NSF Graduate Research Fellowship Program (GRFP)

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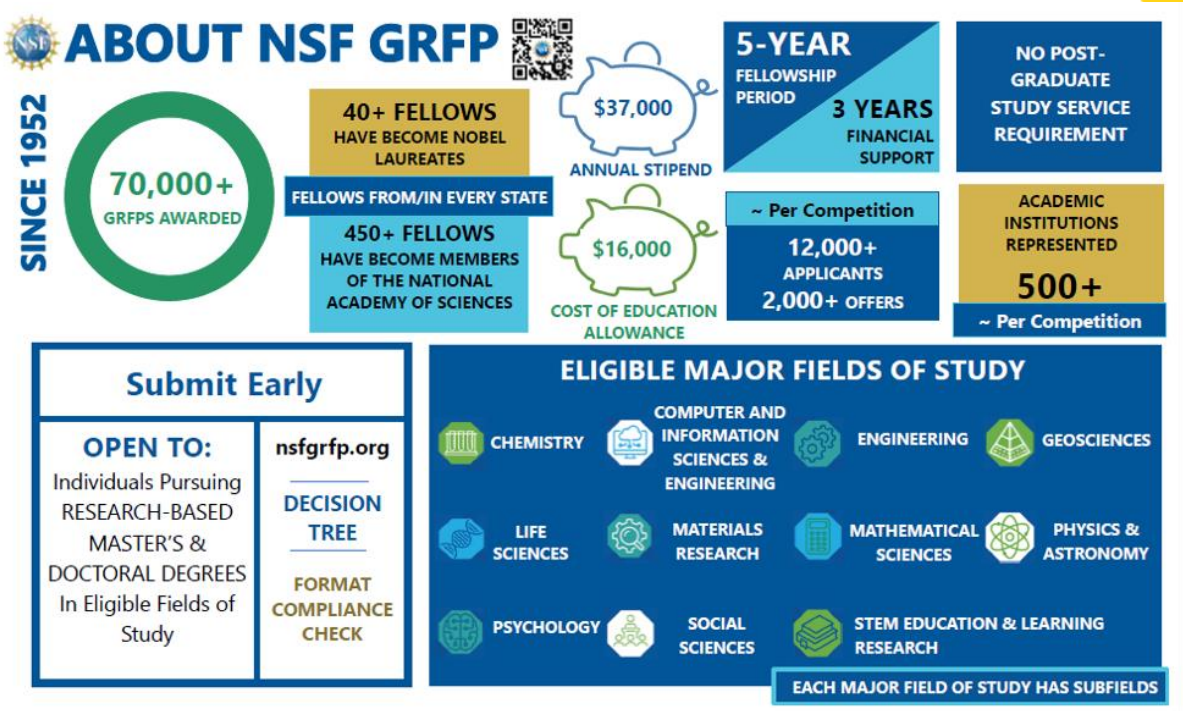
Today's Agenda

- What is the GRFP and why should I apply?
- Eligibility
- Writing the Personal, Relevant Background and Future Goals Statement
- Writing the Graduate Research Statement
- Other components of the application
- Questions/Discussion

What is the GRFP? Why should I apply?

- Goals: "(1) to select, recognize, and financially support early-career individuals with the demonstrated potential to be high achieving scientists and engineers; and (2) to increase participation in science and engineering of the full spectrum of talent in the U.S."
- Awarded to your **institution**. Cost of education allowance covers tuition, mandatory fees
- Honorable Mention is also a significant accomplishment
- Typically due in mid-October, **this year due in early-mid November** (deadline varies by discipline)



Link: NSF GRFP Program Page

Award Information

- 3 years of financial support (in 12-month allocations) usable over a 5-year fellowship period
- Fellowship is transferrable to another institution if awardee chooses to transfer schools
- $53,000 per year ($37,000 Graduate Research Fellowship stipend, $16,000 Cost of Education allowance for tuition and mandatory institutional fees)

