

Data Illuminate a Mountain of Molehills Facing Women Scientists

From the peer-review process to our very concept of what it means to be brilliant, studies show that women face subtle biases and structural barriers to success in the geosciences.



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By [Julia Rosen](#) © 25 January 2017

Every female scientist has a story.

One woman was warned not to wear her wedding ring to job interviews. Another noticed that her adviser showered more praise on his male students. On one occasion, a woman sat silent while the man next to her turned his back to talk to other (male) colleagues for the entire duration of a professional dinner.

What should the women on the receiving end of such slights make of them? They might be random, nothing more than the everyday ups and downs of life as a professional scientist. They could be isolated incidents of sexism. Or they could be symptomatic of broader trends that hinder women in science.

In cases like these, it's impossible to know. "As an individual, you don't really have the sample size to come up with this sort of conclusion," said Jory Lerback, a graduate student at the University of Utah. But now, researchers like Lerback have harnessed the power of data to zoom out and identify systemic problems within the Earth sciences.

In [one study](http://www.nature.com/articles/doi:10.1038/541455a) (http://www.nature.com/articles/doi:10.1038/541455a), led by Lerback and published today in *Nature*, researchers found that women make up a disproportionately small percentage of reviewers for Earth science journals. Another revealed that female geoscientists are less likely to receive glowing [letters of recommendation](http://www.nature.com/ngeo/journal/v9/n11/full/ngeo2819.html) (http://www.nature.com/ngeo/journal/v9/n11/full/ngeo2819.html) when applying to postdoctoral fellowships.

Women face insidious challenges, such as subtle, unconscious bias held by people of both genders.

Researchers say the new results don't reflect overt discrimination, which has declined dramatically in recent decades. Instead, women face more insidious challenges, such as subtle, unconscious bias held by people of both genders and built-in barriers to success.

And they add up. Psychologist [Virginia Valian](http://maxweber.hunter.cuny.edu/psych/faculty/valian/valian.htm) (<http://maxweber.hunter.cuny.edu/psych/faculty/valian/valian.htm>) of Hunter College calls this the “accumulation of disadvantage.” She argues that countless molehills pile up to create formidable mountains standing in the way of female scientists. In the geosciences, women still make up just 20% of faculty (<http://onlinelibrary.wiley.com/doi/10.1002/9781119067573.ch2/summary>) in the United States, despite earning almost a third of Ph.D. degrees in 2000 and more than 40% today.

By using hard data to illuminate lingering problems, many hope that the geoscience community can start bulldozing the remaining molehills. After all, to realize its full potential for innovation and success, science needs all kinds of scientists, said [Tracey Holloway](https://nelson.wisc.edu/sage/people/profile.php?p=1653) (<https://nelson.wisc.edu/sage/people/profile.php?p=1653>), an atmospheric scientist at the University of Wisconsin–Madison and president of the [Earth Science Women’s Network](http://eswonline.org/) (<http://eswonline.org/>).

“For the well-being of the human enterprise, we want all hands on deck.”

Wanted: A Detailed Database

Reviewing papers may not be glamorous, but it plays a fundamental role in the scientific process.



Heather Ford, an independent research fellow at Cambridge University studying paleoclimatology, examines a sediment core on the R/V *Melville*. Ford says that she enjoys reviewing papers, but new data show that women are underrepresented as reviewers in geoscience journals. Credit: Ajay Singh

“I like reviewing papers because I have an opportunity to improve the quality, breadth, and impact of a manuscript,” said Heather Ford, an independent research fellow at Cambridge University studying paleoclimatology. Reviewing also provides important opportunities for early-career scientists like Ford to network with journal editors and interact with fellow scientists.

But it’s hard to determine whether women are well represented among geoscience authors and reviewers, Lerback says. Most publishers don’t ask scientists for their gender, and assigning it based on names can be tricky business. Considering age is also important because the proportion of women decreases among older scientists—a consequence of historic barriers to entry.

The American Geophysical Union (AGU), however, was in a unique position to do such an analysis. It publishes a suite of scientific journals and possesses gender and age information for more than 38,000 geoscientists who belong to the organization or have participated in AGU-sponsored activities, like its sprawling Fall Meeting.

