Partnerships:

A Workshop on Collaborations between the NSF/MPS & Private Foundations

MSRI
Mathematical Sciences Research Institute

About MSRI:

The Mathematical Sciences Research Institute (MSRI) is one of the world's preeminent centers for collaborative research. Researchers—some 2,000 per year—come to MSRI to work in an environment that promotes creativity and the effective interchange of ideas and techniques. MSRI features two focused programs each semester, attended by foremost mathematicians and postdocs from the United States and abroad; the Institute temporarily becomes a world center of activity in those fields.

MSRI takes advantage of its close proximity to the University of California, Berkeley and to the Lawrence Berkeley National Laboratory. MSRI also collaborates nationally with organizations such as the Chicago Mercantile Exchange. The Institute's prize-winning forty-eight thousand square foot building enjoys spectacular views of the San Francisco Bay.

MSRI also serves a wider community through the development of human scientific capital, providing postdoctoral training to extraordinary young scientists and increasing the diversity of the research workforce. The Institute advances the education of young people with conferences on critical issues in mathematics education. MSRI has created a national "math circles" movement of small organizations teaching and engaging in math as a hobby, beyond the standard curricula, for enthusiastic and often gifted kids. MSRI also gives an annual suite of prizes, "Mathical", for children's books related to Mathematics.

MSRI's activity is supported by the National Science Foundation and the National Security Agency. Private individuals, foundations, and over 100 Academic Sponsor Institutions, including the top mathematics departments in the United States, provide crucial support and flexibility.

A sense of the activity and physical plant of MSRI can be had through the short video at http://tinyurl.com/MSRIvideo.

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Foreword

Since the Second World War, the US federal government has made large investments in basic research. Outside the biomedical sphere, the National Science Foundation has emerged as the primary vehicle for these investments, which have paid off many times over. In a recent speech, Eric Lander referred to this as “the Miracle Machine”1 because it has regularly brought extraordinary rewards.

But even federal funding is limited and has particular requirements, and so private philanthropy has played an increasingly important role in funding research. Private sources are able to fund science in ways that the government does not, largely because of differences in the process by which decisions are made in the government and in private foundations. The federal process is necessarily answerable to the public, and thus requires a strong structure that has many safeguards but can be rigid. Private foundations have much more freedom; in some cases they are effectively answerable only to their founders, which allows them to pursue particular aims and take risks that public accountability might not tolerate. In general this has a salutary effect: much as the great diversity in the American university system has given us some of the world’s greatest universities, the multiplicity of funding sources has brought vitality and creativity to the US scientific scene.

Some common themes emerge from the diversity of intents and methods. A number of private-sector projects have dovetailed with the goals of the NSF and led to direct collaboration. In many of these cases the project succeeded because the collaboration brought together the different strengths that federal and private funders offer.

The Partnerships workshop described in this document was designed to showcase concrete current examples of public-private collaborations. The importance that both the NSF and the private foundations attach to the collaborative process was clearly shown by the willingness of the major players to come and to speak frankly, not only about the successes of the collaborations, but also about the difficulties and frictions that sometimes occur.

The purpose of the workshop was to explore and exemplify best practices in order to encourage and enable productive engagements in the future. If it makes the path to public-private partnership easier to traverse, then it will have been a success.

David Eisenbud, Chair of the Organizing Committee, August 22, 2015

[1] Text: https://www.msri.org/system/cms/files/132/files/original/Lander-Case_for_Research.pdf and video: https://vimeo.com/133400574

Main Discussion

Overview

Over the years, the National Science Foundation (NSF) has engaged in many fruitful partnerships with private foundations and industry organizations that fund basic science. Such partnerships allow public and private organizations to leverage each other's complementary strengths, to the benefit of science. As philanthropic funding for science grows, opportunities for such public-private partnerships are increasing.

To get a better picture of the landscape of public-private partnerships, the Mathematical Sciences Research Institute (MSRI) in Berkeley, California, supported by the NSF's Directorate for Mathematical and Physical Sciences (MPS), organized a meeting at the NSF in Arlington, Virginia on May 28 and 29, 2015, called "Partnerships: A Workshop on Collaborations between the NSF/MPS and Private Foundations."

The NSF/MPS was enthusiastic about this meeting on two fronts, said Jennifer Pearl, an MPS program director. First, it presented an opportunity to study examples of partnerships between the NSF and private entities, to see what lessons can be learned. "The point was to go from a collection of one-offs to something where the community understands the lay of the land a little better—what are the good practices and the pitfalls, and what impact do these partnerships have," Pearl said. "It will be useful to be aware of the different models for partnerships, so we don't have to reinvent the wheel each time."

Second, the meeting presented an opportunity to bring together public and private funders of science, in the hope of generating synergies that might eventually lead to new partnerships.

The meeting was attended by more than forty academics and representatives of private foundations, along with dozens of NSF officials. "A lot of the people at the workshop had never been in the same room together," Pearl said.

In an introductory talk, Cynthia Atherton, the program director for science at the Heising-Simons Foundation, observed that government agencies, foundations, and industry don't live in separate boxes when it comes to funding science. "We overlap behind the science grantee," she said. "There's mess at the edges, but maybe that's where all the good is coming from."

Cynthia Atherton

Types of Partnerships

The meeting examined three rough categories of partnerships:

1. **Implicit Partnerships.** Sometimes the NSF and philanthropic organizations support the same venture without explicitly planning a partnership. For example, an entrepreneurial principal investigator (PI) may line up financial support from several institutions. Implicit partnerships also arise frequently in funding institutes and can be an efficient way for different funders to complement each other's programs. Meeting participants heard, for example, about the Simons Foundation's Targeted Grants to Institutes program, which provides funding to several NSF-supported institutes to be used for purposes for which NSF funds cannot be used. Participants in a breakout group about institute funding also discussed the Kavli Foundation's endowment model, which gives institutes a stream of unrestricted money, allowing them a flexibility that isn't easily achieved through NSF grants. (For more on institute funding, see "Institutes: A Long-Standing Arena for Partnerships.")

