Expanding Pathways for Career Research Scientists in Academia

T. Ben Thompson
Sasha Chapin

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Summary

The U.S. university research enterprise is plagued by an odd bug: it encourages experts in science, technology, engineering, and math (STEM) to leave it at the very moment they become recognized as experts. People who pursue advanced degrees in STEM are often compelled by deep interest in research. But upon graduation from master's, Ph.D., or postdoctoral programs, these research-oriented individuals face a difficult choice: largely cede hands-on involvement in research to pursue faculty positions (which increasingly demand that a majority of time be spent on managerial responsibilities, such as applying for grants), give up the higher pay and prestige of the tenure track in order to continue "doing the science" via lower-status staff positions (e.g., lab manager, research software engineer), or leave the academic sector altogether.

Many choose the latter. And when that happens at scale, it harms the broader U.S. scientific enterprise by (i) decreasing federal returns on investment in training STEM researchers, and (ii) slowing scientific progress by creating a dearth of experienced personnel conducting basic research in university labs and mentoring the next generation of researchers. The solution is to strengthen and elevate the role of the career research scientist[1] in academia—the highly trained senior research-group member who is hands-on and in the lab every day—in the university ecosystem. This is, fundamentally, a fairly straightforward workforce-pipeline issue that federal STEM-funding agencies have the power to address. The National Institutes of Health (NIH) and the National Science Foundation (NSF) — two of the largest sources of academic research funding — could begin by hosting high-level discussions around the problem: specifically, through an NSF-led workshop and an NIH-led task force. In parallel, the two agencies can launch immediately tractable efforts to begin making headway in addressing the problem. NSF, for instance, could increase visibility and funding for research software engineers, while NSF and/or NIH could consider providing grants to support "co-founded" research labs jointly led by an established professor or principal investigator (PI) working alongside an experienced career research scientist.

The collective goal of these activities is to infuse technical expertise into the day-to-day ideation and execution of science (especially basic research), thereby accelerating scientific progress and helping the United States retain world scientific leadership.

Challenge and Opportunity

The scientific status quo in the United States is increasingly diverting STEM experts away from direct research opportunities at universities. STEM graduate students interested in hands-on research have few attractive career opportunities in academia:

[1] Research scientists are sometimes also known as "professional staff" or "staff scientists."

those working as staff scientists, lab managers, research software engineers, and similar forego the higher pay and status of the tenure track, while those working as faculty members find themselves encumbered by tasks that are largely unrelated to research.

Making it difficult for STEM experts to pursue hands-on research in university settings harms the broader U.S. scientific enterprise in two ways. First, the federal government disburses huge amounts of money every year—via fellowship funding, research grants, tuition support, and other avenues—to help train early-career STEM researchers. This expenditure is warranted because, as the Association of American Universities explains, "There is broad consensus that university research is a long-term national investment in the future." This investment hinges on university contributions to basic research; universities and colleges account for just 13% of overall U.S. research and development (R&D) activity, but nearly half (48%) of basic research. Limited career opportunities for talented STEM researchers to continue "doing the science" in academic settings therefore limits our national returns on investment in these researchers.

Box 1. Productivity benefits of senior researchers in software-driven fields. Cutting-edge research in nearly all STEM fields increasingly depends on software. Indeed, NSF observes that software is "directly responsible for increased scientific productivity and significant enhancement of researchers' capabilities." Problematically, there is minimal support within academia for development and ongoing maintenance of software. It is all too common for a promising research project at a university lab to wither when the graduate student who wrote the code upon which the project depends finishes their degree and leaves.

The field of deep learning (a branch of artificial intelligence (AI) and machine learning) underscores the value of research software. Progress in deep learning was slow and stuttering until development of user-friendly software tools in the mid-2010s: a development spurred mostly by private-sector investment. The result has been an explosion of productivity in deep learning. Even now, top AI research teams cite software-engineering talent as a critical input upon which their scientific output depends. But while research software engineers are some of the most in-demand and valuable team members in the private sector, career positions for research software engineers are uncommon at academic institutions. How much potential scientific discovery are U.S. university labs failing to recognize as a result of this underinvestment?