Basic Eligibility for NSF GRFP

- Be a U.S. citizen, national, or permanent resident (“green-card” holder)
- Intend to enroll OR be enrolled full-time in a research-based Master’s or doctoral degree program in an eligible field of study in STEM or STEM education
- Never previously accepted a GRFP award
- **Have completed <u>less than one academic year</u>** (according to institution’s academic calendar) **in a graduate degree program** (non-degree coursework does not count and must be clearly identified in transcript)*

*This means that you must apply as either an undergraduate senior, a Bachelor’s degree holder with no prior graduate degree program enrollment, an individual enrolled in a joint bachelor’s-master’s degree program with at least 3 undergraduate years completed, or a first-year graduate student in your first graduate degree program with less than one academic year completed. **Second year graduate students can no longer apply.**

How many times can I apply for the GRFP?

- Undergraduate seniors (final year of undergrad program) and Bachelor's degree holders who have never enrolled in a graduate degree program: **unlimited**
    - **Must be ready to go to graduate school:** confirmation of acceptance in a graduate degree program is required at time of award ***acceptance***. Must enroll in a graduate program that most closely corresponds with the Major Field of Study chosen in your GRFP application no later than fall of the award acceptance year
- Currently enrolled graduate students in their first year of graduate school: **1 time**
- Individuals applying while enrolled in a joint Bachelor's-Master's degree program (after having completed 3 years in the program): **1 time**
- **Eligible applicants may only submit one application per annual competition**

Is my graduate program eligible for the GRFP?

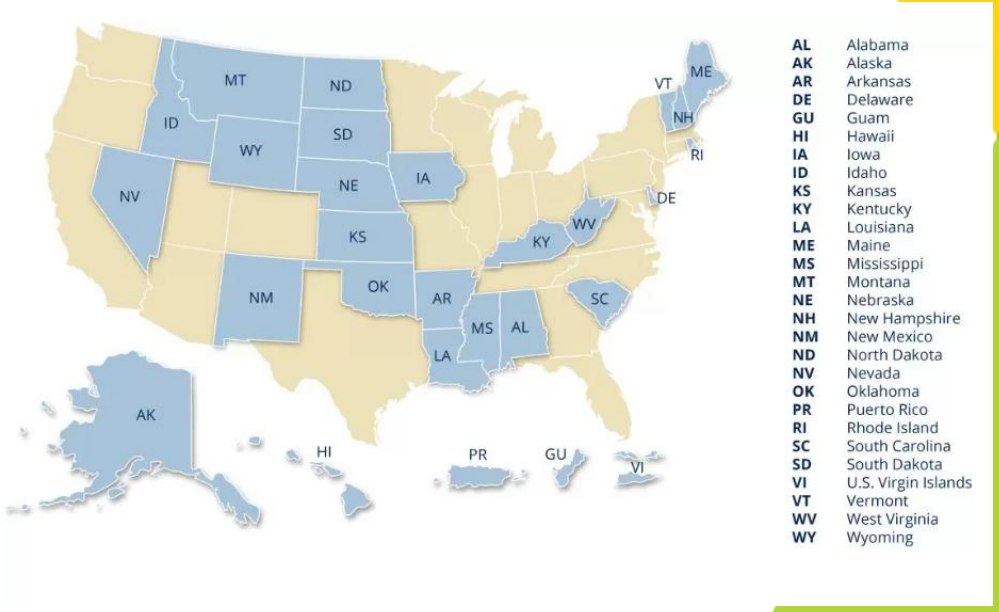
- **Eligible degree programs:** research-based Master's and doctoral degrees in STEM or STEM education
- **Ineligible degree programs (includes currently enrolled/plan to enroll OR on a leave of absence):**
  - Business Administration
  - Public Health, Medicine, Pharmacy, Veterinary Medicine, Dentistry, Clinical Psychology
  - Social Work
  - Law
  - Any practice-oriented professional degrees or programs that include practice-oriented, clinical, or professional training requirements
  - Joint or combined professional degree-science programs (e.g., MD/PhD, JD/PhD) or dual professional degree-science programs

Is my proposed research eligible for the GRFP?

