Office of Emerging Frontiers and Multidisciplinary Activities (EFMA)

# Emerging Frontiers in Research & Innovation

# FY22/23 Solicitation: NSF 21-615

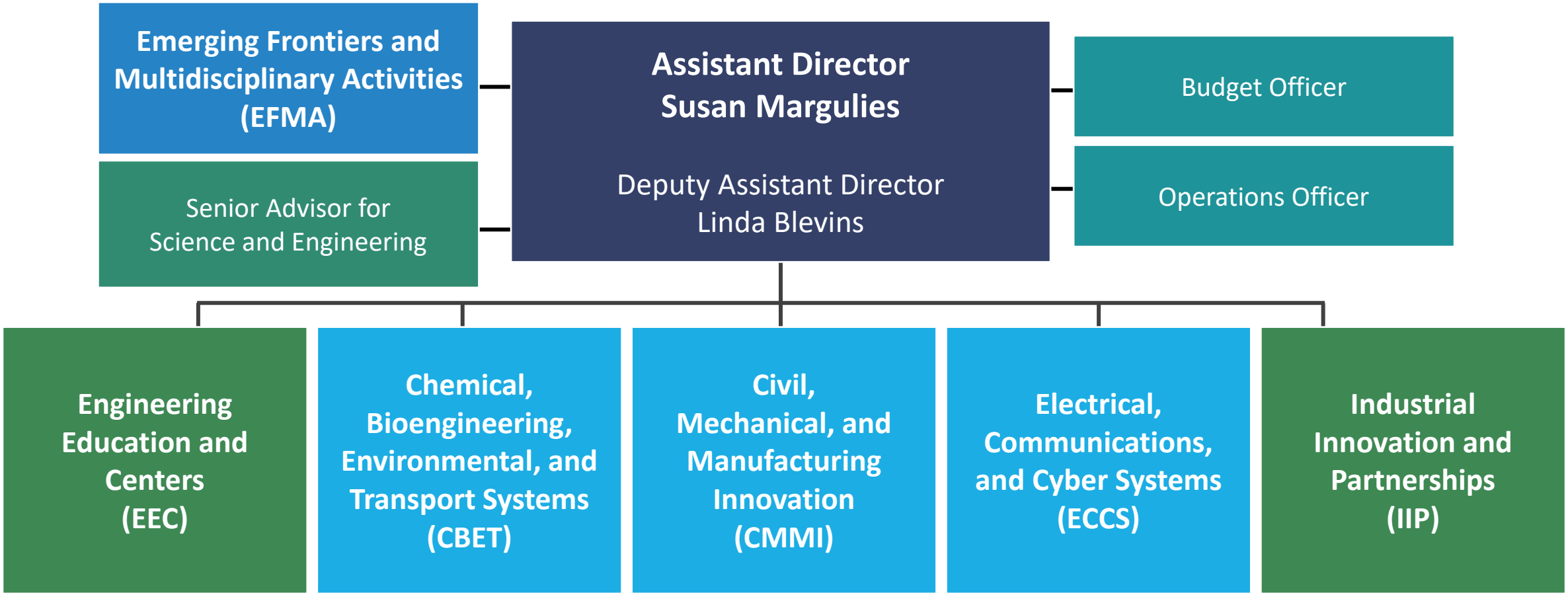
INFORMATIONAL WEBINAR

OCTOBER 15TH, 2021

# AGENDA: October 15th, 2021

| | |
|---|---|
| 2:00 pm | Welcome from Susan Margulies, Assistant Director, NSF/ENG |
| 2:05 pm | Introduction of EFRI Team Members and EFRI Topics |
| 2:10 pm | Overview of EFRI FY2022/23 Program Solicitation |
| 2:45 pm | Questions |

# NSF Directorate for Engineering



# EFRI Team Members

**EFMA Office**

- Sohi Rastegar, *Head, EFMA*
- Louise R. Howe, *Program Director, EFMA*
- Alias Smith, *Associate Program Director, EFMA*
- Terria Davis, *Program Specialist, EFMA*
- Damian Grant, *Student Trainee, EFMA*

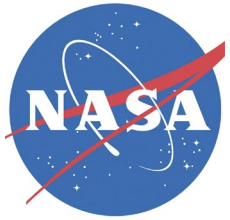
# EFRI Team Members

## EFRI Program Directors

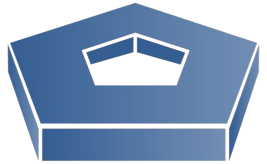
| ELiS: Engineered Living Systems | BRAID: Brain-Inspired Dynamics for Engineering Energy-Efficient Circuits and Artificial Intelligence |
|---|---|
| **Topic Coordinator:** Mamadou Diallo – ENG/CBET | **Topic Coordinator:** Grace Hwang – ENG/CBET |
| Steven Peretti – ENG/CBET | Jordan Berg – ENG/CMMI |
| David Rockcliffe – BIO/MCB | Kenneth Whang – CISE/IIS |
| Elizabeth Mann – MPS/DMR | Edda Thiels – BIO/IOS |
| Khershed Cooper – ENG/CMMI | Rosa Lukaszew – ENG/ECCS |
| Usha Varshney – ENG/ECCS | Sridhar Raghavachari – BIO/IOS |