Second, attrition of STEM talent from academia slows the pace of U.S. scientific progress because most hands-on research activities are conducted by graduate students rather than more experienced personnel. Yet, senior researchers are far more scientifically productive. With years of experience under their belt, senior researchers possess tacit knowledge of how to effectively get research done in a field, can help a team avoid repeating mistakes, and can provide the technical mentorship needed for graduate students to acquire research skills quickly and well. And with graduate students and postdocs typically remaining with a research group for only a few years, career research scientists also provide important continuity across projects. The productivity boosts that senior researchers can deliver are especially well established for software-driven fields (see box).

The absence of attractive job opportunities for career research scientists at most academic institutions is an anomaly. Such opportunities are prevalent in the private sector, at national labs (e.g., those run by the NIH and the Department of Energy) and other government institutions, and in select well-endowed university labs that enjoy more discretionary spending ability. As the dominant funder of university research in the United States, the federal government has massive leverage over the structure of research labs. With some small changes in grant-funding incentives, federal agencies can address this anomaly and bring more senior research scientists into the academic research system.

Plan of Action

Federal STEM-funding agencies — led by NSF and NIH, as the two largest sources of federal funding for academic research — should explore and pursue strategies for changing grant-funding incentives in ways that strengthen and elevate the role of the career research scientist in academia. We split our recommendations into two parts.

The first part focuses on encouraging discussion. The problem of limited career options for trained STEM professionals who want to engage in hands-on research in the academic sector currently flies beneath the radar of many extremely knowledgeable stakeholders inside and outside of the federal government. Bringing these stakeholders together might result in excellent actionable suggestions on how to retain talented research scientists in academia. Second, we suggest two specific projects to make headway on the problem: (i) further support for research software engineers and (ii) a pilot program supporting co-founded research labs. While the recommendations below are targeted to NSF and NIH, other federal STEM-funding agencies (e.g., the Departments of Energy and Defense) can and should consider similar actions.

Part 1. Identify needs, opportunities, and options for federal actions to support and incentivize career research scientists.[2]

Shifting academic employment towards a model more welcoming to career research scientists will require a mix of specific new programs and small and large changes to existing funding structures. However, it is not yet clear which reforms should be prioritized. Our first set of suggestions is designed to start the necessary discussion.

[2] NSF often refers to career research scientists as "professional staff."

Specifically, NSF should start by convening key community members at a workshop (modeled on previous NSF-sponsored workshops, such as the workshop on a National Network of Research Institutes [NNRI]) focused on how the agency can encourage creation of additional career research scientist positions at universities. The workshop should also (i) discuss strategies for publicizing and encouraging outstanding STEM talent to pursue such positions, (ii) identify barriers that discourage universities from posting for career research scientists, and (iii) brainstorm solutions to these barriers. Workshop participants should include representatives from federal agencies that sponsor national labs as well as industry sectors (software, biotech, etc.) that conduct extensive R&D, as these entities are more experienced employers of career research scientists. The workshop should address the following questions:

(1) How can NSF minimize the effects of the "research scientist tax"?[3]

(2) What are the specific problems that a research scientist-centered workforce could address?

(3) What tools does NSF have to affect academic-employment structures? Are there ways to incentivize the employment of research scientists within a project-based funding framework?

(4) Are there ways to relax grant-funding constraints such that PIs could hire contract research scientists when appropriate?

(5) In what areas of research and education does the faculty-as-manager paradigm dominate and in what areas are senior research scientists critical but currently unavailable? To what extent do these areas (problematically) overlap?

(6) How could career research scientists support NSF's core mission of "advancing research and education" (including by training graduate students)?

(7) In an industry-employment landscape that provides highly paid opportunities for career research scientists, how can NSF support universities in talent retention?

(8) What best practices for hiring and retaining career research scientists can be gleaned from existing employment models in national labs and industry?

[3] When grants are very competitive, principal investigators (PIs) won't make decisions that reduce their chances of winning. Funding a (more highly salaried) research scientist instead of two or three graduate students is exactly such a decision. In the NSF lexicon, funding graduate students is one form of "broader impact" that will help distinguish one PI's proposal from other proposals with equal intellectual merit. By proposing to fund a research scientist instead of graduate students, that PI's grant will likely be evaluated more poorly on the broader impacts criteria. Other funding agencies have similar perverse incentives. We term these the "research scientist tax."

