



Office of Emerging Frontiers and  
Multidisciplinary Activities (EFMA)

# Emerging Frontiers in Research & Innovation

## FY24/25 Solicitation: NSF 24-508

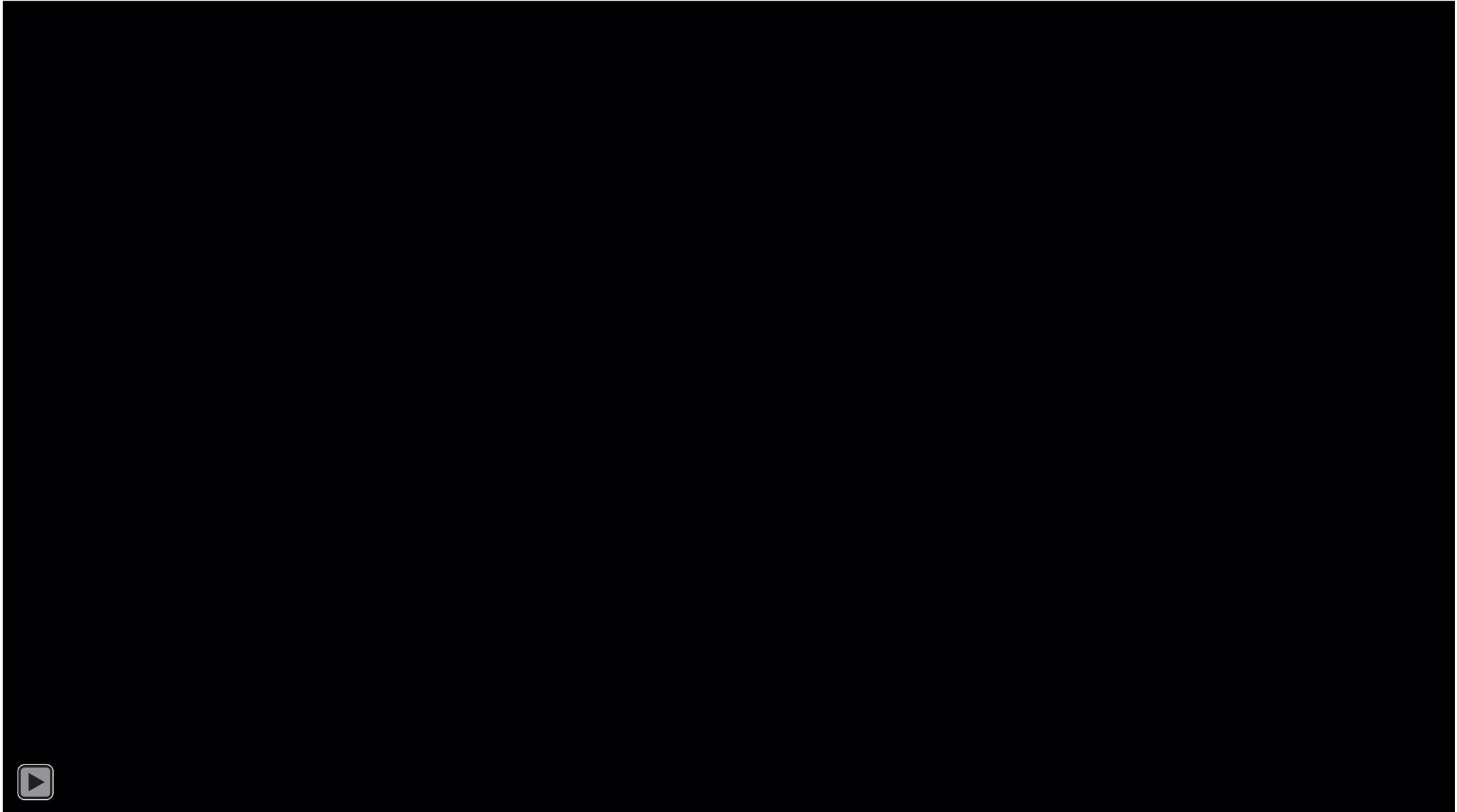
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INFORMATIONAL WEBINAR  
DECEMBER 4<sup>TH</sup>, 2023

# AGENDA:

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- 4:00 pm Welcome from Susan Margulies, Assistant Director, NSF/ENG
- 4:05 pm Introduction of the Emerging Frontiers in Research and Innovation (EFRI) Team
- 4:10 pm Overview of the EFRI *Biocomputing through EnGINeering Organoid Intelligence* (BEGIN OI) Solicitation
- 4:45 pm Questions