Meeting participants broached the idea of providing PIs with direct incentives to create partnerships. For instance, one participant suggested, the NSF could have a funding stream that requires the PI to secure a matching grant from another organization. But carrying out such an idea would be tricky, several people warned. The NSF has strict rules prohibiting researchers from listing external contributions in proposal budgets, in part to avoid a situation in which "only the haves will get grants, not the have-nots," Pearl said. These rules arose partly in reaction to what was seen as "bargain-hunting" by the NSF, said David Eisenbud, MSRI's director and chair of the meeting's organizing committee. "The community felt that in some cases the NSF was choosing the highest bidder rather than the best science. You would have to avoid getting into that trap if you wanted to do something like that again."

For more background on the NSF's rules about reporting cost-sharing commitments, see: http://www.nsf.gov/bfa/dias/policy/csdocs/principles.pdf http://www.nsf.gov/pubs/policydocs/csfaqs_jan13.pdf http://www.nsf.gov/pubs/2009/nsb0920/nsb0920_1.pdf

2. **Explicit Partnerships.** Meeting participants heard about several examples of partnerships in which the NSF and another organization came together to further a particular scientific goal. In one such partnership, MPS and the initiative Stand Up to Cancer took advantage of their respective access to the quantitative science and biology communities to put together an interdisciplinary ideas lab aimed at bringing quantitative tools into cancer research. In the Basic Research to Enable Agricultural Development (BREAD) project, the NSF's partnership with the Bill and Melinda Gates Foundation allowed the project to fund international researchers, something which the NSF generally does not do on its own. Meeting participants also heard about a decades-long partnership between the NSF and the Semiconductor Research Corporation that has given rise to many programs over the years, including the current Nanoelectronics for 2020 and Beyond initiative; these programs have facilitated grantees working closely with industry representatives, something that is not usually a feature of NSF programs. (For more on these three programs, see "Case Study: Stand Up to Cancer"; "Case Study: BREAD"; and "A Long-Term Partnership: The Semiconductor Research Corporation.")

left to right: Karen Santoro, Erin Dawson, Sandra Scholar, Jean Feldman

The discussion of these initiatives made it clear that a successful partnership requires a strong scientific driver, Pearl said, and also a logistical reason why it makes more sense to work together than separately. "There has to be a good, hard rationale to do this," she said. "It can't just be that the other organization has money and we have money, and we both want to fund science."

3. **Large Instrumentation.** Large instruments, whose price tags often reach hundreds of millions of dollars, are nearly always funded by multiple sources in government and the private sector, often through a combination of explicit and implicit partnerships. Tony Tyson, a physicist at the University of California, Davis, told meeting participants about one such example, the Large Synoptic Survey Telescope (LSST), which over the years has received funding from the NSF, the W. M. Keck Foundation, and the software billionaires Bill Gates and Charles Simonyi, among others. (For more details, see "Case Study: The Large Synoptic Survey Telescope.")

At the workshop, a breakout group on large-instrumentation partnerships made several recommendations, including earlier communication between stakeholders about priorities; more explicit partnerships, with carefully delineated goals and strong, centralized project management; clarity on the NSF's rules about how to report cost-sharing commitments from external organizations; and a better mechanism for creating partnerships when the NSF is to be a minor player. (For more details, see "Large Instrumentation: Fertile Ground for Public-Private Partnerships.")

Understanding Partners' Missions

The NSF and private foundations may share the mission of supporting basic science, but their missions also differ in important ways. These differences can be a source of strength in a partnership, allowing the organizations to extend the scope and impact of their programs, but they also present challenges that must be understood by would-be partners.

Unlike private foundations, the NSF has a mission to support all areas of science. "The NSF has larger responsibilities, such as stewardship of disciplines, diversity, and care for scientific communities, in ways that aren't fundamental responsibilities of private foundations," said Caty Pilachowski, an astronomer at Indiana University, Bloomington. As a new generation of private benefactors turn their attention to science funding, concerns have been articulated in the popular press that the nation's scientific agenda could be distorted by the idiosyncratic preferences of a handful of billionaires. "The NSF has to be careful not to be swayed by all that money out there," Pearl said. "Our mandate is to fund research at the national level, and we need to do that no matter what anyone else is doing."

At the same time, the more targeted missions of private foundations can complement the NSF in valuable ways. Atherton identified several types of funding that often hit the "sweet spot" for private funders:

- **Large instrumentation.** Besides the LSST, Atherton gave the example of the Dark Energy Spectroscopic Instrument, a conceptual next-generation dark-energy project. Private foundations, including the Heising-Simons Foundation, have paid for the first prototype, and the US Department of Energy is providing long-term support.

- **Cross-disciplinary research.** Foundations often have more flexibility than the NSF to move across the boundaries of disciplines, Atherton said. She cited the Gordon and Betty Moore Foundation's Marine Microbiology Initiative, which created a tremendous amount of new information—practically a new field, she said.

- **No-strings-attached funding for top researchers.** The NSF primarily gives grants for undertaking specific projects (with a few exceptions such as graduate and postdoctoral fellowships). Some private foundations, by contrast, like to bet on people rather than projects, and to use a light touch. "Sometimes the best thing you can do is give someone with incredible ideas and passion money, and let them run with it," Atherton said.

- **Seed-stage or high-risk projects.** Sometimes a brilliant scientist comes up with a daring idea that might prove transformational—or it might flop. A private foundation often has more latitude than the NSF to take a risk on a novel idea, Atherton said.

Foundations can switch fields very rapidly, Atherton said, depending on their founders' desires and what they learn about the current state of science by attending conferences, reading papers, and networking. "We're looking for gaps that won't be met unless there's private money," she said.

Different Approaches

The NSF and private foundations differ not only in their missions but also in their protocols and how flexible they can be in forming partnerships. The NSF is bound by rules regarding privacy, confidentiality, conflict of interest, what gifts it is allowed to receive, and many other legal matters.

"We have a different construct than private-sector entities," said Sandra Scholar, an assistant general counsel at the NSF. "They have the construct that you can do it unless there's a law against it. For us, the construct is that we can do it if it is within the powers and mission Congress has given us."

It's essential, Scholar said, for would-be partners to engage with the NSF's policy and legal staff early in the partnership process. "If we can help you design the collaboration, we can avoid some things that could be stumbling blocks further down the road," she said.