(9) Are there tools that would increase the prestige and attractiveness of non-faculty but research-oriented positions within academia?

The primary audience for the workshop will be NSF leadership and policymakers. The output of the workshop should be a report suggesting a clear, actionable path forward for those stakeholders to pursue.

NIH should pursue an analogous fact-finding effort, possibly structured as a working group of the Advisory Committee to the Directorate. This working group would identify strategies for incentivizing labs to hire professional staff members, including expert lab technicians, professional biostatisticians, and RSEs. This working group will ultimately recommend to the NIH Director actions that the agency can take to expand the roles of career research scientists in the academic sector. The working group would address questions similar to those explored in the NSF workshop.

Part 2. Launch two pilot projects to begin expanding opportunities for career research scientists.

Pilot 1. Create a new NSF initiative to solicit and fund requests for research software engineer (RSE) support.

Research software engineers (RSEs) build and maintain research software, and train scientists to use that software. Incentivizing the creation of long-term RSE positions at universities will increase scientific productivity and build the infrastructure for sustained scientific progress in the academic sector. Though a wide range of STEM disciplines could benefit from RSE involvement, NSF's Computer and Information Science and Engineering (CISE) Directorate is a good place to start expanding support for RSEs in academic projects.

CISE has previously invested in nascent support structures for professional staff in software and computing fields. The CISE Research Initiation Initiative (CRII) was created to build research independence among early-career researchers working in CISE-related fields by funding graduate-student appointments. Much CRII-funded work involves producing — and in turn, depends on — shared community software. Similarly, the Campus Research Computing Consortium (CaRCC) and RCD Nexus are NSF-supported programs focused on creating guidelines and resources for campus research computing operations and infrastructure. Through these two programs, NSF is helping universities build a foundation of (i) software production and (ii) computing hardware and infrastructure needed to support that software.

However, effective RSEs are crucial for progress in scientific fields outside of CISE's domain. For example, one of this memo's authors has personal experience with NSF-funded geosciences research. PIs working in this field are desperate for funding to hire RSEs, but do not have access to funding for that purpose. Instead, they depend almost entirely on graduate students.

As a component of the workshop recommended above, NSF should highlight other research areas hamstrung by an acute need for RSEs. In addition, CISE should create a follow-on CISE Software Infrastructure Initiative (CSII) that solicits and funds requests from pre-tenure academic researchers in a variety of fields for RSE support. Requests should explain how the requested RSE would (i) catalyze cutting-edge research, and (ii) maintain critical community open-source scientific software. Moreover, academia severely lacks strong mentorship in software engineering. A specific goal of CSII funding should be to support at least a 1:3 ratio of RSEs to graduate students in funded labs. Creative evaluation mechanisms will be needed to assess the success of CSII. The goal of this initiative will be a community of university researchers productively using software created and supported by RSEs hired through CSII funding.

Pilot 2. Provide grants to support "co-founded" research labs jointly led by an established professor or principal investigator (PI) working alongside an experienced career research scientist.

Academic PIs (typically faculty) normally lead their labs and research groups alone. This state of affairs leads to high rates of burnout, possibly leading to poor research success. In some cases, starting an ambitious new project or company with a co-founder makes the endeavor more likely to succeed while being less stressful and isolating. A co-founder can provide a complementary set of skills. For example, the startup incubator Y Combinator is well known for wanting teams to include a CEO visionary and manager working alongside a CTO builder and designer. By contrast, academic PIs are expected to be talented at all aspects of running a modern scientific lab. Developing mechanisms to help scientists come together and benefit from complementary skill sets should be a high priority for science-funding agencies.

We recommend that NSF and/or NIH create a pilot grant program to fund co-founded research labs at universities. Formally co-founded research groups have been successful across scientific domains (e.g., the AbuGoot Lab at MIT and the Carpenter-Singh Lab at the Broad Institute), but remain quite rare. Federal grants for co-founded research labs would build on this proof of concept by competitively awarding 5–7 years of salary and equipment funding to support a lab jointly run by an early-career PI and a career research scientist. A key anticipated benefit of this grant program is increased retention of outstanding researchers in positions that enable them to keep "doing the science." Currently, the most talented STEM researchers become faculty members or leave academia altogether. Career research scientist positions simply cannot offer competitive levels of compensation and prestige. Creating a new, high-profile, grant-funded opportunity for STEM talent to remain in hands-on university lab positions could help shift the status quo. Creating a pathway for co-founded and co-led research labs would also help PIs avoid isolation and burnout while building more robust, healthy, and successful research teams.