Merging these two data sets offered the chance to evaluate both the gender ratio of authors and reviewers for AGU’s journals and how those ratios stacked up against the field’s demographic breakdown. Lerback undertook the task with Brooks Hanson, AGU’s director of publications, and uncovered a complex landscape of small but significant gender differences in geoscience publishing.

How Often Do Women Publish in AGU Journals?

Lerback and Hanson’s results show that women published less than men, submitting an average of 0.79 fewer first-author papers to AGU’s journals in the 4-year period between 2012 and 2015.

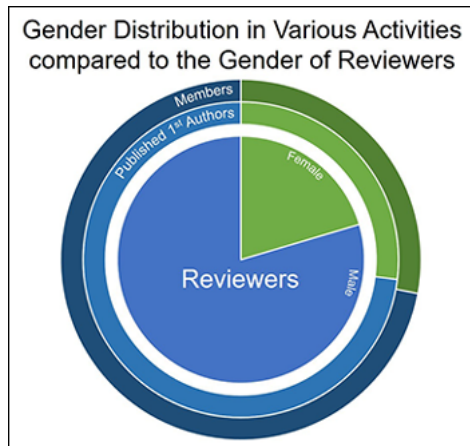
However, women were better represented among first authors (26%) compared to total authors (23%), in contrast to [previous studies](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3718784/#pone.0066212-Conlev1) (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3718784/#pone.0066212-Conlev1>) that found women tended to be listed between the respected first and last author positions. Overall, women also enjoyed a slightly higher acceptance rate than men: 61% vs. 57%.

The researchers attribute this greater success rate either to reverse discrimination (i.e., reviewers actually favoring female scientists) or, more likely, to the fact that women perfect their papers before submission, anticipating heightened scrutiny. “When someone is faced with that sort of mentality, you cover all your bases,” Lerback said. “You check and check and check.”

A Gender Gap in Peer Review

Most worryingly, Lerback and Hanson found that women were chronically underrepresented as reviewers. In total, women made up only 20% of reviewers, even though they comprise 28% of AGU’s membership and 29% of all scientists who have created accounts with AGU.

“That’s a pretty big gap of women who aren’t reviewing,” Lerback said. On its own, this disparity wouldn’t make or break anyone’s career, she added, but it’s problematic because it plays into the larger pattern of gender inequality in the Earth sciences.



A study published today in *Nature* found that women were underrepresented as reviewers for AGU’s journals. The proportion of female reviewers (20%) was smaller than the proportion of published female first authors (27%) and female AGU members (28%). Credit: Lerback and Hanson, 2017, doi:10.1038/541455a

The researchers found that several factors were to blame: Authors didn’t suggest enough female reviewers for their papers, editors didn’t invite enough female reviewers, and women declined to do reviews more often than men.

What’s more, these disparities persisted across age groups. This eliminated the possibility that authors and editors simply sought reviewers from older and more experienced cohorts with fewer female members.

No comparable analyses have been carried out for journals published by the Geological Society of America or the European Geosciences Union. But the new results, based on an analysis of nearly 25,000 authors and 15,000 reviewers, are hard to dismiss as unrepresentative, said [Mary Anne Holmes](http://eas2.unl.edu/~mholmes/) (<http://eas2.unl.edu/~mholmes/>), a sedimentary geologist at the University of Nebraska–Lincoln and a [leading advocate](https://eos.org/agu-news/working-toward-gender-parity-in-the-geosciences) (<https://eos.org/agu-news/working-toward-gender-parity-in-the-geosciences>) for gender equality in the Earth sciences. “The volume of data is pretty overwhelming.”

Brilliant or Intelligent?

Another recent study tells a similar story about differences in the quality of reference letters for male and female geoscientists.

Researchers first realized that letters often reflect gender stereotypes decades ago, and disparities have been clearly documented in [numerous studies](http://journals.sagepub.com/doi/abs/10.1177/0957926503014002277) (<http://psvcnet.apa.org/psvcinfo/2009-21033-018>). But a [new analysis](http://www.nature.com/ngeo/journal/v9/n11/full/ngeo2819.html) (<http://www.nature.com/ngeo/journal/v9/n11/full/ngeo2819.html>), published last fall in *Nature Geoscience*, is the first to look specifically at the Earth sciences and relies on a larger data set than previous work.

