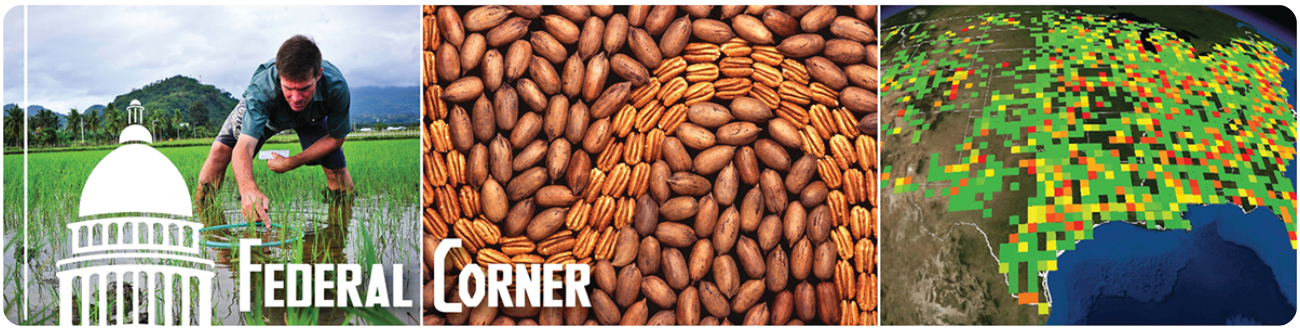
Science Societies

An earth science perspective on Pasteur's quadrant

NSF's mission in basic science includes applied research

By Jonathan G. Wynn

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Jonathan G. Wynn

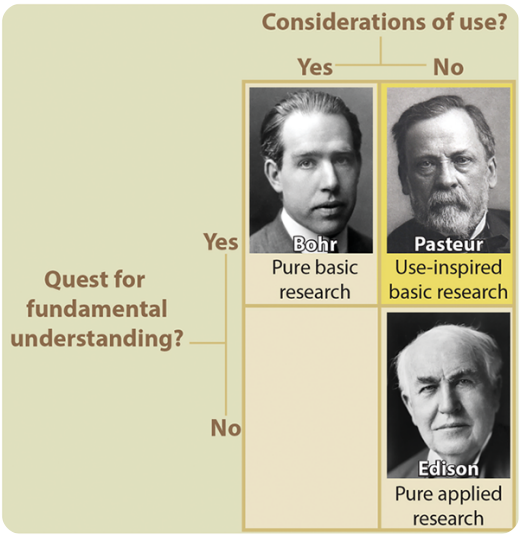
The legislation that created the National Science Foundation (NSF) was inspired by Vannevar Bush's *The Endless Frontier* (1945), which envisioned an agency that would complement longstanding government support for applied research in the agricultural colleges by extending this support to research in fundamental fields. Since NSF's creation by the National Science Foundation Act of 1950 (**https://bit.ly/3fwT9Zx**), its mission has remained true to Bush's ideal "to promote the progress of science; to advance the national health, prosperity and welfare; and to secure the national defense; and for other purposes."

Bush's vision defined NSF's position as a funder of basic science within the landscape of federal science funding, but this NSF origin story sometimes obscures its role to support applied research as well. The NSF Organic Act authorizes initiation and support of "scientific and engineering research, *including applied research* [emphasis added], at academic and other nonprofit institutions, and, at the direction of the President, support applied research at other organizations" (**https://bit.ly/31pGz9B**).

Pasteur's Quadrant: Use-Inspired Basic Research

Donald Stokes, in his 1997 book, *Pasteur's Quadrant: Basic Science and Technological Innovation*, broadened the view of the landscape of federally funded research as

something more than a simple one-dimensional gradient between basic and applied endpoints. Instead, he posed research as a two-dimensional space with axes defined by the motivations for scientific endeavor: “the quest for fundamental understanding” and “consideration of use.” Within this space, three of the four quadrants are identified as practical and productive enterprises, each defined by an iconic pillar of the scientific endeavor.