- **It depends on the overarching project goal…**
- In general, clinical or patient-oriented research is not eligible, e.g., if the goal of the research is directly related to human disease/medical practice
- The research should advance fundamental (not applied) knowledge in a STEM field
- Biomedical engineering and materials research is eligible as long as it applies engineering or materials science principles to problems in medicine while fundamentally advancing engineering or materials science knowledge
- Plant pathology research may be ineligible if the goal of the project is to maximize food production or impact food safety (rather than addressing a basic question in plant bio)
- Research can have implications on policy, but the goal should not be to influence policy

GRFP Honorable Mention

- Honorable Mention is awarded to GRFP applicants whose applications were not QUITE strong enough to make the cut for a funded Graduate Research Fellowship
- In NSF's Established Program to Stimulate Competitive Research (EPSCoR) states, ***academic institutions*** can apply to the new NSF EPSCoR Graduate Fellowship Program (EGFP).
- If the application is successful, the institution is awarded funding to provide 3-year graduate fellowships to new or continuing students who received the NSF GRFP Honorable Mention distinction within the last 3 years



The GRFP Application

1) Personal Information; Education, Work and Other Experience; Proposed Field of Study; Proposed Graduate Study and Graduate School Information

2) Personal, Relevant Background and Future Goals Statement (3-page PDF)

3) Graduate Research Plan Statement (2-page PDF)

4) Official transcripts for all degree-granting programs

5) Letters of Recommendation (provide at least 3 letter writer names with email addresses)

Proposed Graduate Study and Graduate School Information

- Choose major field of study carefully! You will be required to remain in this field
- See Appendix of the GRFP solicitation for a long list of major fields and sub-fields that you can choose
- If you do not yet know what graduate institution you will be attending, don't worry – while your Major Field of Study must be consistent with the one specified in your application, you do not need to attend the proposed institution

The Personal Statement

- A critical component of the application that provides a narrative overview of your academic and professional journey, research interests, and future goals
- This is an opportunity to present yourself **holistically** to the review panel and allows reviewers to understand you beyond your CV and transcripts. You can provide context for your academic and research achievements and showcase your personality, motivations, and unique experiences
- Demonstrates how you fit with NSF's goals, including your potential to contribute to scientific advancement and societal benefits
- This can distinguish you from other applicants with similar qualifications and highlight your ability to communicate effectively (a crucial skill for researchers)

NSF Merit Review Criteria: Intellectual Merit

- ***Your*** potential to *advance knowledge* and understanding in your field and/or across fields
- Demonstrated intellectual ability (grades, curricula, awards, publications, presentations, etc.)
- Other evidence for your potential, such as ability to:
  - Plan and conduct research
  - Work as a member of a team as well as independently
  - Interpret and communicate research
  - Take initiative, solve problems, persist.

NSF Merit Review Criteria: Broader Impacts

- Your potential to benefit society and contribute to specific, desired societal outcomes, which include (but are not limited to):
  - **Increasing participation** for all
  - **Outreach**: mentoring, improving STEM education in schools
  - Increasing **public science literacy**, increasing public engagement with STEM
  - **Community outreach**: science clubs, radio, TV, newspapers, blogs
  - Potential to impact a **globally competitive workforce**
  - Increasing **collaboration** between academia, industry, and others

ARIS Broader Impacts Wizard:
https://aris.marine.rutgers.edu/wizard/intro.php

Getting Started on your Personal Statement

- Brainstorm and free-write – 5 mins
    - ***Prompt: What are several events in your life that you think someone needs to know in order to understand who you are as a person, as a scholar, and as an applicant?***
- Organize: pick out what fits within the program and devote more time to writing about those topics
- Edit: move text around to form a chronological, sensical narrative

Suggestions:

Do:

- Create a unique narrative
- Make it interesting to read – personal, honest, revealing, shows your excitement for research
- Describe actions rather than changes to your mental/emotional state
- Be specific, quantify where you can
- Point out how you fulfill Intellectual Merit and Broader Impacts
- List concrete achievements like research, teaching, awards, publications, etc.