Researchers evaluated more than 1200 letters sent on behalf of scientists applying for postdoctoral fellowships at Columbia University’s Lamont-Doherty Earth Observatory (LDEO) between 2007 and 2012. The letters came from male and female recommenders scattered across 54 countries.



Cynthia Gerlein-Safdi, a Ph.D. student at Princeton University who studies how plants respond to climate, takes a soil sample in Kenya. She is currently applying for postdoc positions and was disheartened to hear reports of gender bias in recommendation letters. Credit: Ekomwa Akuwam

The analysis revealed that letters for men and women differed significantly in tone. Roughly a quarter of male applicants received what the authors classified as excellent letters, which included phrases like “brilliant scientist” and “scientific leader,” compared to 15% of female applicants. Instead, more than 80% of women got letters that praised them in more staid terms, calling them “highly intelligent” and “very knowledgeable.”

After adjusting the results to reflect regional variations between the home country of recommenders and letter length, the researchers found that women were about half as likely to receive excellent letters. This disadvantages women at a critical stage in their careers, the authors wrote.

“It certainly makes me feel highly discouraged and pessimistic,” says Cynthia Gerlein-Safdi, a Ph.D. student at Princeton University studying how plants respond to climate. She is currently in the process of applying for postdoc positions and was disheartened when she heard the results of the study.

“It is highly unlikely that all over the world, there is a systemic deficit in the quality of just the women applicants.”

Because of the archival nature of the study, the researchers could not control for differences in the qualifications of the applicants. However, that probably doesn’t explain the results, said Kuheli Dutt, [assistant director of academic affairs](http://www.ldeo.columbia.edu/ldeo/dir/academic-affairs-diversity/home.html) (http://www.ldeo.columbia.edu/ldeo/dir/academic-affairs-diversity/home.html) at LDEO and lead author of the study.

“It is highly unlikely that all over the world, there is a systemic deficit in the quality of just the women applicants,” she said.

A Competitive Disadvantage

Women remain at a competitive disadvantage even when they have the exact same qualifications as their male counterparts, according to previous studies.

Take the now-[famous study](http://www.pnas.org/content/109/41/16474.abstract) (http://www.pnas.org/content/109/41/16474.abstract) where identical job applications were sent out under different names. Faculty rated the applicants with male names as significantly more competent and hireable for a potential lab manager position than applicants with female names. They offered to pay them more too. [Another study](http://www.pnas.org/content/111/12/4403.short) (http://www.pnas.org/content/111/12/4403.short) found that men were twice as likely to be selected to perform a mathematical calculation on the basis of their appearance alone.

Men were twice as likely to be selected to perform a mathematical calculation on the basis of their appearance alone.

Holmes also points to the story of gender bias in orchestras. Few female musicians made the cut when judges could see them perform during auditions. But when they played from [behind a screen](http://www.nber.org/papers/w5903) (http://www.nber.org/papers/w5903), Holmes said, “the number of women who were hired just rose dramatically.”

Researchers attribute such patterns of discrimination not to intentional exclusion but to the effects of implicit or unconscious biases. These are deep-seated beliefs about groups of people—in this case, women—that stem from common stereotypes and may even conflict with our conscious thoughts and attitudes, according to [Mikki Hebl](http://www.mikkihebl.com/) (http://www.mikkihebl.com/), an applied social psychologist at Rice University.

For instance, many people may support women in science but [subconsciously react](http://www.awis.org/?Implicit_bias) (http://www.awis.org/?Implicit_bias) to the ways in which female stereotypes conflict with stereotypes about scientists.

In a 2008 *Nature Geoscience* [study](http://www.nature.com/nggeo/journal/v1/n2/abs/ngeo113.html) (http://www.nature.com/nggeo/journal/v1/n2/abs/ngeo113.html) led by Holmes, some participants in a focus group tasked with examining why women choose to leave Earth science suggested that it is because they don’t like doing fieldwork or have low interest in the subject matter, ideas that echo long-held ideas about feminine fragility and disposition. However, as “congenial players in the dirt,” Holmes and her coauthors wrote that they don’t believe these are major drivers.