When it comes to identifying worthwhile projects, every foundation has its own approach, Atherton said. Some foundations solicit proposals, while others rely more on word of mouth. For instance, she said, board members often have useful relationships with university administrators. “Sometimes you can say to them, if you ever see a great idea that’s so out of line that it will never get funded, let us know.” Atherton herself has connections at the Department of Energy. “Every so often I pop by to ask them how it’s going, and have you seen any weird papers?”

A private foundation can also approach a grantee directly, Atherton noted, which is less easy for the NSF to do. And unlike the NSF, some foundations help would-be grantees craft their proposals or even develop their concepts before the proposal stage. Many foundations don’t rely on external review, which is the norm for proposals at the NSF. “Sometimes a private foundation can just have the expertise internally to say, ‘It’s a go,’” Atherton said.

The NSF’s peer-review process is considered the gold standard. But given its budget constraints, it is forced to decline many projects that its peer reviewers have rated highly; last year, for example, it funded only 23 percent of proposals. Public-private partnerships that harness the NSF’s peer-review process can be a win for both parties, meeting participants noted: They allow the NSF to extend its reach by providing funding for worthwhile projects that would otherwise be declined, and they also assure private donors that the projects have the NSF’s stamp of approval.

left to right: Karen Santoro, Erin Dawson, Sandra Scholar, Jean Feldman

Such partnerships must be set up carefully, however, since the NSF is wary of seeming to offer its review process to other organizations. “If we’re collaborating with another entity and it will result in a significantly larger proposal pool than would have resulted from an NSF-only solicitation, that can present a problem because we’re spending appropriated funds for someone else’s review process,” Scholar explained.

Meeting participants raised the question of whether the NSF could leverage its review process to help private foundations and scientific projects discover a “mission match,” by informing foundations of worthy projects that the NSF cannot fund. The BREAD project carried out something along these lines: When a proposal was rated highly by an NSF review panel but wasn’t considered a good fit for the NSF’s basic-science orientation, NSF officials would ask the proposal’s PI whether he or she was interested in being contacted by the Gates Foundation, which was open to projects with a more utilitarian bent. “Not surprisingly, no one said no,” said Jane Silverthorne, a deputy assistant director for the biological sciences at the NSF. This referral process, which came to be known informally as BREAD Pudding—since “when you have stale bread, you don’t throw it away, you use it for something”—became almost as successful as the BREAD project itself, Silverthorne said, even though it was never a public project.

After an NSF review process has been concluded, PIs receive unattributed copies of their reviews from the NSF. There’s nothing to prevent a PI from sharing these copies with private foundations. But the NSF has to be careful about doing so itself, warned members of its policy and legal staff. Reviews are protected by the Privacy Act, and while a PI can voluntarily waive privacy, the NSF must avoid any appearance of coercion. PIs “might feel that if they say no, they will be negatively viewed by the NSF,” said Erin Dawson, an assistant general counsel at the NSF.

Most of the time, it’s possible to find a creative solution to such legal and policy obstacles, Scholar said. “Sometimes the way the program has been conceptualized may not work with our statutory funding, but if you come to us early, we can often find a path forward that meets the organization’s goals and complies with NSF’s legal and policy requirements.”

Additional Themes

Discussions at the meeting elicited an assortment of other issues:

How to jump-start partnerships when there is no personal connection. Many of the partnerships described at the meeting came about because individuals at different organizations became acquainted and discovered that their missions were a good match. Presumably, meeting participants observed, many other potentially fruitful matches remain undiscovered because no personal relationship has brought them to light.

It's difficult for would-be partners to discover each other online, noted Jill Pipher, a mathematician at Brown University in Providence, Rhode Island, who reported to the meeting on the discussions of one of the breakout groups. "The NSF's website is pretty overwhelming, and it's hard for foundation folks to figure out what has been done," she said. "And foundation websites can be pretty incomplete."

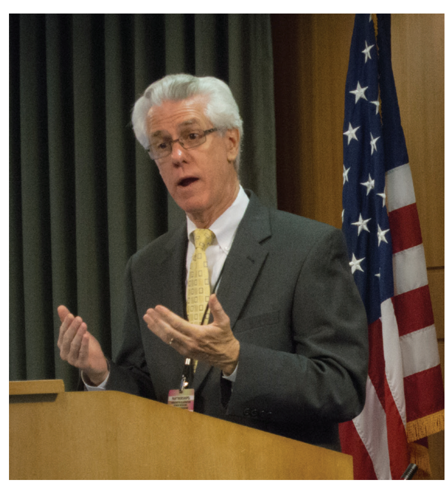
It would be helpful, some meeting participants suggested, if there were a centralized clearinghouse in which individuals and organizations could announce that they were looking for partners for a particular project or scientific goal. "There is no current forum for private foundations and federal funding agencies to get together except through the ephemeral existence of a prior personal relationship," commented Paulette Clancy, a professor of chemical engineering at Cornell University in Ithaca, New York, in written remarks at the meeting. "One recommendation might be to find or create an easy-access portal to facilitate such interactions."

Participants also recommended that the NSF foster connections by holding more workshops similar to the Partnerships meeting. "The NSF should convene an annual meeting that brings foundation representatives and program officers together—many more program officers than are here today, since they are critical for getting information to foundations about who is doing what, and what is exciting on the ground," Pipher said. Such a meeting could involve fewer presentations and more opportunities for conversation and interaction, she suggested.

Sustainability. As Atherton observed in her introductory talk, many foundations like to fund novel, seed-stage research. Likewise, the NSF often funds the early stages of projects without promising continuity of funding. Meeting participants expressed the concern that funders of science may be drawn too strongly to what is new and flashy, at the expense of worthwhile projects that are forced to terminate before they reach their full potential.

The desire to fund novel programs is "a natural human tendency," one participant wrote. "Unless this predilection is balanced in some systematic way—either through NSF policies or through a foundation that wants to grasp this nettle as their specific way of filling a critical gap in the current system—this will continue to lead to the spawning of new programs that do not have sustained support over time. In some areas the churn is truly productive, but in other areas, long-term focus and development of communities needs better nurturing."