Don't:

- Write your resume in essay form
- Reveal TOO much (not a diary entry)
- Include "one-off" things
- Use too much passive voice
- Be negative or cynical
- Boast, brag, or beg

Organizing the Personal Statement

- Powerful, attention-catching introduction
- Your experiences (the “what”) and their value or meaning (the “why”)
    - Must use headings “Intellectual Merit” (How have you advanced knowledge?) and “Broader Impacts” (How have your past experiences prepared/informed you of societal need?)

Vague vs. Concrete Experiences

Vague:

- "During this project, my mind was opened to the possibility of using different languages to create code faster."
- "I showed initiative…I am innovative, diligent, and motivated."
- "During my first year, I became a more curious and capable scientist."
- "I won the Brennan Award."

Concrete:

- "During this project, I collaborated with four other group members to develop a user-friendly Python wrapper for a 10,000-line Fortran library."
- "Frustrated with the direction of my first project, I consulted with my faculty mentor and proposed an entirely new project."
- "I explored the literature and proposed alternative procedures to make the experiment more efficient."
- "I won UVM's prize for top undergraduate summer research proposals (I was chosen from among 78 applicants in the biomedical research field."

When editing/revising, ask…

- Did I show rather than tell?
- Have I revealed who I am?
- Did I show fit for the NSF GRFP?
- What is the point of my story?
- Did I tell my story well or is it missing something?
- Do I need to edit any of this content out completely? (You have very limited space – what isn't adding to the narrative?)
- Did I label the Intellectual Merit and Broader Impacts sections?

Writing Your Research Plan

- Describe your proposed research plan using this general outline:
  - Communicate your research idea and approach.
  - Explain your research plan and methods.
  - What do you expect to learn? How will you know if your project is successful?
  - What would you do next?

Like the Personal Statement, this is a story/narrative!

Example Outline

1. Introduction (doesn't need a section title unless you want to include one – some use "Abstract" or "Overview and Objectives")
    - 3-5 sentence summary of what you'll cover in your Research Plan (problem/knowledge gap you will address, goal statement, specific objectives)
    - *Optional:* list several **Keywords** (words or phrases that quickly characterize your work)

Example Outline

2. Background

- Introduce the current state of research in field you will study (cite ***relevant*** literature)
  - Cite recent publications if you can (published in last 5 or so years)
- Introduce the problem or gap in knowledge that your work will address
- Describe recent work you've done, conveying that what you plan to do is a logical next step

Example Outline

3. Objectives (break into sections for each objective)

- State **what you aim to do** and your **general approach** before going into detail about the methods you'll use (small methodological details are less important than overall approach)
- If you can, include a figure depicting how the objectives are connected under the overarching goal. This is a good resource for diagrams: https://app.diagrams.net/.

Example Outline

Constructing your objectives:

- Generally, avoid objectives that are dependent upon each other's success.
- State what you expect the outcome of each of your objectives to be.
- It's better to identify potential problems and provide reassurance or alternative approaches rather than pretend they're not there.

Example Outline

Constructing your objectives:

- Avoid vague language like “gain understanding about”, or “study”. If you turned your objective into a question, would you be able to tell whether you did what you set out to do? Is there a specific/quantifiable outcome/output that indicates success?
    - Example: “Objective 1: Study gene expression patterns that predict worker ants’ roles.” vs. “Objective 1: Identify the gene expression patterns that predict worker ants’ roles.”

Example Outline

4. **Intellectual Merit**: How is your research advancing the field?

5. **Broader Impacts:**

- What are the inherent societal benefits of your research?
- What activities do you plan to do to enhance the societal benefits of your research?