| ELiS | BRAID |
|---|---|
| **Topic Coordinator: Mamadou Diallo, Program Director, ENG/CBET** | **Topic Coordinator: Grace Hwang, ENG/CBET** |
| Enriqueta Barrera, Program Director, GEO/EAR | Jordan Berg, Program Director, ENG/CMMI |
| Wenda Bauchspies, Program Director, SBE/SES | Rosa Lukaszew, Program Director, ENG/ECCS |
| Giovanna Biscontin, Program Director, ENG/CMMI | Sridhar Raghavachari, Program Director, BIO/IOS |
| Khershed Cooper, Program Director, ENG/CMMI | Kenneth Whang, Program Director, CISE/IIS |
| Steven Peretti, Program Director, ENG/CBET | Edda Thiels, Program Director, BIO/IOS |
| Bianca Garner, Program Director, BIO/MCB | Raymond Adomaitis, Program Director, ENG/CBET |
| Ruyan Guo, Program Director, ENG/ECCS | Aleksandr Simonian, Program Director, ENG/CBET |
| Bruce Hamilton, Program Director, ENG/CBET | Jonathon Fritz, Program Director, SBE/BCS |
| Elizabeth Mann, Program Director, MPS/DMR | Paul Lane, Program Director, MPS/DMR |
| William Olbricht, Program Director, ENG/CBET | Soo-Siang Lim, Program Director, SBE/BCS |
| David Rockcliffe, Program Director, BIO/MCB | Junping Wang, Program Director, MPS/DMS |
| Gerald Schoenknecht, Program Director, BIO/IOS | Andrew Wells, Program Director, ENG/CMMI |
| Brandi Schottel, Program Director, ENG/CBET | Donald Wunsch, Program Director, ENG/ECCS |
| Aleksandr Simonian, Program Director, ENG/CBET | Ying Sun, Program Director, ENG/CBET |
| Usha Varshney, Program Director, ENG/ECCS | Stephen Zehnder, Associate PD, ENG/CBET |
| Lisa Carnell, Program Scientist, NASA Biological and Physical Sciences Division | Steven Peretti, Program Director, ENG/CBET |
| Heather Meeks, Department Director, Defense Threat Reduction Agency | Zhilan Feng, Program Director, MPS/DMS |
| | Hal Greenwald, Group Leader, AFOSR |

# Full EFRI Team







U.S. DEPT OF **DEFENSE**

# Goals of Webinar

The goals of this webinar are:

- To inform the community about the EFRI FY 2022/23 Program Solicitation.

- To respond to questions from potential applicants.

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

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)

# EFRI Topics FY07-21

FY07 **ARES**: Autonomously Reconfigurable Engineered Systems
**CBE**: Cellular and Biomolecular Engineering

FY08 **COPN**: Cognitive Optimization and Prediction
**RESIN**: Resilient and Sustainable Infrastructures

FY09 **BSBA**: Biosensing and Bioactuation
**HyBi**: Hydrocarbons from Biomass

FY10 **SEED**: Science in Energy and Environmental Design
**RESTOR**: Renewable Energy Storage

FY11 **M3C**: Mind, Machines, and Motor Control
**MIKS**: Engineering based on Multicellular and Interkingdom Signaling

FY12/13 **BioFlex**: Flexible Bioelectronics Systems
**PSBR**: Photosynthetic Biorefineries
**ODISSEI**: Origami Design for Integration Of Self-assembling Systems For Engineering Innovation

FY14/15 **2-DARE**: 2-Dimensional Atomic-Layer Research and Engineering

FY16/17 **ACQUIRE**: Advancing Communication Quantum Information Research Engineering
**NewLAW**: New Light and Acoustic Wave Propagation: Breaking reciprocity and time-reversal symmetry

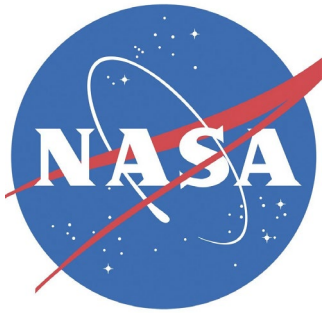
FY18/19 **CEE**: Chromatin and Epigenetic Engineering
**C3 SoRo**: Continuum, Compliant and Configurable Soft Robotics Engineering

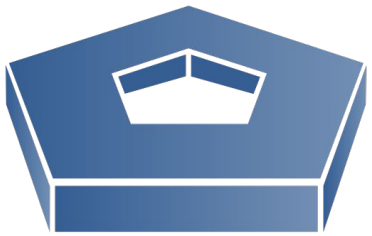
FY20/21 **DCheM**: Distributed Chemical Manufacturing
**E3P**: Engineering the Elimination of End-of-life Plastics

# EFRI FY 2022/23 Topics

ELiS: Engineered Living Systems

BRAID: Brain-Inspired Dynamics for Engineering Energy-Efficient Circuits and Artificial Intelligence



U.S. DEPT OF DEFENSE

# TOPIC 1: Engineered Living Systems (ELiS)

The convergence of engineering, biology and materials science is providing unprecedented opportunities to integrate unicellular and multicellular organisms (e.g., natural/engineered cells, microbial consortia, and plants) into next generation engineered systems capable of performing tasks associated with living systems such as self-replication, self-regulation, self-healing, and environmental responsiveness

# Engineered Living Systems (ELiS)

ELiS will support foundational and convergence research to advance the design, modeling, fabrication, and manufacturing of engineered living systems to address societal needs as well as the associated ethical, legal, and social implications of using living systems as building blocks and components for next-generation sustainable engineering

ELiS will also contribute to the development of the basic science and engineering knowledge needed to advance the respective missions of our Federal Partner Agencies including 1) NASA's goals for sustainable space exploration and 2) the Defense Threat Reduction Agency (DTRA)'s goals for the development and deployment of enabling capabilities to understand the built environment, threats, and vulnerabilities.