Fleming Crim, the assistant director of MPS, said that while sustainability is a concern, the NSF is committed to its traditional open-competition process. "We don't believe that we can start saying, 'OK, you have an award from the Simons Foundation, we will definitely fund the continuation of that,'" he said. "I don't think we'll ever be in a position of making a priori deals to sustain projects, and I don't think the community would want us to. But people coming in with strong proposals and accomplishments fare well."



Fleming Crim

Funding midcareer researchers. Meeting participants noted that while there are many sources of grants and fellowships for young researchers, the number of special opportunities drops dramatically for scientists who are past the early years of their careers. In chemistry, for instance, one meeting participant said, the number of funding opportunities drops from ten to about two as soon as a researcher earns tenure, since many opportunities are exclusively for young investigators.

"It's the riskiest part of a career, when you're past the young-scientist award and you're in this pool," Crim said. Private foundations could explore how to fill this niche, participants suggested.

Increased funding in the form of small grants. Mathematicians and chemists at the meeting commented that their fields would benefit from the availability of more small grants, which tend to be in short supply. In mathematics, few foundations offer such grants, Pipher said, apart from the Simons Foundation, which provides "Collaboration" grants of $35,000 over five years and other small awards. In chemistry, about $100,000 is an appropriate amount to seed an idea, one participant suggested. "My impression is that you have the best chance when you spread the money around, since you never know where the next big insight will be."

Thomas Everhart

Preserving a multiplicity of funding sources. Some participants were concerned that if the NSF and private funding organizations combine their resources too thoroughly, this might reduce the number of different funding opportunities to which researchers can submit proposals. "This is a key concern since researchers are already struggling to find places to apply to," Pipher wrote.

Increasing overall funding for basic science. Atherton began her talk by noting that federal funding for science has been virtually flat in the last fifteen years; meanwhile, the old Bell Labs model of industry-funded basic science is "near extinction," she said. A number of meeting participants highlighted the urgent need to enlarge the total pool of money available for basic research.

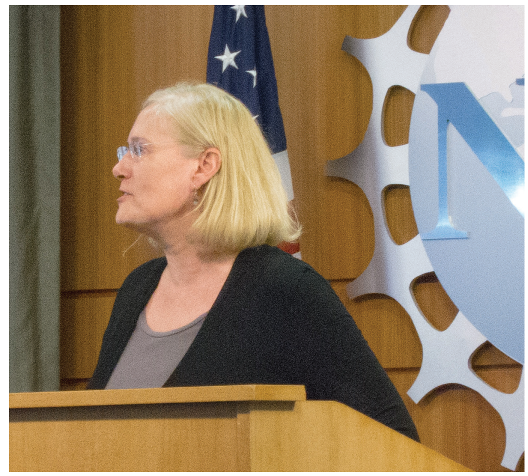
Atherton described the new Science Philanthropy Alliance, a nonprofit organization founded by six private foundations with the aim of increasing private investment in basic research. Other participants spoke of the need to increase public awareness of the importance of basic science.

"I think it's generally not appreciated how much value, both in dollars and cents and in other ways, comes out of fundamental science research," said Thomas Everhart, emeritus president of the California Institute of Technology in Pasadena, in the meeting's closing remarks. This value "takes a while to bubble up to the top, but that case has not been made in an understandable way to the American public. It's up to all of us to make that case better."

Steering committee and NSF representatives:
Back row, left to right: Thomas Everhart, David Eisenbud, Jennifer Pearl, Cynthia Atherton, Celeste Rohlfing, Fleming Crim, Yuri Tschinkel.
Front row, left to right: Paulette Clancy, Caty Pilachowski

Case Study: BREAD

In 2007, Machi Dilworth, then the director of the NSF's Division of Biological Infrastructure, learned that a former colleague, Rob Horsch, was moving from Monsanto to the Bill and Melinda Gates Foundation to become deputy director of its agricultural development program. Dilworth immediately spotted the potential for collaboration. She called Horsch and asked if he was interested in working together.



Jane Silverthorne

Horsch said yes, and over the following year, the two of them, along with other colleagues at both foundations, explored how to create a project that would "bring together the Gates Foundation's track record in agricultural development and the NSF's peer-reviewed marketplace for new ideas," said Jane Silverthorne, a deputy assistant director for the biological sciences at the NSF who was involved in the project from the outset. There was a tremendous need for such a project, she said, since most funding for agricultural development is tightly focused on solving specific, immediate problems, not on bottom-up innovative basic research.

The partners decided that the program would be run through the NSF. But enabling the Gates Foundation to contribute to an NSF program turned out to be a complicated process. First of all, Silverthorne said, "I had to write a proposal to the Gates Foundation, just like anybody else." Silverthorne's program officer at the Gates Foundation worked actively with her on honing the proposal. "I thought this was really interesting, because I was used to running federal granting programs where there's a really bright line between the program officer and the grant writer," Silverthorne said.

Concurrently, NSF officials started the legal steps that would permit the NSF to receive the money. "We realized that we had to work on the mechanism of accepting the money at the same time the proposal was being reviewed, because both were going to take about six months," Silverthorne said.

In 2009, the two foundations announced the creation of the Basic Research to Enable Agricultural Development (BREAD) project to generate science-based solutions to problems concerning smallholder agriculture in developing countries. Each of the two foundations would contribute $24 million over five years.

The project issued a call for proposals that was intentionally very broad. "The danger of a project like BREAD is that if it's too prescriptive, if you say you want to get proposals about problem X, then that's all you'll ever get, and you'll filter out all the innovation you're looking for," Silverthorne said. "We wrote a very open description, and we knew the phone would ring off the hook with people asking us what we meant." It took a while, she said, for would-be grantees to comprehend just how strong the basic-research component would have to be for a proposal to succeed.

The project has run several calls for proposals since then, and has also pursued an approach that is relatively novel for the NSF: a prize competition. "At the NSF, it's harder to develop an effective prize competition than at a mission agency where they're focused on developing a particular product or outcome," Silverthorne said. "But we thought BREAD would be ideal for an ideas challenge."