Example*

concise title

Information-Theoretic Design of Novel Biological Machines

Abstract. Current robots and AIs excel in highly structured environments but cannot adapt to unforeseen circumstances. Living systems, in contrast, are exceedingly robust, adaptive, and self-organizing, providing ideal material for the creation of autonomous adaptive robots. This proposal builds on recent computational work from my lab, in collaboration with developmental biologists at Tufts, that pioneered the development of xenobots, the first Computer-Designed Organisms (CDOs). **Here, I propose to improve the rudimentary design algorithms of CDOs by utilizing information-theoretic signatures of desired behavior, observed in living systems, to guide AI-driven automated design of increasingly performant CDOs.**

Key Words: *evolutionary computation, artificial life, information theory, computer designed organisms*

Be brief: identify the crux of the research problem and the overarching goal of your plan

*Kindly shared by Caitlin Grasso – Computer Science Department

Example

Concisely demonstrate that you're well-read in the literature in your field

Background. Scientists recently introduced the creation of the first Computer-Designed Organisms (CDOs): xenobots [1]. Xenobots are designed in simulation by evolutionary algorithms to perform a desired task, and then built *ab initio* using *Xenopus laevis* stem cells. The living material from which xenobots are made naturally imbues them with robustness that is difficult to realize in artificial materials. For instance, xenobots automatically recover form and function after deep mechanical lacerations. However, because it is unknown how a collective of cells liberated from their morphological fate may act, initial work modeled cell behavior as random noise. This first study searched for body plans that could perform a desired behavior regardless of how cells interacted, and found robust designs in simulation that successfully transferred to reality. But selected behaviors were very simple, e.g. locomotion in a straight line. **My aim is to improve and refine the biological accuracy of computational models of xenobots, allowing more precise control over increasingly complex, and thus increasingly useful, desired behavior.** This proposal outlines a three-phase approach for automatically transferring evolved intelligence observed in nature into computational models using information theory.

Identify the **knowledge gap** (where the existing literature falls short) before stating your goal

Example

Lead with the purpose or objective of this part of the project

I. Reality to 2D Simulation. The first phase, already underway, draws on information theory to indirectly incorporate information dynamics extracted from *in vivo* analysis of xenobots into the evolution of 2D simulated organisms that exhibit desired behavior such as regeneration. Information theory is an attractive method to explore collective behavior due to its system- and task-independent nature [2], allowing for the automatic extraction of information dynamics from disparate systems (e.g., simulated and living) and subsequent comparison. I have already created a cellular model that approximates the development of biological organisms to predefined target shapes. Additionally, transfer entropy measurements have been distilled from videos of calcium signaling in xenobots as they attempt to recover their shape after physical damage. I will use this information to bias an evolutionary algorithm to discover simulated xenobots that not only achieve a specified morphology, but are also robust to damage and mimic the information dynamics deduced from the *in vivo* analysis of the living xenobots. Cellular automata provide a lightweight platform to rapidly test the incorporation of different information metrics as proof of concept.

Provide some justification for your approach

Example

How will you know if you're successful?

II. 3D Simulation to Reality. Information-theoretic objectives that prove useful in 2D simulation will be employed in the computationally intensive evolution of 3D virtual xenobots [1]. Algorithms will incorporate bi-objective optimization to (1) maximize task performance (e.g. locomotion), and (2) mimic information dynamics observed in the biological agents. Biologists at Tufts University will assemble the most promising designs from biological tissues. Progress will be evaluated based on how well the best design transfers to reality as compared to xenobots evolved without the added information metrics.

III. Iteration. Phases I and II represent a complete design iteration (real-to-sim, sim-to-real) whereby information is extracted from CDOs and used to inform the automatic design of the next generation to improve transferability and fine-grained control of *in vivo* behavior (Figure below). Iterating this loop will allow refinement of biological constraints useful in producing predicted behavior. Ultimately, various biological phenomena, expressed as information signatures, could guide the automated design of xenobots

Purpose of this phase

Use figures when you can!