Conclusion

Many breakthroughs in scientific progress have required massive funding and national coordination. This is not one of them. All that needs to be done is allow expert research scientists to do the hands-on work that they've been trained to do. The scientific status quo prevents our nation's basic research enterprise from achieving its full potential, and from harnessing that potential for the common good. Strengthening and elevating the role of career research scientists in the academic sector will empower existing STEM talent to drive scientific progress forward.

Frequently Asked Questions

1. Are there places where research scientists are common?

Yes. The tech sector is a good example. Multiple tech companies have developed senior individual contributor (IC) career paths. These IC career paths allow people to grow their influence while remaining mostly in a hands-on technical role. The most common role of a senior software engineering IC is that of the "tech lead", guiding the technical decision making and execution of a team. Other paths might involve prototyping and architecting a critical new system or diving in and solving an emergency problem. For more details on this kind of career, look at the Staff Engineer book and accompanying discussion.

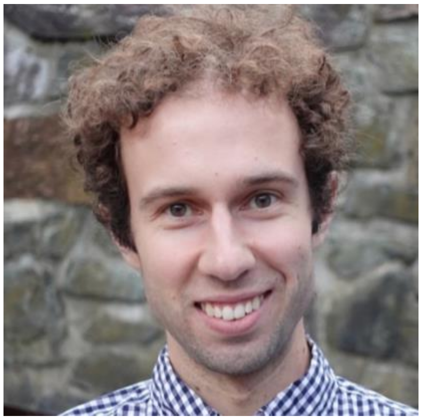
2. Why is now the time for federal STEM-funding agencies to increase support for career research scientists?

The United States has long been the international leader in scientific progress, but that position is being threatened as more countries develop the human capital and infrastructure to compete in a knowledge-oriented economy. In an era where humankind faces mounting existential risks requiring scientific innovation, maintaining U.S. scientific leadership is more important than ever. This requires retaining high-level scientific talent in hands-on, basic research activities. But that goal is undermined by the current structure of employment in American academic science.

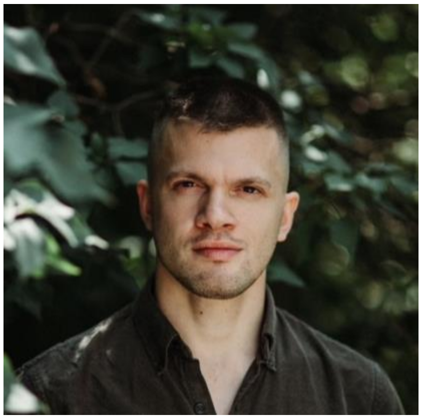
3. Which other federal agencies fund scientific research, and could consider actions similar to those proposed in this memo for NSF and NIH?

Key federal STEM-funding agencies that could also consider ways to support and elevate career research scientist positions include the Departments of Agriculture, Defense, and Energy, as well as the National Aeronautics and Space Administration (NASA).

About the Authors



T. Ben Thompson (Ben) is a computational scientist and software engineer with deep experience in building open-source software for physical simulation and machine learning. While working on his Ph.D. in Earth Science at Harvard, Ben built tools to simulate geometrically realistic earthquakes. More recently at QuantCo, Ben collaborated with economists to build machine-learning systems in e-commerce and insurance. Currently, Ben is starting a company building new statistical-validation tools to help run complex and adaptive drug trials. Ben is also driven to accelerate the scientific process by creating individual-contributor career paths in academia for hands-on technically talented senior scientists.



Sasha Chapin is an author and writing coach. His first book, *All the Wrong Moves,* a memoir about his life as an amateur chess player, was published by Penguin Random House. As a coach, he's had the privilege to help intelligent people from all walks of life articulate their visions, whether commercial, emotional, or otherwise.

About the Day One Project

The Federation of American Scientists' Day One Project is dedicated to democratizing the policymaking process by working with new and expert voices across the science and technology community, helping to develop actionable policies that can improve the lives of all Americans. For more about the Day One Project, visit dayoneproject.org.

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