“We have so many cultural preconceptions of what a genius looks like, what a scientist looks like.”

Problems also stem from the fact that stereotypes about scientists evolved decades ago, when most were men. “We have so many cultural preconceptions of what a genius looks like, what a scientist looks like, what kind of behavior is indicative of somebody being truly devoted to their career,” Holloway said.

“Sometimes, it’s very difficult to differentiate what are characteristics of a good scientist from what are characteristics of a male scientist.”

An Equal Opportunity Challenge

Men aren’t the only ones who fall prey to these subtle biases, however.

In Dutt’s study, female recommenders were equally likely to write stronger letters on behalf of male applicants. And although female editors and authors at AGU’s journals identified a higher proportion of women to review papers than male editors did, the gender ratio of those reviewers still failed to reflect the demographics of the field.

“It’s not really about who’s to blame,” Lerback said. It’s recognizing that everyone is part of the problem.

Both men and women can harbor unconscious bias because it’s based on culturally learned information.

Both men and women can harbor unconscious bias because it’s based on “culturally learned information,” Hebl said. “When we come into the world, we learn that girls wear pink and boys wear blue.” As a result, psychologists have found that we tend to penalize anyone—male or female—who doesn’t conform to our subconscious expectations.

For example, in one 2016 [study](http://www.nytimes.com/2016/10/12/science/women-stem-metaphors.html) (<http://www.nytimes.com/2016/10/12/science/women-stem-metaphors.html>) where male and female subjects were asked to rate the brilliance of various scientific discoveries, researchers found that people of both genders rated discoveries as more exceptional if they were described in ways that fit stereotypes of women as caregivers and men as geniuses.

For men, that meant having a flash of brilliance, and for women, it meant nurturing the seed of an idea as it grew. Discoveries described with the opposite pairings (i.e., women having a flash of brilliance) received more tepid ratings.

Subtle though they may be, these biases make scientists less likely to think of their female colleagues when inviting colloquia speakers, according to Hebl’s research. This may also explain why fewer women [get nominated](https://eos.org/opinions/gender-diversity-cryosphere-science-awards) (<https://eos.org/opinions/gender-diversity-cryosphere-science-awards>) for [awards and honors](http://onlinelibrary.wiley.com/doi/10.1029/2011EO470002/abstract) (<http://onlinelibrary.wiley.com/doi/10.1029/2011EO470002/abstract>) or get asked to author perspective pieces for prestigious journals. A [2012 analysis](http://www.nature.com/nature/journal/v488/n7413/full/488590a.html) (<http://www.nature.com/nature/journal/v488/n7413/full/488590a.html>) found that women wrote just 4% of Earth science News and Views articles in *Nature*.

It’s no surprise, then, that these biases may also arise when authors or editors of a scientific paper brainstorm possible reviewers, Lerback said. “Who makes it through to the forefront of your mind?”

Navigating Hidden Barriers

Unconscious biases aren’t the only impediments to success. Women must also contend with [troubling levels](https://eos.org/opinions/senior-scientists-must-engage-in-the-fight-against-harassment) (<https://eos.org/opinions/senior-scientists-must-engage-in-the-fight-against-harassment>) of [sexual harassment and assault](http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0102172) (<http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0102172>), a lack of mentors, isolation in male-dominated research groups, and a litany of other challenges. Sometimes, the very [architecture of science](https://eos.org/opinions/steps-to-building-a-no-tolerance-culture-for-sexual-harassment) (<https://eos.org/opinions/steps-to-building-a-no-tolerance-culture-for-sexual-harassment>)—designed mostly by and for men—can stand in the way. This becomes particularly evident as women progress beyond graduate school.

For instance, it has long been seen as advantageous for young scientists to move to a new institution immediately after finishing a Ph.D. Until recently, it was actually a requirement for recipients of the National Science Foundation’s prestigious postdoctoral fellowships.

But uprooting can be harder for women than men, said Holloway. Women generally marry and have children at a younger age, and female scientists are more likely to have a partner in academia.