In 2013, the project announced a two-stage competition, starting with a hundred-word idea contest that would award up to twenty-five prizes of $10,000 each. The goal, Silverthorne said, was "to get ideas that very creative people might think of as something that must be done, but they're not necessarily the people who are actually going to do the research."

Next, the NSF ran one of its "EAGER" competitions (short for Early Concept Grants for Exploratory Research), which offered awards of up to $300,000 for two years to researchers who would further develop the ideas that emerged from the first contest (as well as innovative ideas from other origins that also advanced BREAD goals). The competitions engaged a new group of people who hadn't been involved in the earlier solicitations, Silverthorne said. "We received entries from graduate students who were fearless," she said. "They came up with truly innovative ideas."

The BREAD project has led to the development of extraordinary technologies, Silverthorne said. "It has succeeded better than we could have hoped."

For the NSF, one benefit of partnering with a private foundation was that money could be directed to international partners, which the NSF cannot normally fund. Managing the international funding was one of the trickier aspects of the collaboration, said Wayne Parrott, BREAD's program officer at the NSF—in particular, figuring out how to get funds to institutions that were not set up to receive and manage funds from other countries.

The project has resulted in considerable networking between scientists in the United States and ones in developing countries, Silverthorne said. Some US scientists who had never previously worked on research with a developing-country focus have now integrated it into their programs, she said. "Once you get engaged and see the impact of your work in the field, it changes how you look at things."

Institutes: A Long-Standing Arena for Partnerships

Government and private funders have a long history of providing complementary support for research institutes. At the Partnerships meeting, Andrew Millis, associate director for physics at the Simons Foundation and a physics professor at Columbia University in New York City, spoke about the Simons Foundation's Targeted Grants to Institutes program, which he called "a clear example of a public-private partnership which is quite successful."

Andrew Millis

The program supports a wide range of institutions in the United States, Europe, and other locations. In particular, it provides funding, via several different models, to four US institutions: the Kavli Institute for Theoretical Physics (KITP) at the University of California, Santa Barbara; the Mathematical Sciences Research Institute (MSRI) in Berkeley; the Aspen Center for Physics in Colorado; and the Simons Institute for the Theory of Computing at the University of California, Berkeley.

At KITP, which typically runs programs in special areas over the course of one to six months, the NSF provides core funding of about $4.6 million per year, and UC Santa Barbara and other funders provide an additional $2.5 million per year. The Simons Foundation provides $500,000 per year for salary support to enable distinguished scientists to spend long periods at KITP independent of the programs, and to support key program participants who need sabbatical replacement funds or extra money for relocation expenses. "Neither of these things is really possible under NSF and UCSB support," Millis said. The Simons Foundation plays a similar role at MSRI, providing extra support for distinguished visitors.

The Aspen Center for Physics operates on a different model: scientists come for a few weeks, and the NSF provides about $500,000 per year to pay for the institute's staff and some local expenses (Millis noted that the NSF and other agencies also provide substantial indirect funding, since many of the scientists who come charge travel expenses to their research grants). The Simons Foundation provides $100,000 per year to allow scientists from developing countries to participate; in 2014, for example, 44 scientists came to the institute supported by the foundation. "The US funding agencies can't pay for, say, Indian scientists to come," Millis said. "This is a way that foundation support complements agency support and enriches the program to the benefit of all."

At the Simons Institute for the Theory of Computing, the roles are reversed: the Simons Foundation provides the core funding, and industry and government agencies provide modest support for workshops.

Altogether, the institutes are "examples of a model where one entity provides core support, and another entity provides add-ons that otherwise couldn't be supported," Millis said. This model, he said, "minimizes the complications when two different entities are trying to support the same thing, since you don't have to figure out who is responsible for what."

Michael Vogelius, the division director for mathematical sciences at the NSF, said that the division would welcome more involvement from foundations in its institute program. "We've seen significant interaction with, in particular, the Simons Foundation," he said. "We'd like to see the involvement go beyond that one foundation."

Institutes currently represent 13 to 14 percent of the division's portfolio, Vogelius said, and that figure is likely to remain constant. But the NSF can't just continue to give that percentage to institutes that already exist, he said. "To keep things vibrant, we have to be able to potentially create something new, when the community says something is exciting and should have an institute."

That means the division must sometimes reduce or even eliminate funding to an existing institute. "We're strongly encouraging the institutes we are supporting to look for alternate sources of funding," Vogelius said. "It doesn't mean the division would completely disengage, but the institutes would have to find significant other sources to go on. That's where a collaborative public-private partnership could be very helpful." Vogelius pointed to MSRI as an example of how an institute's funding sources can evolve. MSRI has received substantial NSF funding since its creation more than thirty years ago, but it has gradually attracted private donations that now account for more than a third of its funds. "We're encouraging other institutes to think along the same lines as well," Vogelius said.

There are also possibilities for collaboration in the starting of new institutes, Vogelius said. "If a foundation and the division for mathematical sciences have a common interest, we could set up a collaboration right from the beginning. That's something we haven't tried."

Participants in a breakout group focusing on grants to large research groups noted that institutes carry many advantages both to the NSF and to private funders. For example, institutes can give much smaller grants than the NSF does, thereby dispersing funds to a larger proportion of the research community, and they make decisions about those grants closer to the ground, so to speak. And institutes can give their funders considerable leverage. For instance, the Simons Institute for the Theory of Computing funds only local expenses and travel for its visitors, who often get salary support from their universities in the form of sabbatical funds. "We get a leveraging factor of at least four to one, comparing the funding they bring to what we provide," said Richard Karp, the institute's director. Often, universities also offer direct support to institutes; for example, UC Berkeley houses the Simons Institute for the Theory of Computing in one of its campus buildings.

The discussants brought up the question of how to replicate the success of the old Bell Labs model, in which hundreds of scientists rubbed shoulders daily with researchers in different disciplines, and scientists with long-term visions received research support that was not contingent on producing short-term "deliverables." They concluded that one of the main ingredients of Bell Labs' success was local control of research strategizing, rather than control by a distant entity.