# ELiS Cognizant Program Officers

| | | |
|---|---|---|
| **Mamadou Diallo<br>TOPIC COORDINATOR** | **ENG/CBET** | **mdiallo@nsf.gov** |
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| | | |
| *Lisa Carnell* | *NASA Biological and Physical Sciences Division* | Lisa.a.scottcarnell@nasa.gov |
| *Heather Meeks* | *Defense Threat reduction Agency* | Heather.n.meeks4.civ@mail.mil |

# ELiS Research Threads

**Each proposal submitted in response to the EFRI-ELiS track is required to address each of the foundational research components and one of the three research threads listed below**:

**Foundational Research:** 1) design and/or modeling, 2) fabrication and/or manufacturing, and 3) ethical, legal, and social implications.

**Research Thread 1: Sustainable Built Environment**

**Research Thread 2: Monitoring and Surveillance for a Safe Built Environment**

**Research Thread 3: Biomining for Sustainable Metal Extraction and Resource Recovery**

# Foundational Research: Design and/or Modeling

*Design and/or modeling approaches and tools of relevance to this solicitation may include but are not limited to:*

1) Mechanistic mathematical models, computational biology, bioinformatics, artificial intelligence (AI), and machine learning (ML) to support the design and fabrication/manufacturing of the biotic components of engineered living systems

2) Multiscale computational chemistry and computational materials modeling to guide the design, selection, processing, fabrication and/or manufacturing of the material scaffolds and abiotic building blocks of engineered living systems

3) Multiscale (multiphysics) process modeling to guide the fabrication, manufacturing and deployment of engineered living systems of relevance to ELiS research threads

# Foundational Research: Fabrication and/or Manufacturing

Plants require little or no fabrication and/or manufacturing to serve as autonomous engineered living systems.

Fabrication and/or manufacturing will be required to integrate multicellular microorganisms and microbial consortia into robust and viable engineered living systems.

*For microbe-based living systems, proposals with natural/engineered organisms that maintain their viability when exposed to harsh environmental conditions including but not limited to heat, pH extremes, UV inactivation, and desiccation are highly encouraged.*

# Fabrication and/or Manufacturing Methods

*Methods and processes for the fabrication and/or manufacturing of the components and building blocks of the living systems of relevance to ELiS may include but are not limited to:*

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- Seeding, inoculation of abiotic media with microorganisms followed by processing to produce living building materials
- Seeding and inoculation of geomaterials and solid wastes with microorganisms followed by processing to enable biomining and resource recovery
- Electrospinning of suspensions of microorganisms and polymers to produce living fibers
- 3D printing of bioinks, including suspensions of microorganisms, onto substrates (e.g., organic, inorganic and/or polymeric) to produce biofilms and living surfaces

# Research Thread 1: Sustainable Built Environment

Potential and relevant projects for this thread include but are not limited to:

- Residential/commercial buildings with living walls/roofs that capture and store $CO_2$
- Buildings/structures with living foundations that can grow under loadings to strengthen their soil supports
- Buildings with living walls and living surfaces/pavements that can capture, immobilize and/or deactivate airborne and waterborne pathogens (DTRA)
- Engineered reef-like structures that can serve as building blocks for living shorelines to protect coastal areas from sea-level rise due to climate change
- Building blocks for durable low-mass surface habitats on the Moon and Mars using living systems and regolith as components (NASA)

# Research Thread 2: Monitoring and Surveillance for a Safe Built Environment

Potential and relevant projects for this thread include but are not limited to:

- Integrated and multimodal sensor systems based on natural/engineered sentinel cells and microorganisms to monitor the presence and movement of indoor air pollutants and airborne pathogens in residential/commercial buildings and facilities
- Scalable biosensor devices and systems based on natural/engineered sentinel cells and microorganisms with closely integrated data analytics to enable distributed wastewater surveillance in residential/commercial buildings and facilities
- Plant-based biosensor systems that continuously monitor the presence of pathogens and hazardous compounds in the open spaces of the built environment including outdoor gardens, streets/pavements, and urban green spaces such as parks and playgrounds

# Research Thread 3: Biomining for Sustainable Metal Extraction and Resource Recovery

*Focus on two critical unit operations to advance next generation biomining: 1) accelerated bioweathering and 2) biohydrometallurgy*

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**Bioweathering**: We invite convergent research proposals aimed at designing and engineering microbiomes that could accelerate natural biological weathering processes to break down geomaterials (rocks, ores, and minerals), solid wastes (e.g., electronic wastes including spent silicon chips), and lunar/Martian regolith simulants

**Biohydrometallurgy**: We invite convergent research proposals aimed at designing and engineering microbiomes with functional diversity and distributed metabolism that could:

1) Selectively extract and concentrate critical/valuable ions that are released from broken-down minerals, solid wastes, and lunar/Martian regolith simulants; and

2) Convert the released metal ions to metallic particles (e.g., oxides, zero valent and others) that could be recovered using low-energy separation technologies including but not limited to particle separations based on size, density, electrical and magnetic properties

# Education, Workforce Development, and Responsible Innovation

ELiS projects will serve as ideal platforms for pursuing innovative educational and workforce development programs, such as curriculum development and outreach activities that increase awareness and broaden participation of underrepresented minorities in STEM careers.

ELiS proposals are required to address the ethical, legal, and social implications of using living systems as building blocks and components for next-generation sustainable processes, products, and technologies.

Submitted proposals must discuss how challenges resulting from these considerations will be addressed, within the context and scope of the project description. Collaboration with ethicists, social scientists, and economists is strongly encouraged, as appropriate.