Jennifer Hertzberg, paleoceanographer and postdoctoral fellow at the University of Connecticut in Avery Point, inspects a sediment core aboard the R/V *Melville* in the eastern Pacific. She's currently looking for a job but notes that the researcher's life of chasing funding could bleed into family time. Credit: Franco Marcantonio

The demands of certain faculty jobs that require constantly chasing funding can also be daunting to women as they consider starting families, said [Jennifer Hertzberg](http://www.jenniferhertzberg.com/) (<http://www.jenniferhertzberg.com/>). Hertzberg is a paleoceanographer and postdoctoral fellow at the University of Connecticut in Avery Point, who is currently applying for jobs. "If I were having to write research grants all the time, I know that that would fall into afterhours and on the weekends." She's not sure it would be doable with kids.

Academic jobs often require long hours, and data suggest women have fewer to spare. Female scientists with male partners tend to do more housework, according to [a survey](http://www.colorado.edu/eeer/research/documents/ESWNfinalReportALL_2013.pdf) (http://www.colorado.edu/eeer/research/documents/ESWNfinalReportALL_2013.pdf) conducted through the [Earth Science Jobs Network](http://eswnonline.org/resource/the-earth-science-jobs-network-es_jobs_net/) (http://eswnonline.org/resource/the-earth-science-jobs-network-es_jobs_net/), a listserv run by the Earth Science Women's Network that includes both male and female geoscientists. Sixty percent of women reported doing the majority of household upkeep, compared to 20% of men. Fifty percent of women with children also did the majority of parenting work, compared to 9% of men.

In addition, [research suggests](https://www.aap.org/article/ivory-ceiling-service-work#.WlJvbpLw2_s) (https://www.aap.org/article/ivory-ceiling-service-work#.WlJvbpLw2_s) that women may also juggle more obligations at the office. Female associate professors, in particular, typically shoulder heavier administrative, mentoring, and teaching duties at the expense of research. They often serve on many doctoral committees, for example, as one of a few female faculty members in high demand from larger numbers of female students, Holmes said.

All this may explain the small but telling finding in Lerback's study that even when women were asked to review papers, they declined more often than men. "Maybe women aren't stepping up to do these reviews because they're too damn busy," Holmes said.

Data Pave a Path to Progress

At the end of the day, the many challenges facing female scientists weigh on women just starting in their careers. Some feel lucky just to have made it as far as they have, given that the deck is often stacked against them.

"I feel like I have to work harder than a male at the same point in my career."

"It's exhausting," said Ford.

"I feel like I have to work harder than a male at the same point in my career," said Hertzberg.

Many agree that the first step in addressing these problems is raising awareness. And the recent studies should help.

"Data are undeniable facts," said Claudia Jesus-Rydin, a program officer for Earth system sciences at the European Research Council who coordinates its [gender balance initiatives](http://www.wings.lu.se/event/seminar-on-erc-gender-policy-and-action-by-claudia-jesus-rydin) (<http://www.wings.lu.se/event/seminar-on-erc-gender-policy-and-action-by-claudia-jesus-rydin>). Scientists, of all people, should be persuaded of the problem.

But what can scientists do about it?

Knocking Down Barriers

Unconscious bias and structural barriers can take many forms, and the solutions may be as diverse as the problems themselves.

Because unconscious biases are, by definition, unconscious, people can't just decide to change them. However, research suggests that simply recognizing the presence of implicit bias is an important way to reduce its effects. Harvard offers [online bias tests](https://implicit.harvard.edu/implicit/takeatest.html) (<https://implicit.harvard.edu/implicit/takeatest.html>), and many organizations, including universities and professional societies, now offer implicit bias training for awards and hiring committees.

Voluntary training proved most effective at reducing bias. However, forcing people to participate in bias training can actually spark a backlash.

Voluntary training proved most effective at reducing bias, along with strategies like implementing [mentoring programs](https://eos.org/opinions/creating-local-support-networks-for-graduate-student-women) (<https://eos.org/opinions/creating-local-support-networks-for-graduate-student-women>) and fostering social accountability, according to [an analysis](https://hbr.org/2016/07/why-diversity-programs-fail) (<https://hbr.org/2016/07/why-diversity-programs-fail>) of diversity programs in the *Harvard Business Review*. However, the authors found that forcing people to participate in bias training can actually spark a backlash.

