broader impacts of the proposed activity. Provide the following information:

1. In the Overview section provide the name of the PI, the lead organization, and a list of co-PIs and senior personnel together with their organizations. Proposers requesting cloud resources through CloudBank.org should include “CloudAccess” (one word without space) at the end of the Overview section (before the section on Intellectual Merit) of the Project Summary page if incorporating this request into the proposal;
2. A succinct summary of the **intellectual merit** of the proposed project. This should include the potentially transformative nature of the proposed research, and the significant leap or paradigm shift in fundamental engineering knowledge; and
3. Describe the **broader impacts** of the proposed work, including the potential long-term impact on a national need and/or grand challenge. Include a summary of your Broadening Participation Plan.

Proposals that do not separately address in the project summary both intellectual merit and broader impacts will
be returned without review.

Project Description (maximum 15 pages) must include the following subsections:

1. **Intellectual Merit**: Describe the vision and goals of the proposed research, approaches and methodologies to attain the goals, the expected outcomes, and the ethical, legal, and social implications of

the proposed research following the guidance provided in the PAPPG.

2. **Broader Impacts**: Please follow the guidance provided in the PAPPG to prepare the Broader Impacts section. The following solicitation-specific information should also be included:
    i. The Broader Impacts section should include a subsection labeled "**Key Anticipated Outcomes**" that describes how the proposed project will lead to a significant shift in fundamental engineering knowledge and will have strong long-term potential for significant impact on a national need or a grand challenge.
    ii. The Broader Impacts section should also describe ways in which education and outreach are integrated within the research program to effectively achieve societal impact. Concisely articulate unifying and integrative aspects of the proposed research as well as the innovative ideas of the research.
    iii. The Broader Impacts section must include a **Broadening Participation Plan**. The plan must aim to broaden the participation and inclusion of the full spectrum of diverse talents in Engineering. For more information see: Enhancing Diversity in Engineering at the end of Introduction, Section I. If needed, you may include additional information, up to five pages, about your Broadening Participation Plan as a Supplementary Document.
3. **Results from Prior NSF Support**: Please follow the guidance provided in the PAPPG for reporting results from prior NSF support.

References Cited: Indicate with an asterisk any cited publications that resulted from prior research funded by NSF for the PI, or co-PIs.

Budget: Develop a realistic project budget that is consistent with the proposed activities. Provide detailed budget justifications separately for the lead organization's budget and for each subawardee budget. Proposed budgets must include funds for travel by at least one PI and at least one graduate student or researcher to attend an annual EFRI grantees' meeting.

Facilities, Equipment, and Other Resources: Provide a description of available facilities and priorities for their use, if applicable. For EFRI projects requiring additional equipment, justify the need for these resources in the context of the innovative work proposed.

In the **Supplementary Documentation** section, include the following:

1. Provide a **list of key personnel** (PIs, Co-PIs, and Senior Personnel) involved (maximum three pages), including names of institutions, a description of what each person uniquely brings to the project, and a description of how their expertise will be integrated to foster synergy;
2. Provide a detailed **management plan** (maximum three pages) including means of communication, data tracking, management of personnel within the project group, management of intellectual property resulting from the project, and timeline of activities;
3. **Mechanisms for sharing the outcomes** of the research with the scientific community, e.g., publications, web sites, *etc*. (maximum two pages). The description should be specific and should describe what, how, and when the community would have access to the outcomes of the project. This is particularly important for projects that will produce tangible research tools and resources;
4. Proposals that include support for trainees such as undergraduate and graduate students must provide a **student mentoring plan** that describes the mentoring activities that will be provided for such individuals;
5. **Broadening Participation Plan** - You may include additional information, up to five pages, about the Broadening Participation Plan in the Supplementary Documentation section;
6. Proposals must include a **Data Management Plan** (maximum two pages). The data management plan

must include a description for the management, dissemination, and archiving of all digital products generated by the proposed work including data, software, and digital designs (e.g., models for 3D printers). Proposers who feel that the plan cannot fit within the limit of two pages may provide additional detail in an additional Supplementary Document; and

7. A **PowerPoint Slide** summarizing the vision of the EFRI proposal. This slide will be used during review panel discussions.
8. **Cloud Computing Resources** *(If requesting cloud computing resources through CloudBank.org)* include a description of your requests (not to exceed 2 pages) that includes: (1) title of the proposal; (2) the total cost of computing resources, with yearly breakdown; (3) which public cloud providers will be used; and (4) a technical description and justification of the request, along with how the cost was estimated.