# Webinar Housekeeping

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1

The webinar is being recorded and the recording will be posted online

2

The webinar slides will be posted online

3

Questions will be addressed using the Q&A function

4

Send any questions not addressed in the webinar to [efri2024-2025@nsf.gov](mailto:efri2024-2025@nsf.gov)

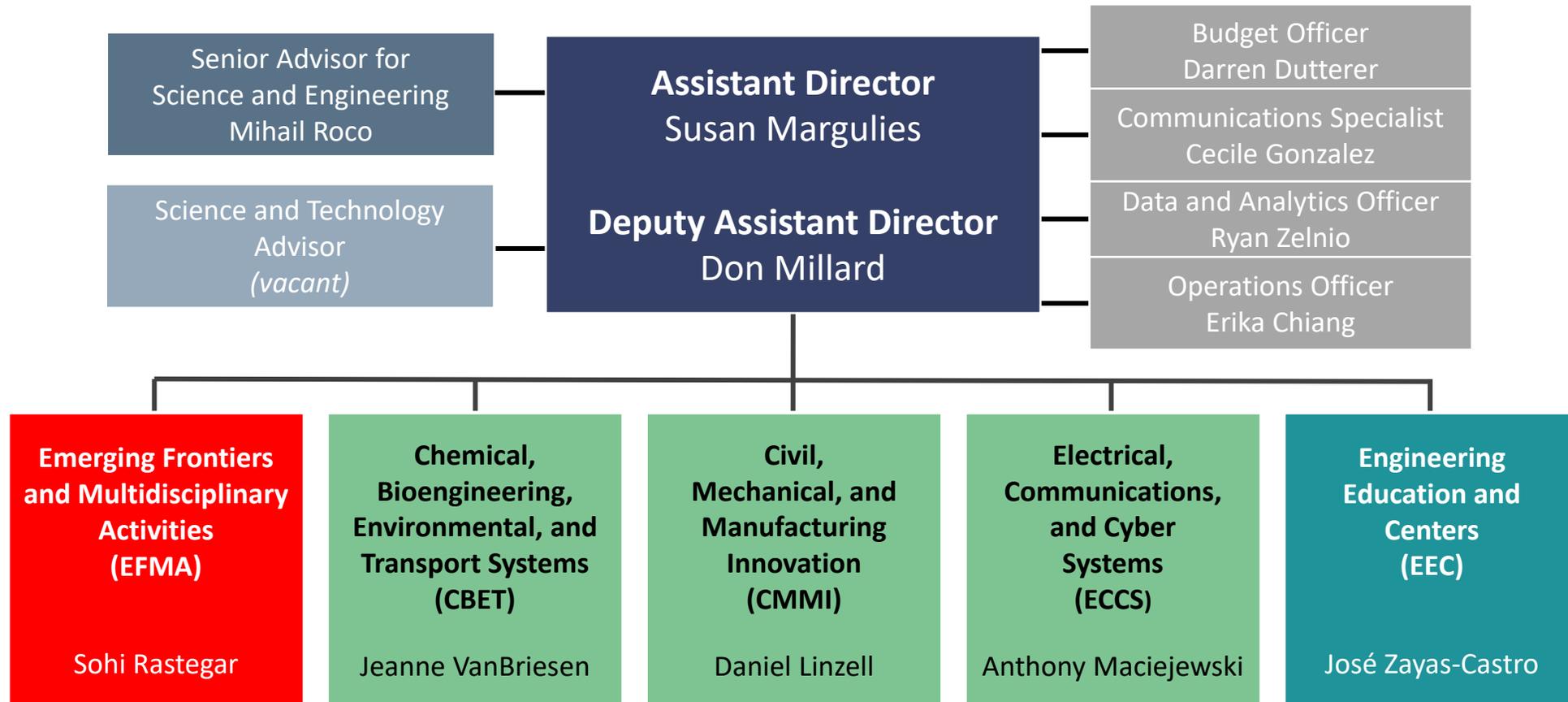
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The Chat Function has been disabled

For more information, please read solicitation NSF 24-508



# NSF Directorate for Engineering



# EFMA Office

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- Sohi Rastegar, *Office Head*
- Louise R. Howe, *Program Director*
- Alias Smith, *Program Director*
- Terria Davis, *Program Specialist*
- Kay-Marie Lamar, *AAAS S&T Policy Fellow*
- Lanita Thomas, *Panel Assistant*
- Ebun Ogunsusi, *Panel Assistant*

