The Dictionary of Common NSF Usage

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Whether you are a newcomer or an experienced researcher with NSF, you may have noticed that the language the agency uses in its solicitations and on its website constantly evolves and changes. In this sense, NSF's mantra of lying at the frontiers of scientific discovery applies both to the ideas it funds and to the language it uses to describe that frontier. ***Fluency in the language used by a funding agency can be exploited to gain additional marginal advantage in writing a successful research narrative***. By contrast, failure to learn an agency's language, either by ignoring that language or showing an indifference to it, can significantly reduce the competitiveness of a proposal. This can occur in several ways: for instance, it may impede your understanding of the solicitation, reduce the clarity with which you interpret the goals and objectives of the agency, and/or degrade the quality of your research narrative, particularly if you are not able to translate your ideas into the language of the funding agency when required.

It is the rare research narrative that does not offer several opportunities to echo the funding agency's language as a way of enhancing a proposal's merits. In this regard, "echo" does not mean "parrot." ***Fluency*** is the operative term here. Adopting the agency's preferred language must be done carefully and appropriately when describing your research. However, if you have not become comfortable with the agency's language, then you have lost an opportunity to gain another competitive advantage in the research narrative.

The recent changes to the NSF merit review process that went into effect this past January 14 offer one example of how NSF language is evolving (New Merit Review Website). Other instances of language change can be found in NSF solicitations, reports, workshops, and the like. Several key language changes at NSF have to do with the evolving definition of terms most often used to describe NSF expectations in solicitations, including broader impacts, innovation, synergy, societal goals, transdisciplinarity, and value-added benefits, among others. Whether you are writing a proposal to NSF or assisting with the development and writing of a proposal to NSF, it is important to keep in mind that ***fluency in NSF's language and terms will translate into a significant competitive advantage during your proposal's review.*** If NSF's language sounds "foreign" to you, then you need to make that language familiar as quickly as possible. The following examples of NSF terms represent a good starting point for this process. In occasional subsequent articles on this topic, more terms will be addressed that play an important role in the competitiveness of your proposals. Understanding and using these clearly and unambiguously will help you demonstrate a clear understanding of the agency's expectations.

Broader Impacts

As is the case with "societal benefits," the most convincing and compelling definition of **broader impacts** will be one that you ***self-define as a logical consequence of the research you propose*** and which you have clearly embedded in the context of that research. The most

effective definition of **broader impacts** will appear to emerge from the research you propose rather than from a repetition of apparently undigested NSF language. In fact, the revised review criteria that became effective January 14 were motivated by many examples of proposers who interpreted NSF examples of **broader impacts** as a mandatory listing of activities required in the project description, ***regardless of their relevance to the proposed research***. To avoid making this mistake, self-define **broader impacts** within the context of the proposed research, ensuring that the definition ***makes sense within that context***.

Any definition and discussion of **broader impacts** needs to begin with an understanding of how NSF defines **broader impacts** at the more general and more global scale (see below NSF quote), and then quickly contextualize it to the scale of your proposed research in a manner that grows out of what you propose. Too often, proposers waste precious time trying to find a prescriptive definition of **broader impacts** (or societal benefits) published by NSF, or attempt to use a pre-existing or "canned" description and force fit it to their particular proposal (see *Do Not Build Your Proposal Out of Spare Parts*, October 1, 2011). This never works. There is no easy way around the fact that the **broader impacts** narrative section (now mandatory under revised merit review criteria) in your proposal must be well thought out and make sense within the context of the research you propose. So review the NSF general discussion of **broader impacts** below, and then start the harder task of self-defining what broader impacts means within the context of your unique research. And remember, sometimes the outcome of your research itself may represent the most compelling **broader impacts** if you succeed in what you propose.

NSF: *"**Broader impacts** may be accomplished through **the research itself, through the activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project**. NSF values the advancement of scientific knowledge and activities that contribute to achievement of societally relevant outcomes. Such outcomes include, but are not limited to: full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education."*

Innovation

NSF's Strategic Plan for FY 2011 to 2016, ***Empowering the Nation through Discovery and Innovation***, focuses on using discovery and **innovation** to benefit large segments of society. The fact that **innovation** appears in the title of this strategic document shows the importance the agency places on this concept. To expand your working definition of what NSF means by **innovation,** familiarize yourself with the NSF Innovation Corps (I-Corps) program. It focuses on a set of activities and programs that prepare scientists and engineers to extend their focus beyond the laboratory in order to broaden the impact of select, NSF-funded, basic-research projects through **innovation**. While **innovation** is the focus of this program, ***it***

appears often as an important component of many NSF programs, making it essential to develop a definition of its meaning. NSF defines **innovation** as a way to help translate scientific and engineering discoveries into ***useful technologies, products and processes***.

The agency objective in advancing **innovation** is to address the fact that, while knowledge gained from NSF-supported basic research frequently advances a particular field of science or engineering, **some results also show immediate potential for broader applicability and impact in the commercial world**. Such results may be translated into technologies with near-term benefits for the economy and society. I-Corp, for example, combines experience and guidance from established entrepreneurs with a targeted curriculum that teaches grantees to identify valuable product opportunities that can emerge from academic research, and offers entrepreneurship training to student participants. NSF seeks to advance this topic through what it often refers to as "**innovation ecosystems**." The NSF investment in **innovation ecosystems** seeks to build on NSF's investment in fundamental research to offer academic researchers and students an opportunity to learn firsthand about technological innovation and entrepreneurship **to fulfill the promise of their discoveries**.

