BERONDA L. MONTGOMERY, FÁTIMA SANCHEZNIETO, AND MARIA LUND DAHLBERG

Academic Mentorship Needs a More Scientific Approach

Research into mentorship demonstrates that supporting the next generation of brilliant minds takes collaboration, innovation, accountability, and rewards.

For an aspiring scientist, intentional support and guidance through effective mentorship can make a career. For that same scientist, negative mentoring experiences—whether well-meaning but neglectful supervision or intentional bullying or harassment—can break a career. University-based scientific education and research depends heavily on established scientists shaping the next generation of brilliant minds, but currently it does not recognize that kind of labor in the way that it rewards publications and successful grant applications. In fact, it is surprising how little attention is paid to the support and guidance of early-career scientists—who heavily contribute to writing grants, doing research, and publishing results. As a community and a culture, academic science must shift toward prioritizing training and mentoring as much as it does the conduct of research. Accomplishing this shift will require deliberate changes to future science policy at all levels to make the development of early career scientists a national priority.

Decades of research into how to make mentorship successful and productive for the careers of aspiring scientists have not been systematically put to use, with the amount and quality of mentorship left to individual principal investigators (PIs), who typically receive little or no mentoring training. Funding priorities reflect this lack of emphasis: for example, only 3% of total National Institutes of Health (NIH) funding in 2020 went to grant mechanisms that specifically required mentorship and training plans. At the National Science Foundation, although grants supporting postdoctoral scientists require a mentoring plan, accountability structures for them are limited. To support the next generation of scientists and build a stronger, more competitive, and more sustainable research enterprise, academic and funding agency leadership must integrate fundamental and celebrated aspects of scientific research—collaboration, innovation, accountability, oversight, and rewards—into the practice of academic mentorship.

Today, mentorship is largely an ad hoc activity, with institutions delegating responsibility to graduate training programs and the PIs of individual research groups. This entrenched, informal system revolves around each scientist's individual commitment to mentorship and personal experience with past mentors. The uneven way the enterprise handles mentoring is reflected in the way the word itself is used (and misused) in various contexts. Often, the word "mentor" is used to refer to the PI who is running a student or postdoctoral researcher's laboratory, even when the true nature of that relationship is merely supervisory or managerial. Lack of a consensus understanding of the approaches to mentorship, the responsibilities involved, and the standards for practice translates into many established scientists and programs claiming to understand and implement mentorship, with relatively few doing so in ways that are intentional and informed.

The Science of Effective Mentorship in STEMM, the 2019 report on mentoring in science, technology, engineering, mathematics, and medicine from the National Academies of Sciences, Engineering, and Medicine, defined mentorship as a "professional, working alliance in which individuals work together over time to support the personal and professional growth, development, and success of the relational partners through the provision of career and psychosocial support." Mentoring relationships, therefore, are reciprocal, defined, and agreed upon by all participating individuals.

The National Academies committee that developed that report also made a series of recommendations that we build on in this article. A key point made in the report is that mentorship is as much a science backed by evidence as are other fields of research. Like other parts of the scientific enterprise, mentoring needs institutional support, commitment to best practices and innovation, accountability and oversight, and rewards and recognition. Effective mentorship, in other words, requires deliberate and intentional actions at the individual as well as institutional levels.

Adopting a collaborative model

In labs throughout the country, including those on the cutting edge of research, mentorship practices still take their cue from the earliest European colleges, where a single, experienced, sage-like scholar served as mentor to a group of excited and engaged students. This literally medieval basis for mentorship in science is so entrenched that most research training programs at the graduate and postdoctoral levels take a hands-off approach to mentoring, leading to a wide variety of mentorship experiences for trainees, even within the same departments and programs.

Scholarship from both industrial and academic perspectives indicates that no one person can provide the full spectrum of career guidance and psychosocial support that even a single mentee, let alone an entire team, will need. Rather, mentees should be given the resources to build comprehensive mentoring networks or mentoring constellations, enabling them to meet individual needs with support and guidance from multiple people. Because their needs will vary based on their strengths, social and intellectual capital, and areas for growth, they will require a wide range and differing number of mentors and resources. One useful tool is mentoring maps, which can guide a mentee through the process of building structured networks of mentors. The network approach can also decrease the burden on any one mentor, allowing them to focus on areas of mentorship that they are best suited to provide.

Just as a research project might involve the collaboration of colleagues—incorporating various perspectives and areas of expertise to fully understand and untangle complex systems—effective research mentoring requires multiple perspectives, ideas, and sources of support. Academic institutions, departments, and leadership committed to the effective mentorship of the next generation of scientists should incorporate collaborative mentorship networks into their training of graduate students and postdoctoral scholars.