# ELiS Requirements

- Interdisciplinary team
- *Each proposal submitted in response to the EFRI-ELiS solicitation is required to address one of the three research threads and each of the foundational research components*
- ELiS teams are expected to identify the ethical, social, economic, health, legal, safety, and environmental considerations of their proposed research, and discuss how challenges resulting from these will be addressed

# TOPIC 2: Brain-inspired dynamics for engineering energy-efficient circuits and artificial intelligence (BRAID)

- Modern AI approaches are energy- and data-inefficient
- Neuroscience research is producing new understanding of biological **learning** processes. Recent advances have revealed the critical interplay of **temporal dynamics** across time scales from milliseconds to lifetimes and neural structures across spatial scales from nanometers to entire brains
- BRAID seeks to exploit emerging **neuroscience** advances for the design of **engineered learning systems** by catalyzing interactions between engineers, neuroscientists, and other disciplines

# BRAID Research Opportunities

- Transform innovative findings from neuroscience into new classes of algorithms, circuits, networks, and devices.
- Seek insights into the co-design of theory, algorithms, and devices that arise from learning in biological organisms.
- Invite proposals from diverse teams of **engineering-led** researchers that may include participants from multiple engineering disciplines, computer and information sciences, the life sciences, the social and behavioral sciences, and the mathematical and physical sciences.
- **The inclusion of theoretical neuroscience expertise on each team is mandatory.**
- The anticipated capabilities arising from this program will include features of intelligence associated with humans and other complex living systems not available in current artificial intelligence and/or machine learning approaches.

# BRAID Cognizant Program Officers

| | | |
|---|---|---|
| **Grace Hwang (TOPIC COORDINATOR)** | **ENG/CBET** | **ghwang@nsf.gov** |
| Jordan Berg | ENG/CMMI | jberg@nsf.gov |
| Rosa “Ale” Lukaszew | ENG/ECCS | rlukasze@nsf.gov |
| Sridhar “Sri” Raghavachari | BIO/IOS | sraghava@nsf.gov |
| Edda “Floh” Thiels | BIO/IOS | ethiels@nsf.gov |
| Ken Whang | CISE/IIS | kwhang@nsf.gov |

*U.S. Air Force Office of Scientific Research (AFOSR):*

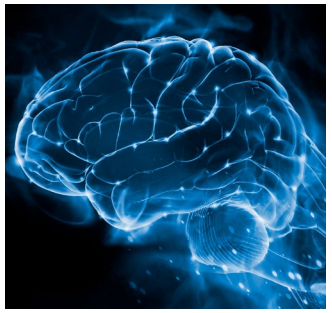
| | | |
|---|---|---|
| Hal Greenwald | Program Officer | neuroscience@us.af.mil |

# BRAID Goal: Achieve unique features of biological learning and decision making for AI

Apply dynamical neuroscience to close the gap in performance and efficiency

- Adaptability
- Flexibility
- Energy efficiency
- Data efficiency
- Continual learning
- One/zero-shot learning
- Causal learning
- Lifelong learning

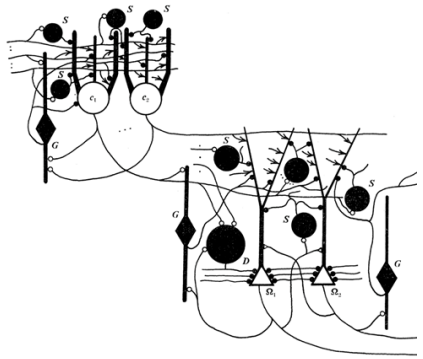
12-20 W



10 MW

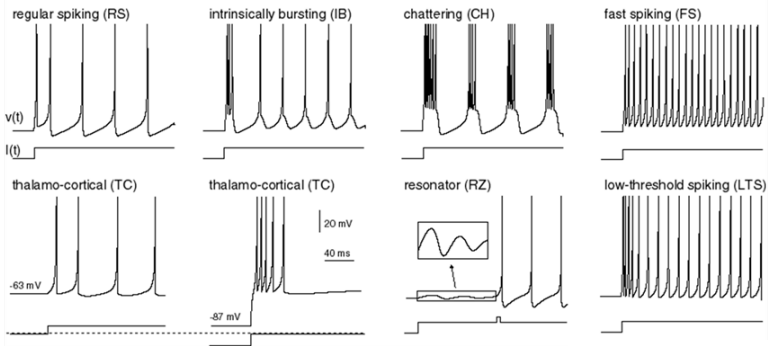

The brain uses a diversity of cell types, neural codes, and self-activation mechanisms across many spatiotemporal scales that remain unexplored in AI/ML

**Sparsity** and **cell types**



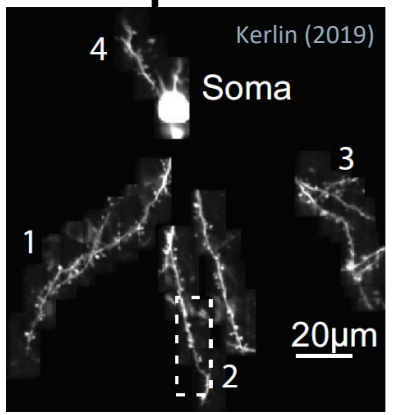
Marr (1971)