The **Data Management Plan** should describe the management of digital assets and intellectual property rights, including plans for sharing data, code, digital designs, information, and materials resulting from the award. Data and other digital products should be identified, and the following described for each of them:

- The types of data, samples, physical collections, software, curriculum materials, and other materials to be produced in the course of the project;
- Metadata to be collected and disseminated with primary data;
- The standards to be used for data and metadata format and content;
- Policies for access and sharing including provisions for appropriate protection of privacy, confidentiality, security, intellectual property, or other rights or requirements;
- Policies and provisions for re-use, re-distribution, and the production of derivatives;
- Release considerations: Timetable, Constraints, Responsible person(s), Public repository used;
- License for use (emphasis on open source licenses such as MIT and GPL);
- All software and code must be in a versioned code repository (e.g., GitHub/BitBucket) and released immediately. Code must be well documented for others to reuse;
- Other digital products including (but not limited to) 3D models for printing, circuit boards designs, phenotyping data, image data, and machine learning models must be included in the data management plan;
- Letters of commitment (uploaded as supplementary document(s)) should be provided from databases or stock centers that agree to distribute project outcomes, including the actions planned and funds needed (if any) for the distribution; and
- In the case of a multi-organizational proposal, the lead organization is responsible for coordinating and managing the intellectual property resulting from the award.

PIs should consult with current data standardization procedures as described by public sites such as DataONE and follow the "The Fair Guiding Principles for Data Management and Stewardship" and those articulated in "Best Practices for Scientific Computing".

Pre-submission Check List:

- No principal investigator (PI) or co-principal investigator (co-PI) is listed as a principal investigator or co-principal investigator on any other EFRI proposal submitted to the EFRI solicitation in this fiscal year;
- The Lead PI or one of the project co-PIs *must* be full-time faculty within an engineering college or department;
- If the proposal has multiple organizations, it must not be submitted as a separately submitted collaborative proposal but as a single proposal with subawards;

- Proposal has a minimum number of 3 PI/co-PIs and a maximum of 5 PI/co-PIs;
- Total budget does not exceed $2,000,000 and is spread over 4 years;
- **Broadening Participation Plan:** All proposals must describe a plan (both in the Project Summary and the Project Description) that aims to broaden the participation and inclusion of the full spectrum of diverse talents in Engineering;
- **Student Mentoring Plan:** Each proposal that requests funding to support undergraduate and/or graduate researchers must include, as a supplementary document, a description of the mentoring activities that will be provided for such individuals;
- A **list of key personnel involved** (maximum three pages), with a description of what each person uniquely brings to the project is provided in the Supplementary Documents section; and
- A **PowerPoint Slide** summarizing the vision of the EFRI proposal. This slide will be used during review panel discussions.

This checklist is provided to aid in the preparation of the proposal. The burden to ensure that the proposal is complete and meets all solicitation requirements remains with the Principal Investigator.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

Budget Preparation Instructions:

The total budget of the project, including any cloud computing resource request from CloudBank.org, may not exceed the budget limits described in this solicitation. The total cost of the cloud computing resources requested from Cloudbank.org should not be included in the NSF budget, and should be specified only in the associated supplementary document described in Section V.A.

C. Due Dates

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

  January 17, 2024

  September 12, 2024

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

  February 22, 2024

  December 12, 2024

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 *Leading the World in Discovery and Innovation, STEM Talent Development and the Delivery of Benefits from Research - NSF Strategic Plan for Fiscal Years (FY) 2022 - 2026* . 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.D.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.D.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 NSF review criteria (intellectual merit and broader impacts), the following criteria will be used in the review of all EFRI proposals.

- ***THREADS*** - Does the proposal address **ALL** three Threads?

- ***TRANSFORMATIVE -*** Does the proposed research represent an opportunity for a significant leap or paradigm shift in fundamental engineering knowledge?
- ***NATIONAL NEED/GRAND CHALLENGE*** - Is there potential for making significant progress on a current national need or grand challenge?
- Responsiveness to "**Programmatic Considerations**" for **EFRI-BEGIN OI** proposals as delineated in Section II. Program Description.
- **Broadening Participation Plan** - Does the plan actively promote, increase, and enhance participation and inclusion of the full spectrum of diverse talents in Engineering?
- Effectiveness of the proposed **Management Plan**.
- **Ethical, Legal, and Social Implications (ELSI)** - Does the proposal address the ethical, legal, and social implications of the proposed research?
- **Student Mentoring Plan** - Does the proposal present a description of the mentoring activities that will be provided for supported undergraduate and graduate students?

B. Review and Selection Process

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

In developing recommendations for awards, review panels as well as NSF staff will consider: the relative merit of the EFRI proposals using the criteria listed above, the potential national impact of the proposed activity, the balance of awards among scientific fields, geographical distribution, and the combined ability of the proposals to meet the objectives of the EFRI Office. The EFRI Office will not normally award more than one proposal from any one lead institution in this competition.

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 proposers whether their proposals have been declined or recommended for funding within six months. Large or particularly complex proposals or proposals from new recipients 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 or the Division of Acquisition and Cooperative Support 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 an NSF Grants and Agreements Officer. 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.

Administrative and National Policy Requirements

Build America, Buy America

As expressed in Executive Order 14005, Ensuring the Future is Made in All of America by All of America's Workers (86 FR 7475), it is the policy of the executive branch to use terms and conditions of Federal financial assistance awards to maximize, consistent with law, the use of goods, products, and materials produced in, and services offered in, the United States.

