

A Path to Gender Equity in the Geosciences: Empowering Women Postdocs

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For decades, the geosciences have struggled to achieve gender equity (Bernard and Cooperdock 2018; Holmes et al. 2008). Despite notable progress (Ranganathan et al. 2021), women in the field remain underrepresented in positions of leadership and influence and across the sectors of academia, research, and industry. This imbalance is particularly pronounced at the postdoctoral level, where the transition from early-career researcher to independent scientist is formative. Although women make up about 49.5% of geosciences Ph.D. students, they only comprise 41.6% of geosciences postdocs (National Center for Science and Engineering Statistics 2023). Furthermore, prior to the COVID-19 pandemic, women made up only about 20% of all faculty in geosciences positions at 4-yr institutions (Glass 2015). While women had made some gains in recent years, comprising 27% of geosciences faculty positions in 2020 (Ranganathan et al. 2021), the pandemic likely offset these gains and has left numerous women researchers at risk of abandoning their academic careers altogether (Alon et al. 2020; Augustus 2021; Cui et al. 2022; Davis et al. 2022; Yildirim and Eslen-Ziya 2021).

Structural barriers, including institutional policies that are insufficiently accommodating of the needs of women and other underrepresented scientists, contribute to the challenges that women scientists face, leading to attrition rates in the geosciences that exceed those of their male counterparts (Ranganathan et al. 2021). These challenges are compounded for women scientists belonging to two or more historically excluded groups, such as women of color (Berhe et al. 2022).

One challenge has been in identifying the structural barriers thought to inhibit the advancement of women scientists. Unconscious biases have been regarded as a major problem in hiring tenure-track female researchers. Yet a recent study by Ceci et al. (2023) examined biases in hiring for tenure-track STEM positions spanning 2000–20 and found that there was only a slight bias in the hiring process and that the process may have even offered advantages to women in hiring for tenure-track positions. Although significant efforts have been made to hire women in the geosciences at the tenure-track level in recent years, far less attention has been given to the plight and conditions of women scientists during their postdoctoral positions, which are crucial points in the careers of scientists and frequently determine their eligibility for tenure-track hiring and other forms of career advancement.

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Postdocs, especially those with young children, are rarely paid well enough to sustain a family. Woolston (2019) estimated the median annual salary for postdocs in 2018 to be \$47,500. Yet the median yearly cost of infant childcare in large counties in the United States at the time was estimated to be \$15,417 (Landivar et al. 2023), or about a third of that salary. Women often leave academic science just before or during their postdoctoral training (Martinez et al. 2007; Ranganathan et al. 2021; Shen 2013). Uncoincidentally, this is also when women are most likely to have children. Women have disproportionately borne the brunt of childcare duties, hindering their careers in most sectors, including the geosciences. Although most of the literature on the subject tends to involve women and binary genders, nonbinary scientists and men scientists with primary caregiving duties can also bear these burdens and need to be considered in formulating ameliorative strategies.

The tenure system and career trajectories in academia often favor continuous and uninterrupted research progress. Interruptions due to family responsibilities or other factors often put caregiving postdocs, particularly women, at significant disadvantage and deter them from seeking a tenure-track career. Postdocs normally have more tenuous positions than tenure-track faculty. While an increasing number of institutions offer tenure-clock extensions for caregiving faculty, postdocs are rarely entitled to such benefits. Institutions have also increasingly adopted formal family leave policies for faculty, although those policies rarely extend to postdocs, particularly if they are funded on limited-term grants or fellowships.

The lack of employment policies that are sufficiently accommodating of caregiving scientists, such as flexible work arrangements and affordable childcare options, can discourage women from furthering their careers. The dearth of institutional support for work–life balance can make it hard if not impossible for women to navigate these dual responsibilities. Cech and Blair-Loy (2019) showed that female scientists are more likely than their male counterparts to leave full-time STEM employment after the birth or adoption of their first child.

Many geoscience research projects require substantial fieldwork and travel, which can be prohibitive for those, especially women, with caregiving duties. Balancing fieldwork with family responsibilities becomes a major impediment, forcing some women to leave academia or change their areas of research. Moreover, women postdocs with research projects that involve fieldwork are likelier than men to be targets of sexual harassment and sexual assault (Clancy et al. 2014).

Compounding these issues, a shortage of female mentors and role models can result in women postdocs lacking the advice and support needed to manage the complexities of academia and careers in the geosciences. Drury et al. (2011) showed that female role models help to retain women in STEM fields. Inadequate or unsupportive mentorship can also hinder the professional growth of women scientists and limit their ability to continue in the field.