> Decades of research into how to make mentorship successful and productive for the careers of aspiring scientists have not been systematically put to use.

Currently, ineffective and even harmful mentorship practices are commonplace in academic science. Regardless of the mentor's intentions, these practices affect the confidence, the mental health, and, ultimately, the retention of early stage researchers in academia. Research on mentorship has shown that negative mentoring experiences are detrimental to the conduct of research, leading to lower job satisfaction, higher likelihood of leaving, and increased stress. Negative mentorship experiences happen more frequently *and with more detrimental impact* to researchers of color, particularly those who are Black or Indigenous, along with researchers who are queer, disabled, and neurodivergent. Those negative experiences then have a downstream effect on the overall diversity of the scientific community as a whole. When the scientific establishment fails to train the next generation of scientists in ways that are intentional and effective, both individuals and the academic research enterprise as a whole are shortchanged—which in turn negatively affects the taxpayers who fund and trust the enterprise and benefit from its findings. Ineffective mentorship ultimately affects everyone.

Supporting innovation and evidence-based practices

Like any science, the science of mentorship evolves as experts in the field innovate solutions. Currently, mentorship researchers are especially interested in how to provide more effective support to minoritized students and professionals. Although studies of mentorship have provided key insights into what works, for whom, and in which contexts, until recently much of the research has focused on practices shown to be effective in majority white populations, rarely taking into account

important factors such as social identity and social capital. The 2019 National Academies report noted the continued persistence of colorblind approaches to mentorship in academia, which involve "focusing exclusively on individual performance measures without consideration of factors that are highly correlated with performance such as social identities, cultural background, and social context, [a focus that] tends to privilege individuals with better preparation, higher social capital, and fewer additional obligations." Such commonplace practices fail to reflect the reality of who stays in and who leaves the system.

Given the long-standing failure of attempts to diversify the scientific research community, designing and implementing inclusive and culturally aware research environments must be a priority. Some evidence-based resources to help advance culturally responsive mentorship practices do exist, but more must be done to fully develop, disseminate, and implement them. For example, the NIH-funded National Research Mentoring Network includes a collective effort focused on "evidence-based mentorship and professional development programming that emphasizes the benefits and challenges of diversity, inclusivity, and culture," according to the network's website. This trove of practices and resources should be leveraged to inform mentoring relationships and built upon to expand understanding of the science of mentorship.

Innovation in mentorship, like innovation in research, though, requires commitments not just from individual PIs, but also from leadership at federal funding agencies, deans and department chairs in academic institutions, and scholars of mentorship. Recent studies on the development and implementation of culturally aware mentorship training have found that, while research mentors reported gaining a deeper understanding of mentee challenges and developing improved communication practices, they also expressed frustration at the lack of institutional support to apply what they learned over the long term. In addition, although both training for PIs and evidence-based metrics to measure PIs' confidence in engaging in culturally aware mentorship behaviors exist, these practices have yet to be widely implemented, sustained, and supported at a systemic level.

Just as innovation in scientific research is supported by offices and executive leadership dedicated to enhancing grant applications, study design, and effective communication of findings, supporting and implementing innovations in mentorship will require investment. Committing financial, human, and structural resources in specific areas—such as requiring mentor training for all faculty taking on trainees—indicates an institution's priorities and commitment. Creating inclusive, equitable, and responsive research environments will require deploying resources, support, and paid personnel to mentorship across an institutional ecosystem.

Providing incentives and accountability

The academic research system currently relies primarily on the individual commitment of PIs to ensure good mentorship. At the level of funders and institutions, there are few mechanisms such as departmental awards to incentivize effective mentorship, and there are even fewer mechanisms to hold individuals accountable for uninformed, neglectful, or even harmful mentorship practices. While lack of training, ineffective communication, or misalignment of expectations and styles contribute to negative mentorship, it is important to recognize that racism, abuse, sexual harassment, ableism, and queer- and transphobia persist in academic spaces to this day with little to no consequences for individuals who cause harm to trainees and their careers. Full commitment of the scientific enterprise to the professional development and retention of future scientists will only be accomplished when proper oversight and regulation of mentorship are established for grants that fund research done by graduate students and postdocs.