# EFRI Biocomputing through EnGINeering Organoid Intelligence (BEGIN OI)

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- **Topic Lead:** Steven Peretti, *Program Director, ENG/CBET*
- **Topic Lead:** Svetlana Tatic-Lucic, *Program Director, ENG/ECCS*
- Jordan Berg, *Program Director, ENG/CMMI*
- Krastan Blagoev, *Program Director, MPS/PHY*
- Jason Borenstein, *Program Director, SBE/OAD*
- Stephanie Gage, *Program Director, CISE/CCF*
- Dwight Kravitz, *Program Director, SBE/BCS*
- Vishal Sharma, *Program Director, CISE/CNS*
- Edda Thiels, *Program Director, BIO/IOS*
- Kenneth Whang, *Program Director, CISE/IIS*
- Steven Zehnder, *Associate Program Director, ENG/CBET*

# Goals of Webinar

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The goals of this webinar are:

- ❖ To inform the community about the EFRI FY 2024/25 Program Solicitation.
- ❖ To respond to questions from potential applicants.

# Key website

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Office of Emerging Frontiers & Multidisciplinary Activities  
(EFMA) Website:

<http://www.nsf.gov/eng/efma>

Please refer to this website for up-to-date information.

# The Emerging Frontiers in Research & Innovation (EFRI) Program

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The EFRI Program serves a critical role in helping the Engineering Directorate to focus on important emerging areas in a timely manner.

- **Community Driven** – Engages the research community (through a DCL) as well as NSF Program Directors to identify and fund a portfolio of projects in strategic emerging, interdisciplinary areas that may not be supported through current NSF programs, and in which ENG research plays the leading role.
- Uses **Potentially Transformative / High risk, High reward** and **Interdisciplinary** as criteria for project selection.
- Signature midscale project-funding mechanism in ENG (\$2M / 4 year projects)

FY07	<b>ARES:</b> Autonomously Reconfigurable Engineered Systems <b>CBE:</b> Cellular and Biomolecular Engineering	FY16/17	<b>ACQUIRE:</b> Advancing Communication Quantum Information Research Engineering <b>NewLAW:</b> New Light and Acoustic Wave Propagation: Breaking reciprocity and time-reversal symmetry
FY08	<b>COPN:</b> Cognitive Optimization and Prediction <b>RESIN:</b> Resilient and Sustainable Infrastructures	FY18/19	<b>CEE:</b> Chromatin and Epigenetic Engineering <b>C3 SoRo:</b> Continuum, Compliant and Configurable Soft Robotics Engineering
FY09	<b>BSBA:</b> Biosensing and Bioactuation <b>HyBi:</b> Hydrocarbons from Biomass	FY20/21	<b>DCheM:</b> Distributed Chemical Manufacturing <b>E3P:</b> Engineering the Elimination of End-of-life Plastics
FY10	<b>SEED:</b> Science in Energy and Environmental Design <b>RESTOR:</b> Renewable Energy Storage	FY22/23	<b>BRAID:</b> Brain-Inspired Dynamics for Engineering Energy-Efficient Circuits and Artificial Intelligence <b>ELiS:</b> Engineered Living Systems
FY11	<b>M3C:</b> Mind, Machines, and Motor Control <b>MIKS:</b> Engineering based on Multicellular and Interkingdom Signaling	FY24/25	<b>BEGIN OI:</b> Biocomputing through EnGINeering Organoid Intelligence <b>PEL:</b> Ideas Lab: Personalized Engineering Learning (NSF 23-627)
FY12/13	<b>BioFlex:</b> Flexible Bioelectronics Systems <b>PSBR:</b> Photosynthetic Biorefineries <b>ODISSEI:</b> Origami Design for Integration Of Self-assembling Systems For Engineering Innovation		
FY14/15	<b>2-DARE:</b> 2-Dimensional Atomic-Layer Research and Engineering		

## EFRI Topics FY07-25

# EFRI FY 2024/25 Topic

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

[View guidelines](#)

24-508

# Biocomputing through EnGINeering Organoid Intelligence (BEGIN OI)

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- The objective of 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.
- 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

# BEGIN OI

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- 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
- Asks investigators to define the bounds of “intelligence” and “learning” needed to achieve responsive and adaptive biological computing and control
- Requires a convergent research approach that engages engineers, biologists, computer scientists, social scientists, ethicists, and others