Another major problem for postdocs, particularly women, is that hiring and careers in the sciences depend largely on one's relationship with one's supervisor, creating a system that is rife for abuse (Moss and Mahmoudi 2021; Puljak 2006). This system of unilateral supervision, especially when exacerbated by inadequate levels of financial and institutional support for postdocs, is likeliest to harm women scientists, along with other underrepresented groups, including foreign nationals and the socioeconomically disadvantaged. Most postdocs depend on a supportive recommendation from their supervisor to advance in their career. Dutt et al. (2016), however, demonstrated the extent to which such recommendations tend to favor male postdocs. More broadly, Marín-Spiotta et al. (2020) and Marín-Spiotta et al. (2023) showed that the academic STEM environment displays hierarchical cultures that facilitate harassment, hostile behavior, and bias. The result is a vicious cycle of inequity and underrepresentation in the geosciences. As efforts to address gender inequity in the field gain momentum, it is essential to examine the intricacies of retaining women in the geosciences and to explore strategies that can pave the way for lasting change.

Universities and funding agencies have recognized these challenges and begun implementing strategies of redress. NSF, for example, sponsors the ADVANCE Program, which provides grants intended to bolster diversity in science and engineering. Some professional society meetings, such as the Ocean Sciences Meeting, provide caregiver grants to boost participation among scientists with family or dependent obligations. These are promising starts.

To combat the structural barriers that women scientists face, research institutions, universities, professional societies, and funding agencies like the NSF and NASA need to reassess the current system of geosciences research and mentoring, identify the major factors impeding gender equity, and target solutions collaboratively and across sectors. The following suggestions are offered to achieve this shared goal, although it should be acknowledged that identifying the structural barriers and impediments women scientists face may not necessarily lead to an agreed-upon set of solutions, including the ones proposed here.

One starting point is to move away from unilateral reporting and toward multiparty accountability. If we truly wish to prevent abuse and misconduct and ensure that women are adequately reflected in the sciences, we need to ensure that as postdocs they do not report to one person alone or find their careers dependent on that person. As Goulet (2021) also pointed out, funding agencies should encourage anonymous reporting tools that could help prevent abusive mentor–mentee relationships, and they should impose sanctions and fines on institutions that knowingly allow such behavior.

Finances matter, as well. Our geosciences community and funding agencies need to provide adequate funding or subsidies for childcare options for postdocs. The National Institutes of Health’s National Research Service Award, for example, offers a childcare allowance of \$2,500 per year to postdocs in medical and biological fields. Although in need of expansion, the award offers one promising model of support that geosciences sponsors could adopt.

Clear guidelines and support systems are also needed. Institutions and agencies can work together to reveal and address the hidden barriers that underrepresented groups, especially women scientists, face; support their inclusion in conferences and other collaborations; compensate them for acts of “hidden labor,” including the service tasks they are often and disproportionately assigned (Guarino and Borden 2017); set standards for their workloads and obligations to ensure fairness in allotment and distribution of responsibility; investigate ways of supporting mental health and creating affirmative workplace environments; and establish clear guidelines in promotion, advancement, and contracts for continuation or renewal, particularly among postdocs.

Further strategies for redress could include professional societies, such as the American Meteorological Society (AMS) and American Geophysical Union, highlighting the achievements of more early-career scientists, particularly women postdocs, and creating additional awards for this purpose. For example, one or more awards could highlight scientists who have arrived at their success through nontraditional paths, including military backgrounds or post-family or medical leaves. AMS, in addition to the four early-career awards that it currently sponsors, should designate an award category for women and others identifying with historically underrepresented groups. Additionally, institutions and professional societies could help to promote and support mentoring programs for women postdoc scientists, such as the Mentoring Physical Oceanography Women to Increase Retention (MPOWIR; Clem et al. 2014) program, which has shown success in helping to retain women in physical oceanography. Last, scientists nominated for senior awards and fellowships in the geosciences could be asked to supply evidence of their mentorship achievements, such as letters from past or present mentees. Although such evidence is often imperfect, it can begin a discussion about the dedication good scientists should make to their mentees and the extent to which science itself is a fundamentally collaborative discipline. Such evidence could also discourage abuse

or mistreatment of mentees and encourage open communication about responsibilities and obligations in mentor–mentee relationships.

In the end, women are unlikely to advance in the geosciences if the institutions and funding agencies do not do more to support them, particularly at the postdoctoral level. By acknowledging the barriers and constraints that women postdocs face and adopting targeted strategies to address them, the geosciences community can start to create an environment where women are empowered to flourish, contribute, and ultimately shape the future of the field.

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