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Niels Bohr represents “pure basic research”—creative discoveries that inspire scientific wonder without immediate utility. Thomas Edison represents “pure applied research”—discoveries and innovations inspired directly by immediate practical application. Louis Pasteur represents the quadrant where both basic and applied research interface—i.e., “use-inspired basic research,” for which the motivation behind the quest for knowledge is constrained neither solely by wonder nor practicality but lies at the intersection of these two inspirational forces. Research in Pasteur's quadrant aims to discover and unravel the nature of processes underlying phenomena relevant to society. It promotes basic discoveries that translate into broadly defined, yet immediately relevant, societal benefits or applications. This dual motivation reflects NSF's merit review system, which considers equally the intellectual merit and broader impacts of proposed research—i.e., both the potential to advance science and

the potential to provide beneficial societal outcomes (**https://bit.ly/30vXLuW**).

In terms of Stokes' landscape of funding agency motivations, one might picture NSF's mission as spanning the entire range between Bohr's and Pasteur's quadrants—both are defined by basic research on fundamental principles. Meanwhile, NSF's partnerships with other federal agencies provide a direct means of exchange of ideas between the basic knowledge created in Pasteur's quadrant and its applications that are further developed in Edison's "pure applied research" quadrant.

A Perspective from Earth Sciences

From my perspective as an earth scientist within the Geosciences Directorate of NSF, I see many of our current programs and partnerships as predominantly within Pasteur's "use-inspired basic research" quadrant. This is because the goals of many of NSF's earth science programs are to support basic discoveries of earth system processes that will also enable a better understanding of earth's changing environments. Although NSF rarely goes further towards Edison's "pure applied research" quadrant alone, we partner with other agencies to do so.

Many core disciplinary programs within NSF's Division of Earth Sciences may tend towards Bohr's "pure basic research" quadrant, but these are complemented by a plethora of integrative, cross-directorate, NSF-wide, and interagency initiatives that help develop broader impacts and applications of this basic research to immediate societal benefit. Furthermore, NSF's current "10 Big Ideas" (**https://bit.ly/3irqUO7**) embody the research motivations of Pasteur's "use-inspired basic research" quadrant, including the concept of convergence research (1 of the 10 Big Ideas), which is described as "a means of solving vexing research problems, in particular, problems focusing on societal needs" by "integrating knowledge, methods, and expertise from different disciplines." As a result, many of NSF's earth science research programs and

initiatives are inspired by the utility of helping society to understand, cope with, and mitigate the impacts of natural geohazards, global environmental changes, and earth's limited resources.

How to Navigate NSF's Funding Programs

The National Science Foundation is constantly developing new ideas and initiatives that will continue to span the entire range of Pasteur's “use-inspired basic research” quadrant. How can you identify and apply for the ideal program for your research? How can you design an effective, integrated research project that addresses NSFs merit review criteria? The Proposal & Award Policies and Procedures Guide (PAPPG) of NSF is the definitive source for procedures, and the NSF website (**https://bit.ly/30vfzX0**) provides program descriptions, solicitations, and dear colleague letters with details of policies, procedures, and opportunities. Additionally, one of the best ways to get to know NSF's programs is to talk to NSF program officers about their current programs and initiatives. Program officers are a mix of federal employees and temporary rotators hired from research and educational institutions who have a range of relevant perspectives and experience on how to navigate NSF's research programs and initiatives. Outreach opportunities in which program officers participate (**www.nsf.gov/events**) include NSF Days, scheduled webinars, and workshops, both virtual and in person (although the balance has shifted currently to virtual), in addition to professional society meetings, including the ASA, CSSA, and SSSA Annual Meeting. I encourage readers of *CSA News* magazine to utilize these events to discuss how their research fits into the landscape of cross-agency and other federal funding opportunities.

Erratum

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