Example

Allude to future research

capable of a wider variety of tasks. While this first iteration focuses on extracting transfer entropy measurements between cells that inform our understanding of xenobots' robustness to damage, this strategy could be extended, for example, to investigate information dynamics between xenobots in a collective that could be used to promote self-organizing behavior in the design of xenobot swarms.

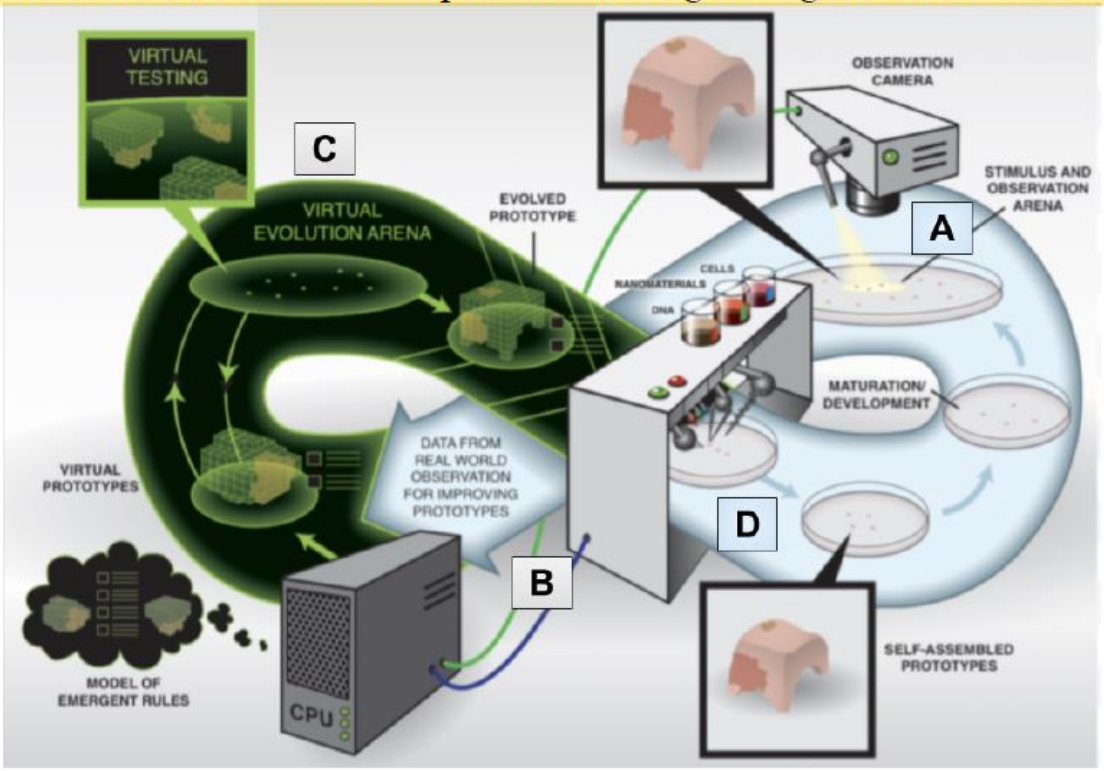


Figure 1. Sim-to-real, real-to-sim cycle. *In vivo* behavior of computer-designed organisms (CDOs) is observed (**A**). Information dynamics are extracted and incorporated into the evolutionary design algorithm (**B**) to bias the search toward virtual agents that both maximize a target objective (e.g. locomotion) and mimic information dynamics deduced from real-world observations (**C**). Most performant designs are constructed from biological material (**D**). The *in vivo* behavior of the new CDOs is observed and the cycle repeats.

Example

Clearly state the contribution of your work to the field (should fill the knowledge gap identified in your background section)

Intellectual Merit. This work is positioned within a greater research effort connecting institutions (UVM, Tufts, and Arizona State University) and disciplines (computer science, developmental biology, information theory, robotics, AI and complex systems) that represents an orthogonal approach to traditional AI and robotics. This work's contribution lies in the exploitation of *in vivo* information dynamics to yield more reliable, robust, and adaptive behavior in novel organisms. My formal training in computer science and biomedical engineering make me an ideal candidate to pursue this work, and has provided me with a solid foundation to apply computational skills to developmental and synthetic biology. Importantly, I have access to and am familiar with the Vermont Advanced Computing Core, providing for GPU-accelerated computation to carry out the proposed work.