Currently, the majority of graduate students and postdocs supported by NIH are funded on R mechanism grants (the organization uses letters to code different kinds of programs it supports), which do not have any mandates for holding PIs accountable for providing evidence-based training and mentorship practices. NIH does have established mechanisms—such as its individual K or institutional T awards—that include varying levels of accountability for mentorship education or support. However, in the same way that it is accepted practice for scientists to explain the "what" and the "how" of their proposed research project, PIs should be asked to demonstrate the "who" *and* the "how" they will provide career development and support of their research teams. Including this as a requirement on all research funding should be part of the responsible conduct of research. Funding agencies and academic leaders who are committed to improving mentorship need to work to develop rigorous guidelines that incentivize good mentoring behavior and ensure that evaluation of mentoring plans becomes a meaningful and integrated part of all research proposals that fund trainees, not just the small percentage currently specified for training.

Academic institutions can also incentivize and facilitate improved mentoring in numerous ways: through providing resources and training faculty, conducting rigorous evaluation, and recognizing effective mentoring in a manner that rewards faculty and reflects the true value of these activities. Today, when mentoring is recognized, it is often woven into recognition and evaluation of an individual's

Like other parts of the scientific enterprise, mentoring needs institutional support, commitment to best practices and innovation, accountability and oversight, and rewards and recognition.

teaching or service—but it deserves its own stand-alone evaluation. Throughout academia, there are performance expectations, rewards, and metrics broadly recognized as demonstrating excellence; these should be offered for mentorship, with the same stature and career import as research awards. Likewise, research merit reviews should directly acknowledge mentoring—contrary to the current practice of irregularly applying quantitative metrics to the number of students and postdocs trained.

The science of mentorship can help inform the performance expectations, rewards, and metrics for the evaluation and recognition of mentorship by faculty members. The 2019 National Academies report notes that leaders can establish guidelines for evaluating mentorship, include mentorship outcomes in annual reviews and promotion and tenure packages, and provide clear criteria for mentorship awards. Merit and review committees can incorporate anonymized feedback on mentoring, enabling leaders to identify promising practices that deserve amplification and reward, as well as areas of individual or collective focus for improvement. In their annual and promotion reviews, faculty members could be asked to report on their mentoring philosophies, their mentees' contributions to manuscripts and grants, any mentoring awards received, and bilateral assessments measuring outcomes of mentoring. When hiring new faculty members, leaders could ask for mentoring statements or certifications of completing mentorship education, which institutions could provide for their graduate students, postdocs, and faculty. In elevating mentoring preparation and stewardship to institution-wide priorities, campus leaders can take concrete steps to improve the quality of mentoring for early career researchers.

Mentorship as a science

Leaders set the tone, both culturally and systemically, within their spheres of power. They guide the development of those around them and can align policy, culture, and practices with what we know works to unlock the greatest productivity and creativity among all scientists. Funders and academic leaders have a moral imperative to begin implementing the systemic changes needed.

To transform mentorship and provide the support early-career scientists need, institutions will need to use evidence-based practices and innovations at the system level, while providing leadership support and accountability structures. Doing so will entail structural changes in how trainees are supported, as well as how some established scientists are recognized.

Our goal is a future in which mentorship is deeply and intentionally embedded into the scientific enterprise, starting with funding and extending to academic leadership and individual PIs. We envision mentorship as intentionally involving teams, including people who specifically focus on mentorship. Together, these teams would provide support for the scientific, pedagogic, and career development of future scientists. Universities would fund offices dedicated to providing mentorship education and support to both students and faculty in the same fashion as done in research safety and ethics offices. Faculty responsible for mentoring students or benefiting from their labor would submit training and development plans demonstrating competence and intentionality in the stewardship of their career development. Promotion and tenure would explicitly take mentorship into account, and mentorship education would be a part of all careers.

Mentorship is central to the research ecosystem, and it must be treated as such. Mentorship takes skill, time, effort, resources, and dedicated individuals who should be adequately trained, recognized, and valued. Intentions, however good, will not make up for a lack of intentionality: our future scientists and science are at stake.

Beronda L. Montgomery *is a mentoring and academic leadership scholar who is vice president for academic affairs and dean of Grinnell College.* ***Fátima Sancheznieto*** *is a STEM training and mentorship researcher at the University of Wisconsin–Madison and the president of Future of Research, a volunteer nonprofit that advocates for early career researchers.* ***Maria Lund Dahlberg*** *is the acting director of the Board on Higher Education and Workforce of the National Academies of Sciences, Engineering, and Medicine, where she oversees a portfolio of work, including the* Science of Effective Mentorship in STEMM.

"The Next 75 Years of Science Policy" has been made possible through the generous support of The Kavli Foundation.