Societal Goals/Impacts/Benefits/Implications

NSF now specifically addresse**s societal goals** in the revised review criteria (effective January 14, 2013). The second of three guiding principles NSF recently published as part of the revised guidelines states: "*NSF projects, in the aggregate, should contribute more broadly to **achieving societal goals***." Moreover, ***the potential for the proposed activity to benefit society or advance desired societal outcomes*** is now one element of the five elements (described by NSF as "the things NSF cares about") that NSF reviewers and program officers are to consider under the new guidelines in evaluating how well proposals address both the Intellectual Merit and Broader Impacts criteria. Here again, a good working definition of what NSF means by **societal goals/impacts** is important to developing a competitive proposal.

Like the broader impacts criterion, advancing **societal goals** often presents a challenge for principal investigators to address in the research narrative, and often confuses proposers trying to understand NSF's expectations. This difficulty arises when principal investigators expect NSF to tell them precisely what the agency means by **Societal Goals/ Impacts/ Benefits/ Implications.** But this will never happen. In the end, the definition of **societal goals** and **societal benefits** as addressed in the research narrative needs to be organic to, or a logical extension of, the proposed research. Your specific definition of **societal impacts** needs to be ***incubated in the context of your research rather than from a prescriptive definition provided by NSF***. As in the case of broader impacts, NSF provides a generic sense of these terms with the expectation that they will be tightly mapped to the context of your particular proposal. Basically, NSF expects that the research team responding to the **societal benefits** requirements in any solicitation will do so through a process of thoughtful consideration of the implications of the research within the context of its presentation in the project description. Your **societal benefits** discussion should be a logical outgrowth of that within your specific context. ***The most convincing and compelling societal benefits statement definition will be the one you self-define in the context of your proposed research.*** This brings to mind the position in which Nobel physicist I. I. Rabi found himself after the end of WWII when he told his research

colleagues that they were facing deep budget cuts to the laboratory: "***Well, there is no more money available for equipment. Now we are going to have to start to think***." And so it will be for PIs deciding how to define and respond to NSF requirements related to **societal impacts**.

Transformative Research

Transformative research has become the mantra of many research agencies. However, it is advisable to recognize an agency-specific component to the definition. "Transformative research" means something different at NIH than it means at NSF, a difference that your research narrative will need to recognize. This article, will focus on the NSF definition of **transformative research** as addressed in the agency's 2007 report, "*Enhancing Support of **Transformative Research** at the National Science Foundation.* In this report, the National Science Board presented its findings and recommendations that NSF should enhance its ability to identify and fund **transformative research**. NSF has consequently adopted the following working definition for **transformative research**:

*"**Transformative research** involves ideas, discoveries, or tools that radically change our understanding of an important existing scientific or engineering concept or educational practice or leads to the creation of a new paradigm or field of science, engineering, or education. Such research challenges current understanding or provides pathways to new frontiers."*

Transformative research results often do not fit within established models or theories and may initially be unexpected or difficult to interpret; their transformative nature and utility might not be recognized until years later. Characteristics of **transformative research** are that it:

(a) Challenges conventional wisdom,

(b) Leads to unexpected insights that enable new techniques or methodologies, or

(c) Redefines the boundaries of science, engineering, or education.

Transformative research often results from a novel approach or new methodology. Thus, some (but not all) **transformative research** will be viewed as risky. An interdisciplinary approach to research often produces **transformative research**, but not all interdisciplinary research is transformative and not all **transformative research** is interdisciplinary. Although there is no set formula that produces **transformative research**, everyone seems to agree that "you know it when you see it." Additionally, the Advisory Committee for GPRA (Government Performance and Results Act of 1993) Performance Assessment (AC/GPA) identified awards it considered potentially transformative in the *Report of the Advisory Committee for GPRA Performance Assessment, FY2009*.

The following are examples of **transformative research**. The letters that follow reference the characteristics listed above:

- The continental drift model—at first controversial and then proved correct 50 years later based on new analytical methods and sampling of the ocean floor. (a)
- The discovery of metallic glasses, at first an obscure theoretical possibility that eventually made possible the operation of today's integrated circuits. (a)
- The idea that polar ice sheets could serve as neutrino detectors, originally tested in Greenland through an NSF SGER award. (a, b)
- The discovery of the widespread exchange of genetic information in the environment, both among microbes and between microbes and higher organisms, which alters

evolutionary changes such as in the development of disease resistance and revises our fundamental understanding of The Tree of Life. (a, b).

- Research into large-scale, hypertext web searches that eventually led to the creation of Google. (b)
- The use of magnetic resonance imaging as a tool for monitoring brain function, which greatly expanded the limits of behavioral research. (b)
- The cross-disciplinary coordination of investigations into cognitive simulation and pedagogical techniques that resulted in today's highly effective cognitive tutors. (b)
- The development of the Force Concept Inventory in Physics, which set a direction for improvement in education based on measurement of students' deep understanding of scientific concepts. (b, c)
- Research on Very Large Scale Integrated circuit design methodology that not only led to the microelectronic revolution's cell-phones, personal data assistants, and supercomputers, but also provided the intellectual framework of abstraction that pervades most of today's computer science. (c)
- The careful refinement of distance measures in the Universe, intended to fine-tune cosmological parameters, which instead gave rise to radically new physics, and the concept of dark energy. (c)