It would be advantageous, the discussants decided, for institutes to receive at least a small proportion of their funds as unrestricted money, which would allow for flexibility and local control. That is the model in the seventeen institutes funded by the Kavli Foundation, which provides support in the form of endowments, typically paying out about $1 million per year, to be used at the discretion of the institute's leaders. "The goal is to be as flexible as possible," said Christopher Martin, a science program officer at the Kavli Foundation. "If one year they wanted to spend it all on an instrument, they could. Another year, they could do fifty seed grants."

Large Instrumentation: Fertile Ground for Public-Private Partnerships

Large instruments, such as telescopes, commonly involve investments from both government agencies and private donors. Tony Tyson, a physicist at the University of California, Davis, gave a talk on one such example, the Large Synoptic Survey Telescope, which has received funding from the NSF, software billionaires Bill Gates and Charles Simonyi, and other donors (for more detail, see "Case Study: The Large Synoptic Survey Telescope). As the cost of some next-generation instruments starts to reach hundreds of millions of dollars, it is imperative that public and private funders of science coordinate their efforts, meeting participants agreed. A breakout-group discussion on the funding of large instrumentation elicited a number of requests and recommendations:

Earlier communication between stakeholders. Private foundations should be included in the planning process from the beginning. "It would be very helpful in [astronomy] if private foundations were more engaged in decadal and large-scale planning," said Caty Pilachowski, an astronomer at Indiana University, Bloomington, who reported on the breakout group's conclusions. "Understanding their priorities and the community's priorities early on might facilitate good decisions, and perhaps enlarge the pool of funding in a way that benefits science."

The group recommended that the NSF's Directorate for Mathematical and Physical Sciences, together with private foundations, convene periodic community workshops to discuss scientific instrumentation needs. "The familiarity, working relationships, and shared vision that would be engendered by such workshops among private and public funders would be extremely valuable in fostering potential partnerships," Pilachowski wrote in a summary of the group's discussion.

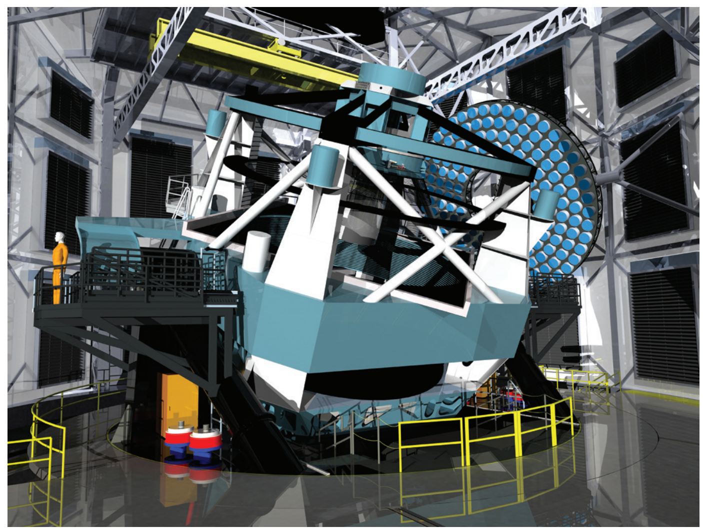
Clarity on how to report cost-sharing commitments to the NSF. For the NSF to make good decisions about large-instrumentation proposals, it must comprehend the full extent of the project, including funding commitments by other organizations. However, NSF rules forbid listing such external commitments in a proposal's budget, which may only contain information about how NSF funds will be used. "There was considerable concern [in the breakout group] that reviewers of proposals where the NSF is one of several partners need full information about the scope of the project, cost, risk, everything, even if they're just reviewing the NSF piece," Pilachowski said. "Without that, it's hard to make a good recommendation."

In a panel discussion on logistics, NSF officials told meeting participants that there is a way to report external funding commitments in a grant proposal: this information cannot appear in the budget, but it may be listed in the "Facilities, Equipment and Other Resources" section of the proposal. Information included in that section is considered voluntary uncommitted cost sharing and is not financially auditable by the NSF. "A lot of folks have thought the whole proposal is off-limits for identifying these contributions," said Jean Feldman, head of the policy office in the NSF's Division of Institution and Award Support. "But you can do it."

Informal conversation at the meeting made it clear that many researchers remain unaware of this avenue for reporting external funding commitments. "There's clearly confusion in the community," Pilachowski said. It would be useful, the breakout group recommended, for the NSF to give the scientific community clear directions about what information to provide in proposals.

Strong project management throughout the life span of a project. Coordinating a large-instrument project involving many sources of funding is challenging. Earlier projects have, on occasion, incurred embarrassing cost and schedule overruns, one meeting participant noted, and as a result the NSF is increasingly determined to adopt best practices of project management. It's critical, Pilachowski wrote, to understand "how joint technical and financial oversight might be managed through the life of a project."

Better understanding of partnership mechanisms when the NSF is a minor partner. "The NSF Large Facilities Office and the process for [Major Research Equipment and Facilities Construction (MREFC)] funding seem to be currently set up for projects that are dominated by NSF funding; there is a cradle-to-grave planning process all run by the NSF," commented Claire Max, a professor of astronomy and astrophysics at the University of California, Santa Cruz, and director of the University of California Observatories, in written remarks at the meeting. "There needs to be an official on-ramp for a project that is already well under way with private funding, in which the NSF might become a minority partner. This is a current issue for the Thirty Meter Telescope project, and negotiations seem to be under way in this case. The final policy should be broad enough to apply to other large new facilities initiatives as well."



Funding for mid-scale initiatives. There's a need for expanded funding of midsize equipment, in the 10-to-50-million-dollar range—"more than a tabletop but not a telescope or synchrotron," as one participant described it. In astronomy, such initiatives have been "dramatically underfunded," Pilachowski said. "There's great demand in my community." This is an area in which private foundations could make a difference, participants said.

How to sustain the science. NSF large-instrumentation initiatives funded through the MREFC program do not include funding for operations, which must be carved out of the divisional budget. Nor do such initiatives include funding for the science to be performed on the new instrument. Meanwhile, the operating costs of these complex new facilities are increasing and can crowd out science funding, one astronomer at the meeting noted. NASA employs a very different model, some meeting participants commented, that pays for operating costs of a large instrument and also for the cost of doing the science on it.