**Temporal dynamics (ms – days)**



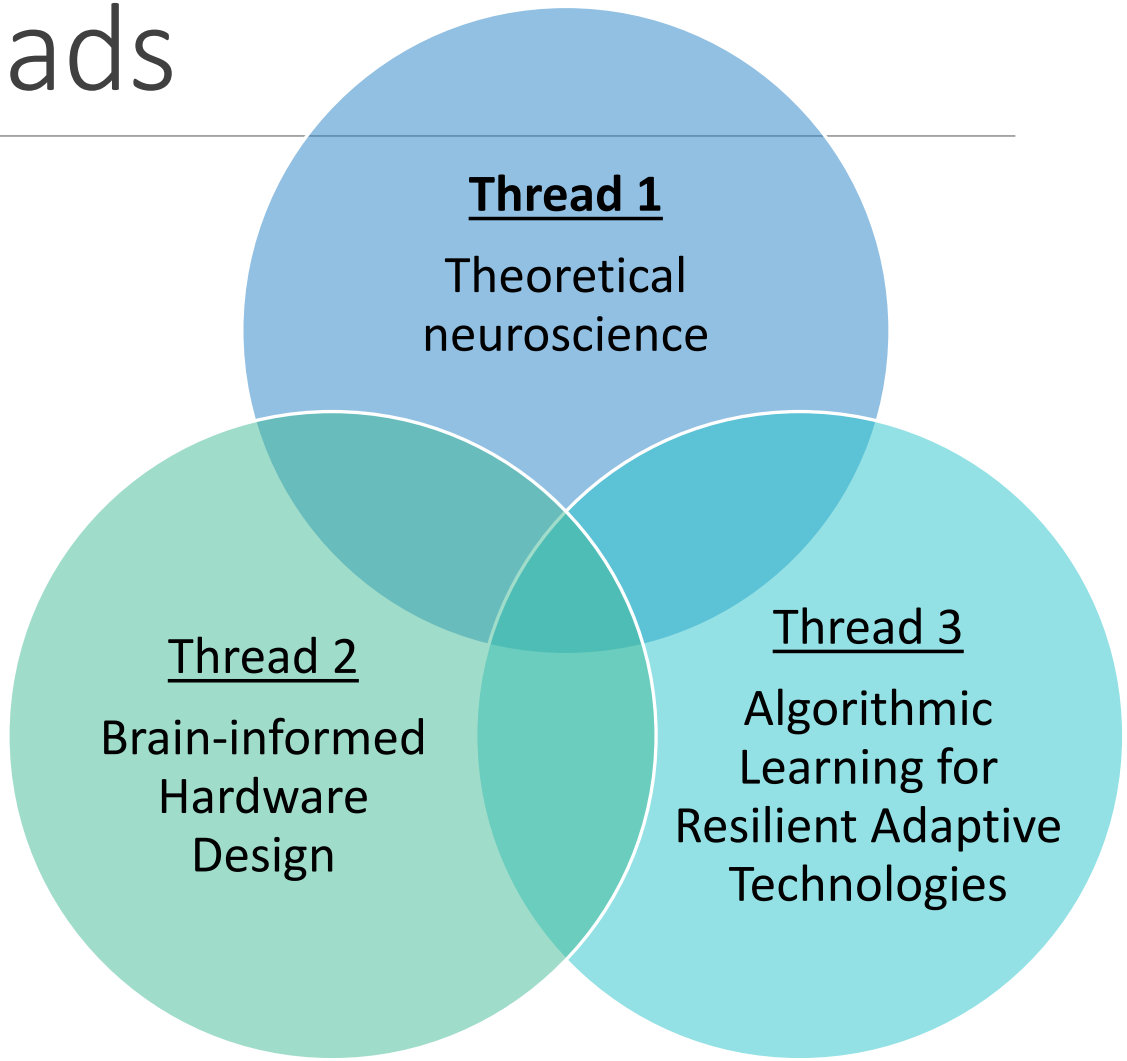

Izhikevich (2007)

**Subcellular computation**



# BRAID: Research Threads

- Proposals should demonstrate how principles of biological intelligence can be translated to engineered learning systems in the context of situated relationships between **brain**, **body**, and **environment** by drawing from models and knowledge of theoretical neuroscience.
- Each BRAID proposal must address Thread 1 and at least one of the other threads. **Response to Thread 1 is mandatory.**



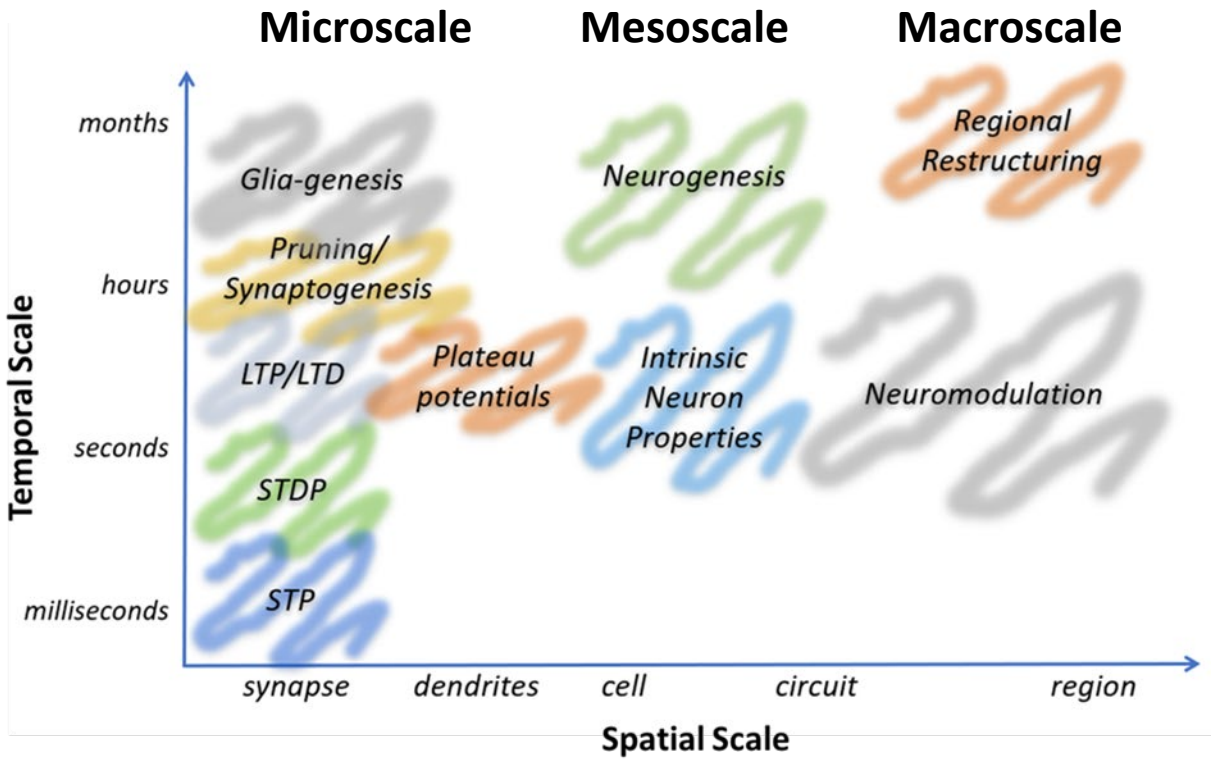
# BRAID Research Thread 1: Theoretical Neuroscience