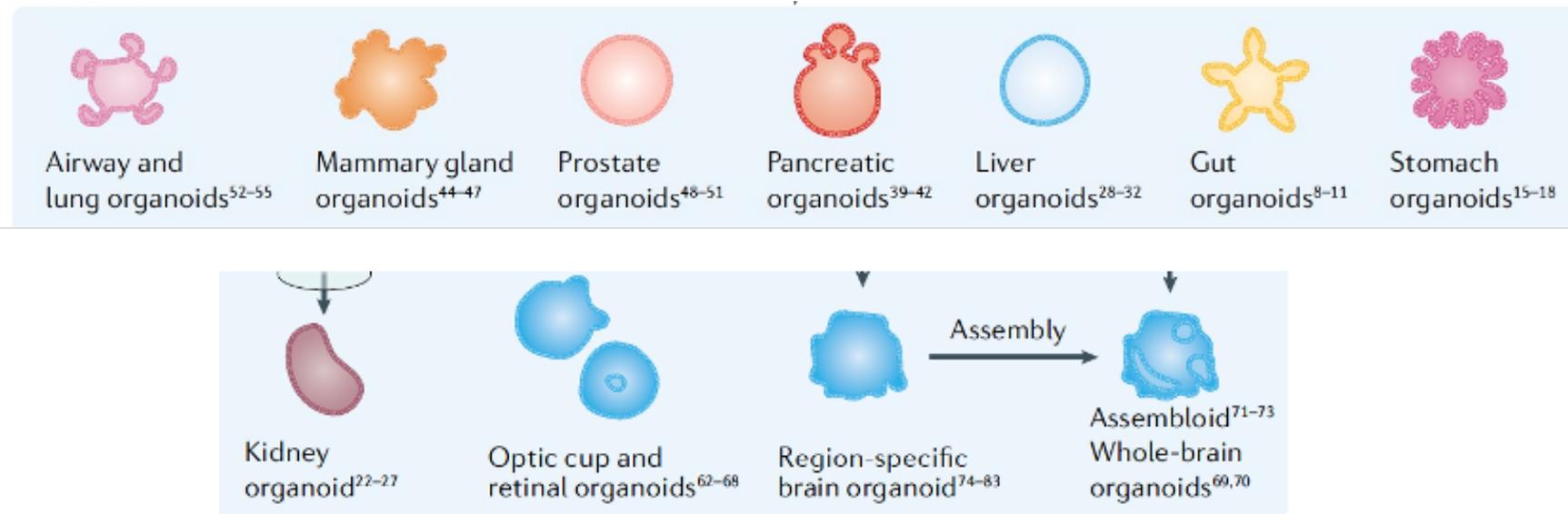
# Foundational Concepts

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- **No organ is an island**, entire of itself, every organ is a piece of the body, a part of the main. (apologies to John Donne)
- **Intelligence**: “the ability to acquire and apply knowledge and skills”
- **Biomimetics**: “principles from engineering, chemistry and biology are applied to the synthesis of materials, synthetic systems or machines that have functions that mimic biological processes”
- **Bioethics**: biological research activities are fundamentally intertwined with Ethical, Legal, and Social Implications

# No organ is an island, but is independently "intelligent"

- Organoids can be developed from a variety of sources, and embody varied aspects of intelligence



Adapted from <https://doi.org/10.1038/s41578-021-00279-y>

# Biomimetics

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- **Interoception:** bidirectional signal processing between the brain and the organs that generates a representation of the internal state of an organism
  - Mediated by vagus nerve and endocrine systems
  - Therefore, organs convert physical or chemical signals into electrical signals. How do we capitalize on/mimic those processes?
  - How does the nervous system learn to interpret those signals?
  - Can we create an analogous learning process for organoids?