Realizing the full promise of the large instruments currently under development will require not just small grants to scientists but also the coordinated development of new data-analysis tools, Tyson wrote. "This is not served well by the small-grants program, or by MREFC, or limited midscale instrumentation programs at NSF," he wrote. "While the traditional small-grants program can be an excellent source of discovery (and must be retained), there is a looming need for another parallel science innovation mode in the era of mega-facilities which create massive open data."

A Long-Term Partnership: The Semiconductor Research Corporation

For the past three decades, the NSF has collaborated with the Semiconductor Research Corporation (SRC), an industry consortium founded in 1982 to promote the continuation of Moore's Law—the well-known observation by Intel cofounder Gordon Moore that the number of transistors per computer chip doubles roughly every two years.

Paulette Clancy

At the time of the consortium's creation, US semiconductor companies were losing market share, mainly to Japanese companies, and the US government was cutting back on funding for research related to silicon technologies, because it considered the technology to be established. Meanwhile, "the Bell Labs of the world were being squeezed out," said Celia Merzbacher, SRC's Vice President for Innovative Partnerships. Leaders in the semiconductor industry recognized that they needed to combine forces to meet their ongoing need for fundamental research, so they created SRC to support university researchers and foster a continued pipeline of ideas and personnel from academia into industry. Today, the consortium has member companies and university partners all over the world, and in 2014 it supported the research of more than two thousand students and five hundred faculty members.

The corporation's focus on basic research makes its mission a good fit with that of the NSF, Merzbacher said. Since the 1980s, the two organizations have had an overarching memorandum of understanding in place, renewed every five years, that states their mutual interest in supporting university research and education.

When program directors at the NSF and SRC identify an area in which they want to work together, they make a subsidiary agreement outlining the specifics for a jointly funded project. For example, Merzbacher said, when SRC decided to establish a hardware cybersecurity program, it approached NSF program directors, who were also interested in growing that part of their ongoing cybersecurity program. The NSF and SRC held a joint workshop on cybersecurity hardware that became the basis for a solicitation in 2014, and the first set of projects were funded at the end of that year. The NSF and SRC have also recently collaborated on a "Nanoelectronics for 2020 and Beyond" initiative, to support interdisciplinary teams of researchers looking for innovative ways to create nontraditional materials and processes for future generations of electronic devices.

In such collaborations, Merzbacher said, the NSF typically manages the review process, but SRC recommends industry reviewers. NSF and SRC officials choose projects to be jointly funded via separate funding agreements with each of the two organizations. Over the years, these partnerships have awarded a total of about $100 million.

The strong interaction between government and industry significantly enhances the science that comes out of the projects, Merzbacher said. SRC facilitates interplay between industry experts and academics by providing annual reviews, frequent webinars, and industry liaisons. This industry participation gives scientists a reality check about whether their research is relevant, observed Paulette Clancy, a professor of chemical engineering at Cornell University in Ithaca, New York, who has received funding from the NSF and SRC for decades. At the same time, Clancy said, SRC brings to the table a level of comfort with failure that is sometimes absent from federal funding agencies. “The SRC companies understand that sometimes a particular avenue of investigation is a dead end, and that’s OK,” she said. “That’s more tricky with a federal funding agency.”

One of the most beneficial aspects of the partnership, Clancy said, is its emphasis on education and subsequent employment, which has always been a focus of SRC, since industry depends on a steady flow of well-educated students. Funding is available for undergraduate and graduate students, and students can attend an annual conference at which they present posters or papers, network, and get a glimpse of career options outside academia. “The advantages to the students are profound,” Clancy said.

Celia Merzbacher

Case Study: The Large Synoptic Survey Telescope

On April 14, 2015, the first stone was laid in Chile for the Large Synoptic Survey Telescope (LSST), whose light-gathering power and uniquely wide field will allow it to collect a detailed digital survey of the available deep universe every week. The telescope is "sort of a genome project for astronomy," said Tony Tyson, a physicist now at the University of California, Davis. "You can serve everyone's science from one single scan of the sky." The telescope's genesis, he said, is "a story of private and public engagement at various critical phases."

In the late 1990s, Tyson and his colleagues at Bell Labs realized that the rapid miniaturization of electronics, together with other technological advances, might make it possible to create what he called "a totally different sky survey design with unprecedented grasp." To achieve this, numerous technical challenges would have to be overcome, the researchers realized, such as the creation of a camera with a three-gigapixel focal plane and fast readout. However, Tyson said, he realized that "physics would not stop us from making it, so I decided to pursue the idea."

Tyson began marshaling support from the astronomy community, starting with a 1998 conference at the Stanford Linear Accelerator Center and a 2001 workshop at the Aspen Center for Physics (which is itself a public-private partnership, he noted), and later creating a 501(c)(3) nonprofit corporation for the project which now has thirty-nine institutional members, mostly universities. "We rapidly got the world community interested in this notion," he said. On the basis of arguments from Tyson and others, the 2000 Astronomy and Astrophysics Decadal Survey recommended the LSST as a major initiative for the coming decade.

Tony Tyson, Susan Hutchison

For about five years, the project suffered from an overall lack of funding, moving slowly with limited support from Bell Labs and several other institutions, as well as an NSF Advanced Technologies and Instrumentation grant to design the telescope's optical charge-coupled devices. Between 2005 and 2007, however, the project received a combined $3 million from Wayne Rosing and Dorothy Largay and the W. M. Keck Foundation, and an NSF design and development award for an initial amount of $4 million. And in 2007, the project received a critical boost from the software billionaires Charles Simonyi and Bill Gates, who pledged $20 million and $10 million, respectively, to develop the telescope's mirrors. "At the point when we started rolling on this, the project became real in many people's view, including the NSF," Tyson said. "We started getting much more R&D support from the NSF and the Department of Energy."

In 2010, the LSST was selected as the highest-priority ground-based instrument in the 2010 Astronomy and Astrophysics Decadal Survey, and in 2014, the project obtained an NSF Major Research Equipment and Facilities Construction investment. All told, the NSF and the Department of Energy have awarded hundreds of millions of dollars toward the construction of the LSST facility.