Objective: Explore spatiotemporal mechanisms of biological learning based on experimental neuroscience, neurotechnologies, theories, and computational models of multi-scale interactions that explain complex observations in neural data across scales: microscale, mesoscale, and macroscale.

Goal: Incorporate concepts and insights from modern neuroscience via the creation of new theories to develop a new generation of engineered energy-efficient circuits and learning systems.

Desired Outcomes

- Distill neuroscience principles to inform the design of energy-efficient brain-informed hardware for learning (Thread 2)
- Create new theories for translation to algorithms and learning rules to achieve resilient adaptive technologies (Thread 3)




Adapted from J.B. Aimone, Neural Algorithm and Computing Beyond Moore's Law, Communications of the ACM 2019.

# BRAID Research Thread 2: Brain-informed Hardware Design

Objective: To create new classes of hardware that can support learning with the extreme energy and data efficiency characteristic of biological systems.

Goal: To extract the principles by which biological learning occurs through dynamic processes arising in neuroanatomical structures and to create engineering analogs of those processes and structures.

Desired Features

- Co-design of novel learning circuits with innovative models of learning based on theoretical neuroscience is required.
- Beyond neuromorphic engineering is highly encouraged.
- Incorporation of innovative sensor, circuitry and actuation technologies with new learning is in scope.
- Exploration of novel material systems and multifunctional devices with convincing pathways for learning is in scope.
- Use of software simulators in lieu of hardware fabrication is permissible.

# BRAID Research Thread 3: Algorithmic Learning for Resilient Adaptive Technologies

Objective: To translate theories and models of biological learning into engineered learning systems with extreme data efficiency and adaptive resilience in dynamic environments.

Goal: To achieve real-time sensing, learning, decision-making, and prediction in novel, uncertain, and rapidly changing conditions, driven by small amounts of data over short time horizons.

Desired Features

- ❑ Accommodate data of variable sparsity, size, modality, and distribution.
- ❑ Create compatible frameworks for uncertainty quantification.
- ❑ Trade off context-dependent constraints versus performance.
- ❑ Improve capability for out-of-distribution generalization.

# BRAID: Requirements [1 of 2]

- Proposal team should be engineering-led and include other disciplines.
- Theoretical neuroscience expertise is mandatory.
- Proposals are required to integrate ethical considerations and implications of their research including research integrity, diversity of the research team, and societal impacts. Include scientific or engineering analysis of ethical and societal implications in the research plan and broader impacts.
- Proposals should
  - include quantitative performance metrics and a rigorous validation plan. Validation plan can be based on experiments, analytic solution, or simulation.
  - advance fundamental understanding in two or more disciplines as they relate to at least two out of the three research threads.
- Interactions between engineers and neuroscientists must be lasting throughout the period of performance culminating in a transdisciplinary demonstration by the end of the project.

# BRAID: Requirements [2 of 2]

- Metrics of Performance: All BRAID projects must formulate quantitative metrics to evaluate the new engineered learning systems with respect to alternative learning approaches. **Energy metrics alone are insufficient**.
- Experimental Verification: All BRAID projects must involve experiments that demonstrate realistic continual, causal, or other forms of learning in **data-sparse** environments for each project's resilient adaptive learning algorithms and/or hardware platforms.
- Experimental demonstrations that exemplify the societal benefits of engineered learning systems are encouraged, e.g., in the domains of: autonomous systems, rehabilitation, manufacturing, or technologies that boost U.S. competitiveness.
- Neuroscience Inspiration: Proposals must clearly identify which principles of biological learning from neuroscience are the basis of their proposed engineered learning system
- **Proposed projects must address at least two of the three threads. Thread 1 is mandatory.**

# BRAID: Additional Resources

**Neural Datasets:**

http://brain-map.org/

http://crcns.org/

https://neuinfo.org/rin/suggested-data-repositories?p1=SCR_006770

https://nda.nih.gov/about/about-us.html

https://www.microns-explorer.org/cortical-mm3

https://www.nwb.org/

**Cloud Computing:**

Proposals may request cloud computing resources to use public clouds through CloudBank (https://CloudBank.org)

Contact Deepankar Medhi at dmedhi@nsf.gov or 703-292-2935 if you have questions about CloudBank.

**Hardware:**

Access to hardware is available through NSF's National Nanotechnology Coordinated Infrastructure (NNCI) https://nnci.net/

Contact Larry Goldberg at lgoldber@nsf.gov or 703-292-8339 if you have questions about NNCI.