# Ethical, Legal, and Social Implications (ELSI)

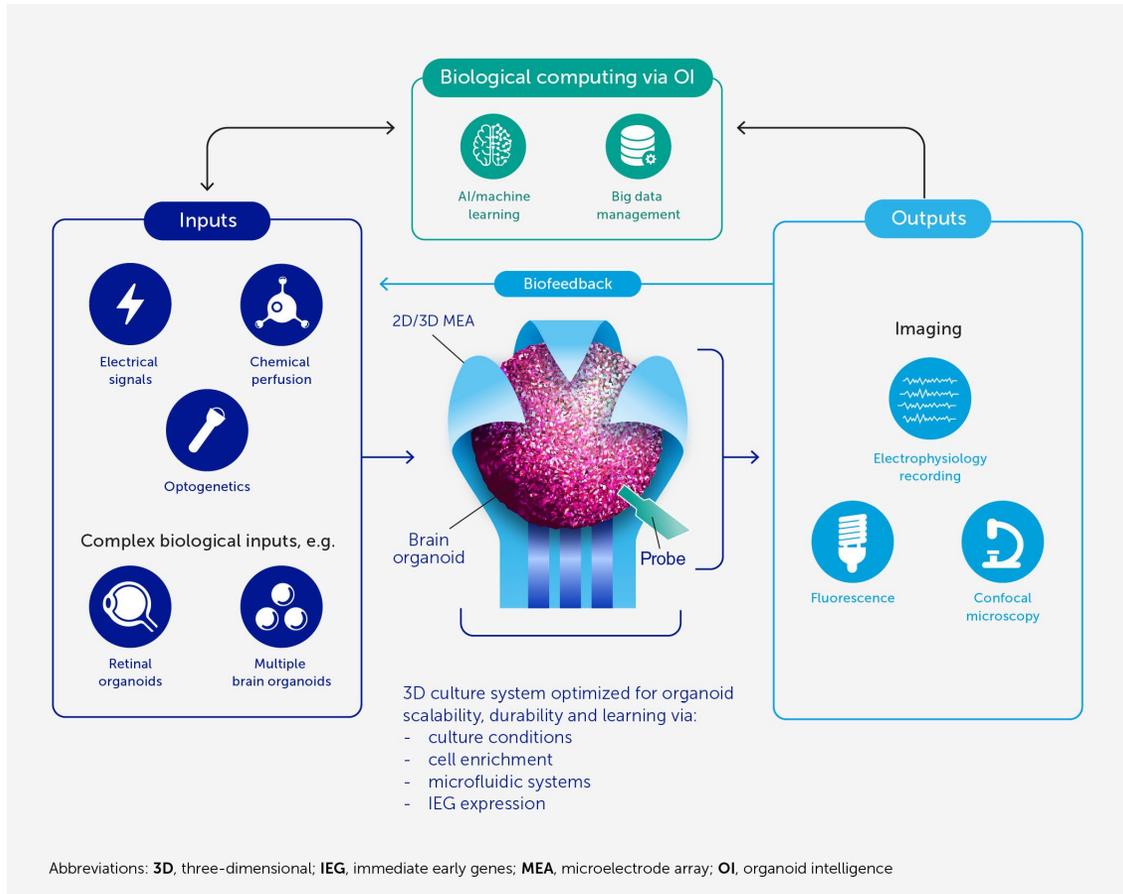
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Responsible development requires embedding ELSI considerations into the project.

A variety of approaches in ethics could influence how ELSI considerations are framed. These include but are not limited to:

- Principlism (for example, applying principles such as beneficence or respect for persons)
- Case-based reasoning
- Ethical theories or frameworks (such as Utilitarianism or Virtue Ethics)
- Codes of ethics (for example, from professional organizations)