Describe **your** intellectual merit as a researcher, and how institutional resources at your grad program (if you know it) will help you complete your project successfully

Example

Describe contributions to society outside of your specific field (***broader*** impacts)

Talk about your future research goals too, and their societal impact

Broader Impacts. CDOs are biocompatible and biodegradable making them strong candidates for drug delivery systems and environmental remediation. This research may also contribute insights on cellular processes that produce macroscale form and function, potentially benefiting the study of developmental diseases. Although such future applications appeal to my goals of combining an engineering mindset with biomedical technologies to help people, I am also fascinated by the basic science I could pursue: the novel approach to transfer knowledge from biological to virtual agents in an automated fashion could be used to extract information from a variety of living systems to glean insight into universal information signatures of adaptive systems. This could guide construction of future robots and AI systems whether they are built from biological materials, artificial materials, or combinations of both. The creation of CDOs also raises important ethical concerns. As part of my research plan, I will build on previous work that considered the ethics of CDOs [3]. This will involve collaborations with philosophers and social scientists to better understand the responsibilities of computer scientists in the early development of living technologies.

List a variety of broader impacts, as long as they have a clear relation to the proposed work

If your work could have negative impacts, you can address how those will be mitigated

A few more tips…

- Keep in mind:
  - Avoid jargon.
  - Communicate clearly for non-specialists.
  - Make your contributions clear.
- Be sure to address NSF's Merit Review Criteria (Intellectual Merit and Broader Impacts) under separate headings.
- Follow formatting instructions exactly as published in the GRFP solicitation!

Transcripts

- TRANSCRIPTS ARE REQUIRED FOR ALL DEGREE-GRANTING INSTITUTIONS. Must list undergraduate institution and may include transcripts for all other institutions listed in Education section of application
- Check solicitation for more specific instructions

Reference Letters

- **May <u>not</u> be from your family members**
- Limited to **2 pages** each and must be signed by the letter writer (name, professional title, department, institution)
- Make sure your reference letter writers know about GRFP and NSF's Intellectual Merit and Broader Impacts criteria
- Ask if they think they know you well enough to write a strong letter
- Discuss with them why you think you're a good candidate for GRFP and provide application materials if you can (Personal Statement, Research Statement)

Reference Letters, cont.

- **2** reference letters are mandatory, must provide contact information (email) for at least **3** reference letter writers
- **Up to 5 reference letters permitted** (highly recommended – rank in order of preference, as top three will be considered for application). Letter writers will not be notified of ranking
- Check solicitation for specific letter formatting instructions
- Potential letter writers:
    - Research/thesis advisor
    - Lab manager/supervisor
    - Professors who know you well

Application Review Process

- Your application will be reviewed by disciplinary and interdisciplinary STEM experts
- Applications are assigned to reviewers based on **your chosen** Major Field of Study
- Prepare your statements with your audience in mind: reviewers have broad disciplinary expertise but may not be specialists
- Be sure to read the Application Review Information section of the GRFP solicitation and double check that your application fulfills the review criteria
- **Remember: you are only being reviewed against other applicants at your academic level**

Some Final Tips for Preparing Your Application

- Set aside dedicated time to prepare your application!
- Get any logistical stuff involving other people (like notifying reference letter writers) out of the way as soon as possible
- Keep the program solicitation by your side as you prepare your application
- Consult the FAQ page as needed

Resources

- Alex Lang's website – LOTS of GRFP proposal examples in various fields of study: Alex Lang - NSF Fellowship (alexhunterlang.com)
- Undergraduate Writing Center and Graduate Writing Center at UVM – one-on-one writing assistance appointments available
- NSF GRFP Solicitation – the official instructions!