Funding from the NSF and the Department of Energy, together with investments from international partners, is expected to cover the facility's operations, but not the development of the special tools that will allow the scientific community and the wider public to analyze and exploit the telescope's data. "The next mission is to enable the science," said Tyson, who estimated that this piece of the project will require about $10 million. Simonyi and Gates are actively helping with this goal; they have created a fundraising video and a $1 million matching challenge grant that is in effect through January 2016.

Ultimately, the LSST project will make its data available to anyone with an Internet connection, from eminent astronomers to schoolchildren. "We want everyone—not just black belts but every curious mind—to have a personal relationship with the universe," Tyson said.

Case Study: Stand Up to Cancer

Sung Poblete

Some of the most productive approaches to cancer treatment in the coming decades are expected to arise out of a convergence of ideas from clinical oncology and quantitative sciences such as physics, mathematics, and engineering. Stand Up to Cancer (SU2C), a charitable program of the Entertainment Industry Foundation that was launched in 2008 to fund translational cancer research, has always offered funding not just for oncologists but also for quantitative scientists. However, until recently the organization's solicitations didn't attract many applications from top scientists in quantitative fields. "I think physicists thought, 'It will be very clinically oriented, so I won't apply,'" said Sung Poblete, SU2C's CEO.

Poblete and other officials at SU2C were considering how best to bring together the biology and quantitative science communities, when they discovered that for several years, the NSF and the National Cancer Institute (NCI) had been discussing the exact same question. In 2014, the three organizations formed a partnership that allowed them to pool their strengths. "Stand Up to Cancer had access to one of these communities, and the NSF to the other," said Denise Caldwell, director of the Division of Physics at the NSF.

The partnership, which also included the V Foundation for Cancer Research, put together initial funds of $11.5 million to support translational biophysics using a structure akin to the NSF's Ideas Lab model, which brings together scientists for a five-day intensive workshop to develop proposals.

The Convergence Ideas Lab, held at the Institute for Advanced Study in Princeton, N.J., from February 13 to 18, 2015, attracted twenty-three scientists, all leaders in their fields: nine clinical oncologists, and fourteen quantitative scientists who had published papers in the biological sciences.

After two days of lectures and discussions that one participant described as "a fire hose of information," the researchers formed interdisciplinary teams that generated four short research proposals over the next three days. In the months that followed, the teams fleshed out these proposals, which have been submitted to the NSF and are under review during the summer of 2015. Successful proposals will be eligible to receive funding from the NSF and NCI to support senior quantitative scientists, and from the two private charities to support clinical fellows and postdoctoral researchers.

Stand Up to Cancer has brought aboard additional private donors from charitable foundations and industry, who have contributed a further $8.5 million to the project. "The unusual pairing of a Hollywood initiative like Stand Up to Cancer and the National Science Foundation received significant attention," Poblete said.

The NSF's arrangement with SU2C is a true partnership, Caldwell said—"not an add-on, an extra." Making it work required extensive discussions, as well as consultation with the NSF's Office of the General Counsel. "In these kinds of interactions, it's important that each party has a full understanding of where the other party is coming from," she said. "The US government has rules, things we can and can't do."

Both sides had to be willing to put in time and effort to make things work, Caldwell said. "At times it looked like, how are we going to deal with this?" she said. "The thing is, at the end of the day we both wanted the same thing. As long as the science is the driver, and you keep that at the forefront, you can figure out the rest."

Getting Private Donors to Fund Your Science: Dos and Don’ts

As executive director for the Charles and Lisa Simonyi Fund for Arts and Sciences, Susan Hutchison helped orchestrate the fund’s $20 million gift to the Large Synoptic Survey Telescope (LSST). “I’ve spent a lot of time, as a nonscientist, with marvelous astronomers and astrophysicists at our board meetings,” she said. At the Partnerships meeting, Hutchison offered a number of tips to scientists who are trying to interest private donors in funding their research.

Form a personal relationship with the donor. Don’t spend more time talking than listening, Hutchison advised—instead, ask questions and try to find out what makes the donor tick. “In learning that, sometimes you can find what we call a ‘mission match’ more easily.”

Don’t be shy—tell the donor how much money it will take to get the job done. “I’ve sat across from people asking for money so many times,” Hutchison said. “They’ll spend half an hour telling me what they want done, then they smile, and I have to read their minds.” If the donor doesn’t know the project’s price tag, it’s hard to make a decision. “Most scientists are reluctant to ask for money, because they think they’re asking for themselves.” But donors think of themselves as making an investment, not a gift, and they look to the scientists to provide a return on that investment—not a monetary return, but a “psychic” return, as Hutchison put it.

Tony Tyson, Susan Hutchison

Show how your project affects real people. “We need the story laid out to us, so that we understand that by investing in your project, we’re going to help change the world.” The LSST, for example, has a strong educational component, since the telescope’s data can be shared in homes and classrooms all over the world. “Schoolchildren is a terrific ask,” Hutchison said. If your project helps children, “you have it made.”

Sometimes, start small. Large science projects can take a page out of the direct-mail handbook—request a small contribution to hook a donor, and then ask for more money once the donor trusts the project and feels committed to it. Landing large donations “often first requires getting connected, so the communication can begin.”

Apply peer pressure. The LSST produced a video in which Bill Gates and Charles Simonyi extol the benefits of the project and ask others to join them in supporting it. “Peer pressure really works.”

Don’t expect people to give. “No one likes being guilted into giving. They have to be convinced that it’s something that’s going to matter to them.”

Spend money to make money. Sometimes, it’s worth hiring a professional fundraiser. “It takes tremendous experience and skill to be a superb fundraiser. You can’t do it on your own just because you have a good project.”

Workshop Organizers

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Partnerships

A multiplicity of funding sources brings vitality and creativity to the US scientific scene, much as the great diversity in the American university system has given us some of the world's greatest universities. Both the Federal Government, with its great but still limited resources and the private foundations, with their greater diversity and flexibility, play important roles.

The Partnerships workshop described in this document was designed to showcase concrete current examples of public-private collaborations. The importance that both the NSF and the private foundations attach to the collaborative process was clearly shown by the willingness of the major players to come, and to speak frankly, not only about the successes of the collaborations, but also about the difficulties and frictions that sometimes occur.

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Mathematical Sciences Research Institute