**Ethical Research:**

https://www.nsf.gov/bfa/dias/policy/rcr.jsp

https://onlineethics.org

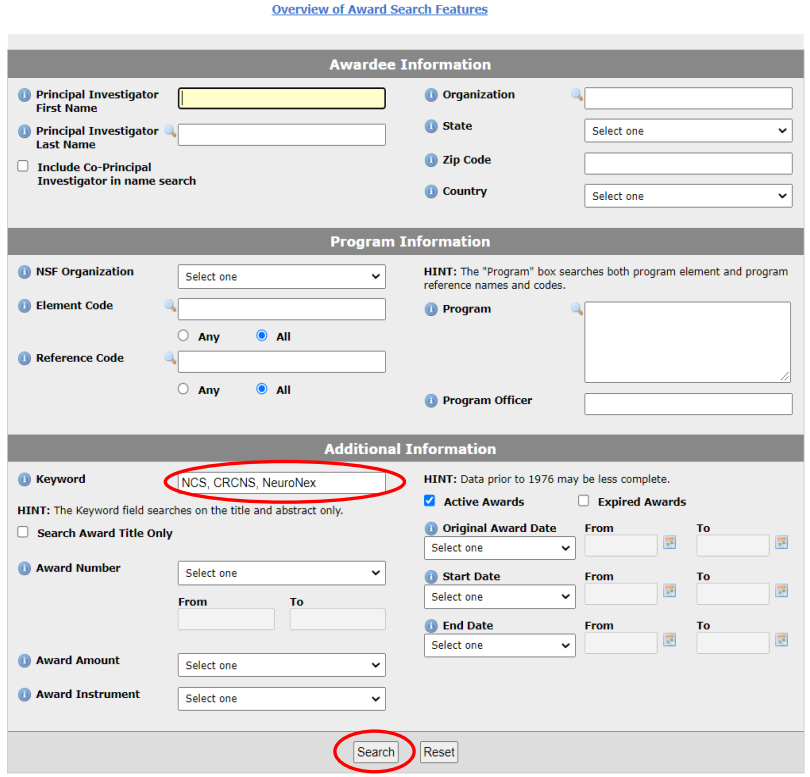
https://braininitiative.nih.gov/brain-programs/neuroethics

# Finding experts in neuroscience

You may wish to visit the US BRAIN Investigator's meeting at https://www.braininitiative.org/events/pimeeting/

Or go to the NSF public advanced search engine: https://www.nsf.gov/awardsearch/advancedSearch.jsp

Enter 'NCS, CRCNS, NeuroNex' in the Keyword field and hit 'Search'.

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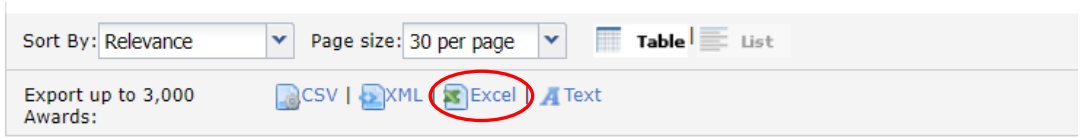

# Solicitation Requirements

# Award Size and Information

Team Proposals Only:

- 3-5 PIs/co-PIs

Award size will depend on the type of research program proposed

Up to 4 years in duration

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

Up to $30M in FY 2022 for entire competition, subject to availability of funds

# Eligibility: PIs & co-PIs

**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

**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://www.nsf.gov/pubs/policydocs/pappg22_1/pappg_2.jsp#IIE5

# No Collaborative Proposals

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. FastLane will automatically provide a cumulative budget.*

- *Preliminary proposals should not include separate subaward budgets; however, the budget justification should include planned levels for subawards to any partner organization(s). Enter the anticipated total level of subaward support on line G5, Subawards*

# Broadening Participation Plan

ENG promotes diversity in all aspects of its programs.

As part of the EFRI 2022/23 Solicitation, EFRI requires all projects to include a Broadening Participation Plan.

The goal is to increase the participation of underrepresented groups in the field of engineering and in engineering research.

Promoting diversity in the human resources engaged in the EFRI projects should concomitantly expand diversity of thought, ideas, and approaches to defining and solving important research questions.

# Broadening Participation Activities: Examples

- 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 apply for post-award supplements to engage undergraduate researchers and teachers, using REU & RET supplements; or to apply for REM supplements to diversify EFRI research teams
- Engagement of faculty and/or student researchers at minority serving institutions, community colleges, or high schools in the research project
- Enhancement of/collaboration with existing diversity programs at your home institution and/or nearby institutions
- Senior Personnel serving as role models and mentors for an underrepresented student population
- Providing tutoring opportunities for underrepresented middle school, high school, and undergraduate students
- Outreach activities that will interest and attract underrepresented K-12 students to engineering undergraduate programs

# A Letter of Intent (LOI) Is Required
# Due Date: November 10th, 2021

A Letter of Intent is REQUIRED

One Page

1. **TITLE** - Title of the EFRI proposal preceded by the words “EFRI ELiS:” or “EFRI BRAID:” 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 (only for LOI):

- Sponsored Projects Office (SPO) Submission is **not** required
- A Minimum of 2 and Max. of 4 Other Senior Project Personnel (co-PIs)
- A Minimum of 0 and Max. of 3 Other Participating Organizations

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

A Letter of Intent is REQUIRED

**Submission of multiple LOIs by PIs is NOT permitted**

# Preliminary Proposals Are Required
# Due Date: December 16th, 2021

Must be submitted through FastLane and meet formatting requirements in NSF Proposal & Award Policies and Procedures Guide (PAPPG) https://www.nsf.gov/pubs/policydocs/pappg22_1/index.jsp

Project Summary (one page limit)