# Research Thread 1: Biocomputing Theory and Modeling

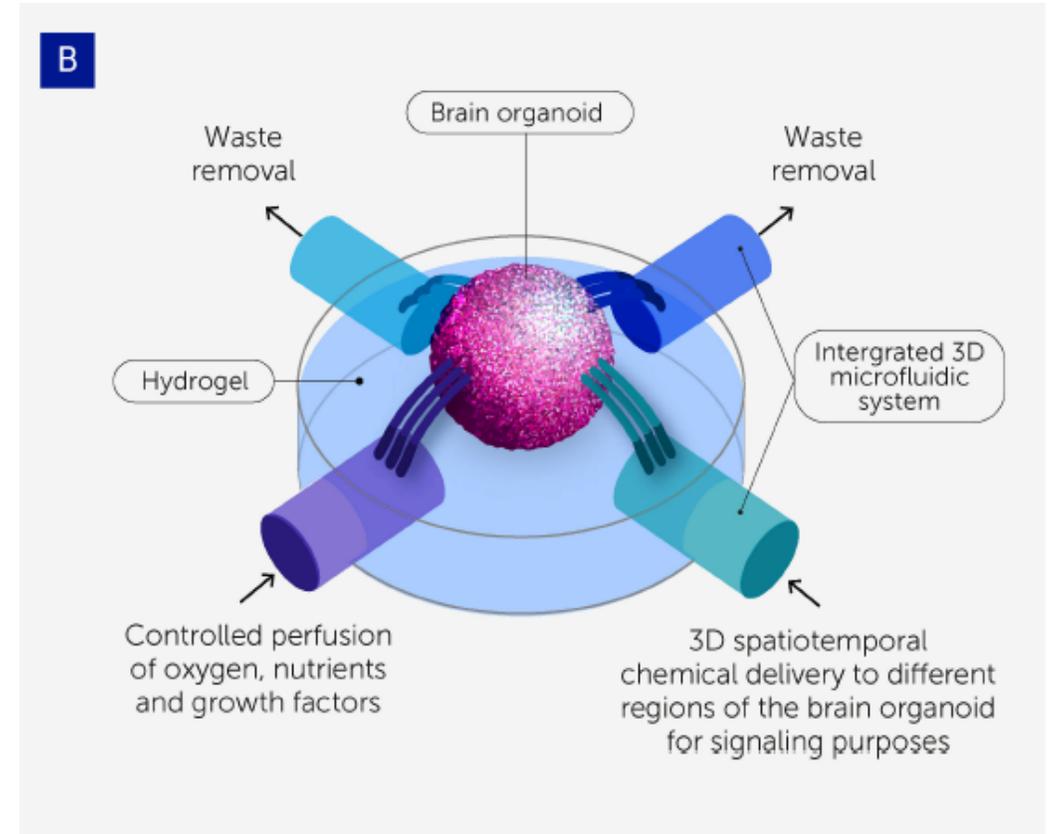


- New computational models/AI approaches that describe the ability for storage and retrieval
- Effectively interpret the complex biological outputs into meaningful information
- Computational strategies may be highly reliant on nature of inputs and outputs; which in turn depends on the sensing and signaling systems employed

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

To create an organoid-based computer, one must:

- Keep it alive and fully functional – this may require, for example, the development of a digital twin of the organoid to effectively control the culture environment
- Develop a robust signaling interface that allows for appropriate inputs to be introduced and outputs to be sensed and quantified



Adapted from DOI 10.3389/fsci.2023.1017235

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

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The objective of this thread is to investigate ELSI issues raised by the proposed research 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.

# Solicitation Requirements

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# Award Size and Information

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## Team Proposals Only:

- 3-5 PIs/co-PIs

Up to 4 years in duration

Up to \$2M over grant lifetime (including both direct and indirect costs)

Up to \$30M in FY 2024 and FY 2025 combined, subject to availability of funds

# Eligibility: PIs & co-PIs

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## **PI Limit:**

- Principal Investigators (PI) must be full-time tenured or tenure-track faculty as determined by the submitting organization; or meet requirements described in the solicitation if the proposal is submitted by a non-profit, non-academic organization.
- A minimum of one PI and two co-PIs must participate.
- Maximum number of PI plus co-PIs: 5
- **At least one PI or co-PI must be full-time faculty in a College or Department of Engineering**

**Limit on Number of Proposals per Organization:** None Specified.

**Limit on Number of Proposals per individual (PI or co-PI):** **One per fiscal year**

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.

# Eligibility: Organizations

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## Organization Limit:

- EFRI proposals may be submitted by a single organization or by a group of organizations consisting of a lead organization in partnership with one or more partner organizations.
- Proposals may be submitted by:
  - Institutions of Higher Education: universities and two- and four-year colleges (including community colleges) accredited in, and having a campus located in the United States, acting on behalf of their faculty members.
  - 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.
- Only U.S. organizations are eligible to be the lead organization.
- For interaction with industry, when appropriate for the proposed research, the GOALI mechanism (Grant Opportunities for Academic Liaison with Industry) may be used.  
<https://new.nsf.gov/policies/pappg/23-1/ch-2-proposal-preparation#2F5>

# No Collaborative Proposals

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For each proposed project, a single proposal should be submitted by the lead institution with subawards to partners institutions

**No “Collaborative Proposals” are permitted**

- *The proposal will include a budget for each of the four years proposed.*

# Broadening Participation Plan

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ENG promotes diversity in all aspects of its programs.

As part of the EFRI 2024/25 Solicitation, EFRI requires all projects to include a Broadening Participation Plan.

The goal is to broaden the participation and include the full spectrum of diverse talents in Engineering.

Expand the diversity of thought, ideas, and approaches to defining and solving important research questions.