For AGU's part, Hanson said that the organization is "trying to expand the diversity of our editorial teams and reviewers." And since recommendation letter differences have come to light, many universities have [compiled tips](http://www.csw.arizona.edu/sites/default/files/csw_2015-10-20_lorbias_pdf_o.pdf) (http://www.csw.arizona.edu/sites/default/files/csw_2015-10-20_lorbias_pdf_o.pdf) for reducing bias. They include emphasizing accomplishments over effort and steering clear of personal details, which crop up disproportionately in letters for female applicants.

Holloway has worked with AGU to increase the diversity of its awards, primarily by encouraging a more diverse pool of people to do the nominating. Award committees also stopped emphasizing a candidate's h-index—a measure of their citations—after studies showed that men self-cite more than women. And in 2016, female scientists represented 30% of nominees and winners, twice the ratio in 2014 and roughly equal to the proportion of female AGU members. A [similar effort](http://blogs.egu.eu/geolog/2016/06/24/gender-equality-in-the-geosciences-is-it-a-numbers-game/) (<http://blogs.egu.eu/geolog/2016/06/24/gender-equality-in-the-geosciences-is-it-a-numbers-game/>) is under way within the European Geosciences Union.

Holmes cites other innovative efforts at places like Lehigh University and the University of California, Irvine, where men are trained to be so-called [equity advisers](http://advance.uci.edu/About.html) (<http://advance.uci.edu/About.html>). The idea is that men can then serve as advocates for women, for instance, on hiring committees.

"I really like that idea," Holmes said. "Ya'll step up to the plate and take some of the burden."

Finding a Way Forward

Gender equality is always a touchy subject, and addressing it as a community will require a careful balancing act, Hebl said. Scientists have to hold each other accountable whenever unconscious bias rears its head. But they should also be tolerant as people learn how to recognize and acknowledge it.

"We all make mistakes," Hebl said. "If there are not safe spaces to make mistakes and learn, it can harbor pools of hatred."



Elizabeth Orr, a Ph.D. student at the University of Cincinnati studying glacial geomorphology, collects samples to date the timing of glacial retreat in the Pir Panjal Range of northern India. Despite gender-based obstacles standing in the way of female geoscientists, she says she's committed to science.

Credit: Sourav Saha

And as scientists work to address the challenges facing women, they shouldn't forget that that the road is even harder for people of color and those with different sexual orientations and gender identities, said Robyn Dahl, a paleontologist at Western Washington University in Bellingham. Dahl is biracial and a lesbian and works on increasing diversity in fields involving science, technology, engineering, and math.

Policies and structures may need to change too, and that may entail a bit of trial and error. Some well-intentioned strategies, like paid parental leave for both men and women at research universities, appears to have backfired. [A recent study](http://legacy.iza.org/en/webcontent/publications/papers/viewAbstract?dp_id=9904) (http://legacy.iza.org/en/webcontent/publications/papers/viewAbstract?dp_id=9904) suggested that it did not level the playing field, as hoped, but actually helped male faculty gain tenure while reducing women's chances.

Nonetheless, any efforts to increase flexibility mark a step in the right direction, Holmes said. The academic career path is often described as a pipeline toward professorhood from which women disproportionately "leak" out. But times are changing.

"The new metaphor is something more like an interstate expressway," Holmes said. "There are a lot of on ramps, a lot of rest areas, and other destinations to go to."

Many early-career researchers are fueled up and ready for the ride, despite the curves ahead.

"I love my job, and I can't imagine myself doing anything else in life other than working in the geosciences," said [Elizabeth Orr](http://www.artsci.uc.edu/departments/geology/faculty--staff-and-students.html?eid=orreh&thecomp=uceprof) (<http://www.artsci.uc.edu/departments/geology/faculty--staff-and-students.html?eid=orreh&thecomp=uceprof>), a Ph.D. student at the University of Cincinnati studying glacial geomorphology.

"I am here to stay."

—Julia Rosen (email: julia.rosen@nasw.org (<mailto:julia.rosen@nasw.org>); [@ScienceJulia](https://twitter.com/sciencejulia) (<https://twitter.com/sciencejulia>)), Freelance Journalist

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