Preliminary proposals that do not separately address both intellectual merit and broader impacts in the Project Summary will be returned without review

Project Description (five page limit) includes:

1. Vision and Goals (~1 page)
2. Approach and Methodology ( ~3 pages)
3. Transformative Impact (~1 page). Describe the transformative aspects of the project including how the synergy of experts from different disciplines will achieve a significant advancement of fundamental engineering knowledge and will have strong potential for long term impact on a national need or grand challenge. **Include a succinct statement of your preliminary Broadening Participation Plan.**

References Cited; Biographical sketches; Budget; Current/Pending Support

# Preliminary Proposals Are Required
# Due Date: December 16th, 2021

Must be submitted through FastLane and meet formatting requirements in NSF Proposal & Award Policies and Procedures Guide (PAPPG)
https://www.nsf.gov/pubs/policydocs/pappg22_1/index.jsp

Supplementary Documentation:

- List of key personnel; Collaborators & Other Affiliations Information
- A single PowerPoint slide summarizing the vision of the EFRI proposal. This will be used during review panel discussions of the Preliminary Proposals.

# Full Proposals Will Be Invited By Mid-Feb, 2022
# Submission Due Date: March 10th, 2022

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

Proposal budget must include funds for travel by 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
# Submit Via FastLane

## 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

## 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

Required Letters of Intent due on **November 10, 2021**

Preliminary Proposals due on **December 16, 2021**

Based on the reviews, a limited number will be invited **by mid-February 2022** to submit full proposals.

Invited Full Proposals are due on **March 10, 2022**

Invited Full Proposals will be reviewed in **Spring/Summer 2022**

# Review Criteria

NSB-approved Merit Review Criteria

- Intellectual Merit
- Broader Impacts

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

- Integration of Research and Education
- Integrating Diversity into NSF Programs, Projects and Activities

# Review Criteria:
# EFRI Solicitation-Specific

**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 **Specific Programmatic Considerations** for each topic?

**Broadening Participation Plan -** Does the plan actively promote, increase, and enhance the participation of underrepresented groups in the field of engineering and in engineering research?

Effectiveness of the proposed **Management Plan.**

# EFRI-2022/23 (NSF 21-615)
# Important Solicitation Dates

| | |
|---|---|
| Oct 15th, 2021 | Informational Webinar |
| Nov 10th, 2021 | Letter of Intent Due (required) |
| Dec 16th, 2021 | Preliminary Proposal Due (required) |
| Mar 10th, 2022 | Full Proposal Deadline (by invitation only) |

# Questions

**EFRI2022@nsf.gov – EFRI-specific questions**

**ELiS@nsf.gov – ELiS-specific questions**

**BRAID@nsf.gov – BRAID-specific questions**

# Program Guidance: Participation Limit

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

# Program Guidance: Co-PI Limit

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

You may include additional senior personnel beyond the maximum 5 PI/coPIs; there is no formal limitation on the number of additional senior personnel.

# Program Guidance: Engineer PI/co-PI

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

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.E.5.
https://www.nsf.gov/pubs/policydocs/pappg22_1/pappg_2.jsp#IIE5

# Program Guidance:
# Co-PI from a National Lab

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.

Preliminary inquiry must be made by sending an email to the relevant Program Director that explains the unique capability of the FFRDC or national laboratory. If permission is granted, a written statement from the cognizant NSF PO must be submitted as part of the preliminary and final proposal submission.

# Program Guidance:
# Co-PI from a non-US institution

The NSF Proposal & Award Policies and Procedures Guide (PAPPG) NSF22-1, Chapter I.E.6 states:

"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."

Preliminary inquiry must be made by sending an email to the appropriate Program Director that explains the unique capability of the foreign organization. If permission is granted, a written statement from the cognizant NSF PO must be submitted as part of the preliminary and final proposal submission.

# Program Guidance: Consultants

Professional engineers can be consultants on an EFRI proposal

# Program Guidance: Participating Institutions

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

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 per topic.

# Program Guidance: LOI Format

Letter of Intent must be submitted using Fastlane.

Fastlane 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 Fastlane.

# Program Guidance:
# ELiS - Addressing Multiple Threads

All ELiS proposals need to fully comply with the Foundational Research components.

It is strongly encouraged that proposals focus on only one Research Thread.

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

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 annual DCL)

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

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

# Acronyms and Terminology

| | | | |
|---|---|---|---|
| **BIO** | Directorate for Biological Sciences | **CBET** | Division of Chemical, Bioengineering, Environmental & Transport Systems |
| **CHE** | Division of Chemistry | **CMMI** | Civil, Mechanical & Manufacturing Innovation |
| **COA** | Collaborators and Other Affiliations | **Co-PI** | Co-Principal Investigator |
| **DMR** | Division of Materials Research | **DOE** | Department of Energy |
| **ECCS** | Division of Electrical, Communications and Cyber Systems | **EEC** | Division of Engineering Education and Centers |
| **EFRI** | Emerging Frontiers in Research and Innovation | **EFMA** | Office of Emerging Frontiers and Multidisciplinary Activities |
| **ENG** | Directorate for Engineering | **IIP** | Division of Industrial Innovation and Partnerships |
| **MCB** | Division of Molecular and Cellular Biosciences | **MPS** | Directorate for Mathematical and Physical Sciences |
| **NIST** | National Institute of Standards and Technology | **NSB** | National Science Board |
| **NSF** | National Science Foundation | **PAPPG** | Proposal & Award Policies & Procedures Guide |
| **PHY** | Division of Physics | **PI** | Principal Investigator |
| **SBE** | Directorate for Social, Behavioral and Economic Sciences | **SES** | Division of Social and Economic Sciences |

# Key website

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

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

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