# Broadening Participation Activities: Examples

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- Inclusion of persons from underrepresented groups as PI, Co-PI, and/or other senior personnel, as appropriate for the project
- Inclusion of persons from underrepresented groups as graduate students, undergraduate students, and post-doctoral researchers
- Plans to diversify EFRI research teams through post-award supplements engaging persons from underrepresented groups including undergraduate researchers and teachers, such as [REU](#), [RET](#), or [REM](#) supplements
- Engagement of faculty and/or student researchers at minority-serving institutions, community colleges, technical schools, and/or high schools in the research project
- Enhancement of/collaboration with existing broadening participation programs at your home institution and/or nearby institutions
- Outreach activities that will interest and attract K-12 students from underrepresented groups to engineering undergraduate programs

# A Letter of Intent (LOI) Is Required

## Due Date: January 17<sup>th</sup>, 2024

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One Page

1. **TITLE** - Title of the EFRI proposal preceded by the words “EFRI BEGIN OI:” as appropriate
2. **TEAM** - Names, departmental and organizational affiliation, and expertise of the PI and at least two co-PIs
3. **SYNOPSIS (GOALS)** - Brief description of the specific goals of the proposal (maximum 250 words)

Additional Requirement:

- Submission by an Authorized Organizational Representative (AOR) is required
- A Minimum of 2 and Max. of 4 Other Senior Project Personnel (co-PIs)
- A Minimum of 0 and Max. of 4 Other Participating Organizations

LOIs are not merit reviewed and no feedback is provided to the submitters

**Submission of multiple LOIs by a PI is NOT permitted**

# Full Proposal Submission

## Due Date: February 22<sup>nd</sup>, 2024

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Follow NSF Proposal & Award Policies & Procedures Guide or Grants.gov Application Guide

Project Summary (**one page limit**)

- **Proposals that do not separately address both intellectual merit and broader impacts in Project Summary will be returned without review**

Project Description (15 page limit)

- Must include under Broader Impacts: Key Anticipated Outcomes; Broadening Participation Plan

Additional Sections include:

- References Cited; Biographical sketches; Budget; Current and Pending Support; Facilities, Equipment, & Other Resources

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

# Full Proposal

## Supplementary Documentation

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### Supplementary Documentation:

**List of Key Personnel:** Provide a succinct description of what each person uniquely brings to the project and how their expertise will be integrated to foster synergy (3 pages max)

Detailed management plan (3 pages max)

**Mechanisms for sharing the outcomes of the research** with the scientific community (2 pages max)

**Post-doctoral researcher mentoring plan**, if requesting support for post-doc(s)

**Student Mentoring Plan**, describing mentoring activities for undergraduate and graduate students

**Broadening Participation Plan** – additional information up to 5 pages

**Data management plan** (2 pages, plus additional document if needed)

**Single PowerPoint slide** summarizing the vision of the EFRI proposal

**Cloud Computing Resource Request**, if requesting support for CloudBank computing resources

### Single Copy Documents: Collaborators & Other Affiliations

NSF requires the use of a specific spreadsheet template for identifying COA information.

This document must be submitted for each PI, co-PI, and every other senior project personnel member.

# Review & Award Process

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Required Letters of Intent due on **January 17, 2024**

Full Proposals are due on **February 22, 2024**

Full Proposals will be reviewed in **Spring 2024**

Awards are expected to be made **by August 2024**, subject to availability of funds

# Review Criteria

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## NSB-approved Merit Review Criteria

- Intellectual Merit
- Broader Impacts

NSF Program Staff will also give careful consideration to the following:

- Integration of ELSI within the project
- Broadening Participation in Engineering and Science

# Review Criteria:

## EFRI Solicitation-Specific

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- **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?
- Is the proposal responsive to the **Programmatic Considerations** for **EFRI-BEGIN OI**?
- **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?

# EFRI-2024/25 (NSF 24-508)

## Important Solicitation Dates

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Dec 4<sup>th</sup>, 2023

Informational Webinar

Jan 17<sup>th</sup>, 2024

Letter of Intent Due  
(**required**)

Feb 22<sup>nd</sup>, 2024

Full Proposal Deadline

# Questions

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[efri2024-2025@nsf.gov](mailto:efri2024-2025@nsf.gov)

# Program Guidance: Participation Limit

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Each investigator may participate as either PI or co-PI on only a single proposal submitted in one fiscal year.

# Program Guidance: Co-PI Limit

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Each proposal *must* have a minimum of 2 co-PIs and a maximum of 4 co-PIs

# Program Guidance: Engineer PI/co-PI

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The Lead PI or one of the project co-PIs *must* be full-time tenured or tenure-track faculty within a College or Department of Engineering

# Program Guidance: Industry co-PI

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For interaction with industry, when appropriate for the proposed research, the GOALI mechanism (Grant Opportunities for Academic Liaison with Industry) may be used. See PAPPG Chapter II.F.5.