Consistent with the requirements of the Build America, Buy America Act (Pub. L. 117-58, Division G, Title IX, Subtitle A, November 15, 2021), no funding made available through this funding opportunity may be obligated for an award unless all iron, steel, manufactured products, and construction materials used in the project are produced in the United States. For additional information, visit NSF's Build America, Buy America webpage.

Special Award Conditions:

Recipients must include in the proposal budget funds for travel by the PI and one graduate student or one researcher to attend an annual EFRI grantees' meeting. Recipients will be required to attend and present their research results and plans annually at an annual EFRI grantees' conference for the duration of their award.

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.

Additional reporting requirement

EFRI recipients who receive supplemental funding through the Research Experience and Mentoring (REM) Program must discuss the impact of the supplemental funding on increasing the participation of underrepresented groups in engineering in their annual and final project reports. Accumulated quantitative data on race, gender and disability are expected. Additional data obtained through the required evaluation should also be provided, including the impact of mentoring on research participants (RPs), and/or changes in the RPs' skill sets, understanding of science/engineering principles, attitudes towards research, and career trajectories as a result of their participation in the program. If recipients have received sequential REM supplements, longitudinal data should be provided.

Each partner organization will receive copies of annual and final reports submitted by recipients for any awards co-funded by that organization after approval by the cognizant NSF program officer.

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:

- efri2024-2025@nsf.gov – General questions about the EFRI program
- Sohi Rastegar, Office Head, ENG/EFMA, telephone: (703) 292-8305, email: srastega@nsf.gov
- Alias Smith, ENG/EFMA, telephone: (703) 292-8367, email: alismith@nsf.gov
- BEGIN OI - Topic Lead, Steven W. Peretti, ENG/CBET, telephone: (703) 292 7029, email: speretti@nsf.gov

- BEGIN OI - Topic Lead, Svetlana Tatic-Lucic, ENG/ECCS, telephone: (703) 292-4627, email: staticlu@nsf.gov
- Edda Thiels, BIO/IOS, telephone: (703) 292-8421, email: ethiels@nsf.gov
- Kenneth C. Whang, CISE/IIS, telephone: (703) 292-5149, email: kwhang@nsf.gov
- Vishal Sharma, CISE/CNS, telephone: (703) 292-8950, email: vsharma@nsf.gov
- Jordan M. Berg, ENG/CMMI, telephone: (703) 292-5365, email: jberg@nsf.gov
- Steven M. Zehnder, ENG/CBET, telephone: (703) 292-7014, email: szehnder@nsf.gov
- Krastan B. Blagoev, MPS/PHY, telephone: (703) 292-4666, email: kblagoev@nsf.gov
- Jason D. Borenstein, SBE/OAD, telephone: (703) 292-4207, email: jborenst@nsf.gov
- Dwight Kravitz, SBE/BCS, telephone: (703) 292-4502, email: dkravitz@nsf.gov

For questions related to the use of NSF systems contact:

- NSF Help Desk: 1-800-381-1532
- Research.gov Help Desk e-mail: rgov@nsf.gov
- 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.

The following Program Officers may also be contacted for content-specific questions on the EFRI BEGIN OI Topic.

Biocomputing through EnGINeering Organoid Intelligence (BEGIN OI),

- Topic Coordinator: Steven Peretti, Program Director, ENG/CBET, telephone: (703) 292-7029, email: speretti@nsf.gov
- Topic Coordinator: Svetlana Tatic-Lucic, Program Director, ENG/ECCS, telephone: (703) 292-4627, email: staticlu@nsf.gov
- Krastan Blagoev, Program Director, MPS/PHY, telephone: (703) 292-4666, email: kblagoev@nsf.gov
- Jordan Berg, Program Director, ENG/CMMI, telephone: (703) 292-5365, email: jberg@nsf.gov
- Jason Borenstein, Program Director, SBE/OAD, telephone: (703) 292-4207, email: jborenst@nsf.gov
- Dwight Kravitz, Program Director, SBE/BCS, telephone: (703) 292-4502, email dkravitz@nsf.gov
- Kenneth Whang, Program Director, CISE/IIS, telephone: (703) 292-5146, email: kwhang@nsf.gov
- Vishal Sharma, Program Director, CISE/CNS, telephone: (703) 292-8950, email: vsharma@nsf.gov
- Stephanie Gage, Program Director, CISE/CCF, telephone: (703) 292-4748, email: sgage@nsf.gov
- Edda Thiels, Program Director, BIO/IOS, telephone: (703) 292-8167, email: ethiels@nsf.gov
- Stephen Zehnder, Associate Program Director, ENG/CBET, telephone: (703) 292-7014, email: szehnder@nsf.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.F.7 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 proposers 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 proposers or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See System of Record Notices, NSF-50, "Principal Investigator/Proposal File and Associated Records," and NSF-51, "Reviewer/Proposal File and Associated Records." Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

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

Suzanne H. Plimpton
Reports Clearance Officer
Policy Office, Division of Institution and Award Support
Office of Budget, Finance, and Award Management
National Science Foundation
Alexandria, VA 22314

Randolph Building, 401 Dulany Street, Alexandria, VA 22314,
Tel: (703) 292-5111