<https://new.nsf.gov/policies/pappg/23-1/ch-2-proposal-preparation#2F5>

# Program Guidance:

## Co-PI from a National Lab

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NSF does not normally support research or education activities by scientists, engineers or educators employed by Federal agencies or Federally Funded Research and Development Centers (FFRDCs).

Preliminary inquiry must be made by sending an email to [efri2024-2025@nsf.gov](mailto:efri2024-2025@nsf.gov) that explains the unique capability of the FFRDC or national laboratory. If permission is granted, a written statement from the cognizant NSF PD must be included as part of the proposal submission.

# Program Guidance:

## Co-PI from a non-US institution

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### **US-Israel Binational Science Foundation (BSF) – NSF 20-094**

Provides for an international collaboration arrangement whereby U.S. researchers may receive funding from the NSF and Israeli researchers may receive funding from the BSF

***Foreign Organizations** – NSF rarely provides direct funding support to foreign organizations. NSF will consider proposals for cooperative projects involving U.S. and foreign organizations, provided support is requested only for the U.S. portion of the collaborative effort. (PAPPG NSF 231, Chapter I.E.2c)*

Preliminary inquiry must be made by sending an email to [efri2024-2025@nsf.gov](mailto:efri2024-2025@nsf.gov) that explains the unique capability of the FFRDC or national laboratory. If permission is granted, a written statement from the cognizant NSF PD must be submitted as part of the proposal submission.

# Program Guidance: Consultants

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Professional engineers can be consultants on an EFRI proposal

# Program Guidance:

## Participating Institutions

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There is no limit to the number of participating institutions allowed on an EFRI proposal.

(Limits are imposed in the Letter of Intent purely for administrative purposes so that key individuals and organizations can be identified early on)

# Program Guidance:

## Participating Institutions

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There is no limit to the number of EFRI proposals that may be submitted by a single organization.

However, the EFMA Office will not normally award more than one proposal from any one lead institution in the annual EFRI competition.

# Program Guidance: LOI Format

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Research.gov templates will walk you through submitting the Letter of Intent and automatically format the LOI.

Please prepare your text in a word-processing (or similar) program on your computer and cut and paste the required information into Research.gov.

# REM: Research Experience & Mentoring Supplements for Active EFRI Awards

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The goal is to provide research experiences and mentoring opportunities to STEM students and/or educators that may ultimately enhance their career and academic trajectories while enhancing EFRI-supported research.

REM supplement requests may be submitted by EFRI grantees with an active award (in response to the active DCL)

*(REM supplements are also now available for Engineering Research Center (ERC) and Industry-University Cooperative Research Centers (IUCRC) awards)*

REM participants are expected to present their findings at the annual Emerging Researchers National (ERN) Conference in STEM and may also present at EFMA-sponsored grantees meetings.

# Acronyms and Terminology

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<b>BCS</b>	Division of Behavioral and Cognitive Sciences	<b>BIO</b>	Directorate for Biological Sciences
<b>CBET</b>	Division of Chemical, Bioengineering, Environmental & Transport Systems	<b>CISE</b>	Directorate for Computer and Information Science and Engineering
<b>CMMI</b>	Division of Civil, Mechanical & Manufacturing Innovation	<b>CNS</b>	Division of Computer and Network Systems
<b>COA</b>	Collaborators and Other Affiliations	<b>Co-PI</b>	Co-Principal Investigator
<b>ECCS</b>	Division of Electrical, Communications and Cyber Systems	<b>EFMA</b>	Office of Emerging Frontiers and Multidisciplinary Activities
<b>EFRI</b>	Emerging Frontiers in Research and Innovation	<b>ENG</b>	Directorate for Engineering
<b>IIS</b>	Division of Information and Intelligent Systems	<b>IOS</b>	Division of Integrative Organismal Systems
<b>MPS</b>	Directorate for Mathematical and Physical Sciences	<b>NSB</b>	National Science Board
<b>NSF</b>	National Science Foundation	<b>OAD</b>	Office of the Assistant Director
<b>PAPPG</b>	Proposal & Award Policies & Procedures Guide	<b>PHY</b>	Division of Physics
<b>PI</b>	Principal Investigator	<b>SBE</b>	Directorate for Social, Behavioral and Economic Sciences

# Key Resource

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Please refer to the EFMA website for up-to-date information:

<http://www.nsf.gov/eng/efma>