



Emmanuelle Charpentier (left) and Jennifer Doudna (right) won the 2020 Nobel Prize in Chemistry — the first all-female team to win a Nobel.

SEEKING GENDER PARITY IN SCIENTIFIC PARTNERSHIPS

Female scientists must navigate institutional barriers when forming collaborations. **By Sara Reardon**

Nobel laureates Jennifer Doudna and Emmanuelle Charpentier first met at a 2011 conference in Puerto Rico, where both gave talks about a then little-known biological system called CRISPR–Cas9, which bacteria use as an immune defence. They immediately hit it off. “She was coming to CRISPR from a very different perspective than I was,” Doudna says. “And I liked her.”

The two women began working together across fields and continents – Doudna is a biochemist at the University of California, Berkeley. Charpentier, a microbiologist, was at Umeå University in Sweden at the time. Over the next year, they adapted the CRISPR system to edit DNA in any species. The technique is now used to genetically modify organisms for

everything from routine laboratory research to agricultural uses and cancer therapies.

In 2020, Doudna and Charpentier became the first all-female team to win a Nobel prize, and only the second winning team to include more than one woman. Aside from winning science’s top medal, Doudna calls the collaboration with Charpentier “one of the great joys of my life”. Their complementary scientific expertise and commitment to the collaboration made the work enjoyable. “I loved her intensity and quiet sense of humour,” Doudna adds. “Because we worked in time zones 9 hours apart, the project progressed quickly, in part because one of us was always working.”

Collaborations, particularly across disciplines, are increasingly necessary for performing quality science and for career

advancement. Doudna, like many other scientists who spoke to *Nature*, says that gender plays no part in who she chooses to collaborate with or recruit into her lab. But for many female researchers, who are in a minority in most fields, navigating this landscape can be tricky. Breaking into the ‘old boy networks’ of senior scientists and their male protégés can be difficult for women. Ensuring that they receive proper credit for their work can also be a challenge. Female scientists, who, as a whole, are more junior than their male counterparts, often have to decide whether they want to collaborate with a well-resourced scientist, who is more likely to be male, or with a peer of any gender whose stature won’t overshadow them. By collaborating with other women, whether through informal mentorships and networks,

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building diverse lab groups or securing savvy co-authorships, female scientists can push back against the systemic barriers to female-led team research.

Who's doing the science?

The gender make-up of research teams has real-world impacts. Men and women tend to ask different questions – particularly in research involving sex and gender¹. (Little research has focused on other gender identities.)

“Who's doing the science really determines the science that is done,” says Londa Schiebinger, a science historian at Stanford University in California. Historically, science has largely ignored sex and gender as factors in medicine: drugs are often tested only in male mice, and women are frequently excluded from clinical trials, resulting in therapies that are most appropriate for men². Biomedical research trials have skewed so heavily male that in 2014, the US National Institutes of Health (NIH) announced that preclinical research trials must include male and female animals and cell lines.

These oversights appear throughout science and engineering: crash test dummies are mainly designed with male-typical anatomy, and male and female marine organisms might respond differently to climate change, but these differences haven't been thoroughly investigated.

Research teams with any number of women are less likely to ignore such issues. Schiebinger and her colleagues analysed authorship of more than 1.5 million medical-research papers and found that those with female authors were significantly more likely to consider sex and gender in their methodology and conclusions³. From that perspective, gender diversity isn't even about equality, Schiebinger says. “That's just doing excellent science.”

But one woman on a team might not be enough, she adds: studies show that members of a minority group need to make up 25–30% of a business team before their voices are heard⁴. Schiebinger adds that inclusive research must consider the perspectives of a wide range of groups, including women of colour, people with various socioeconomic statuses and backgrounds, and LGBT+ individuals. “Diverse bodies in the room or on the team is not enough: everyone needs to learn the skills of sex, gender and intersectional analysis,” she says. “This should not be the burden of under-represented groups.”

Authorship disputes

But for many women, deciding whether to join collaborations can be fraught. That can be especially true for women of colour, says Laurel Smith-Doerr, a sociologist at the University of Massachusetts Amherst. In surveys, her team found that women of colour are more likely than white women to report having had their ideas stolen or not getting



Science historian Londa Schiebinger has researched gender equality in science.

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credit. Anecdotally, she says, women of colour often report receiving well-meaning advice to avoid collaboration to ensure that their work receives proper recognition – advice that Smith-Doerr says is flawed because collaborations are necessary to produce good science.

Smith-Doerr's unpublished surveys show that women of colour tend to have fewer collaboration opportunities. “It's not about an individual choice,” she says. “It's that there are gendered and racialized systems where men have privilege. And that extends to collaboration.”

Women are more likely than men to report having been involved in authorship disputes. In 2021, information scientist Cassidy Sugimoto at the Georgia Institute of Technology in Atlanta surveyed 5,575 scientists about such disputes. Women said these arguments resulted in fewer future collaborations, either because they voluntarily withdrew or were shut out by collaborators. The researchers found that men often did not even discuss authorship until the paper was about to be published, if at all. Women were more likely to discuss authorship at the onset of the collaboration⁵.

Women just starting out in science must stand their ground. “Being first author on a paper during your doctoral career is a major predictor of staying in science,” Sugimoto says. She adds that lab heads should ensure that female students and trainees get the chance to plan and lead the kind of work that will lead to first authorship on publications. In 2021, her team analysed authors' contributor roles in 30,000 research papers and found that women were more likely to have performed technical work, whereas men had more of a role in study design⁶. Male PhD students also end up with more first-author publications⁷. “This is a call for [principal investigators] to think about the distribution of labour,” Sugimoto says.

For new faculty members who want to start

collaborations, much comes down to accessing established networks to find not only potential collaborators, but also mentors who can help with things such as patenting inventions, dealing with difficult colleagues, and career advancement. “Informal mentoring is so crucial to all faculty because parts of our job are not written down anywhere,” Smith-Doerr says. Informal mentoring, she adds, “is something men find naturally, and women don't”.

One solution, she suggests, is mutual mentoring groups in which women in different departments across an institution can help one another with non-obvious job tasks. ‘Cluster hiring’ schemes that simultaneously recruit several faculty members in similar lines of work can help to ensure that new hires have access to collaborators and peer mentors in their institutions, she adds. She notes that men and senior researchers of any gender can help to create space for women through simple steps, such as meeting one-on-one and making sure that expectations for their research and writing contributions are clear, and that credit is allocated equitably.

Banding together

Women who feel excluded from the old boy network might be able to work together, finding collaborators at conferences and offering help to more junior women. That's not something that necessarily comes naturally to women, for many reasons, says Joyce Benenson, a psychologist at Emmanuel College in Boston, Massachusetts. For one thing, women are just as prone as men to showing implicit bias against hiring women⁸. Also, women who are focused on advancing their own careers might not offer help to younger women, says Benenson. But to loosen the grip of male-dominated networks in science, she adds, women should consider forming strategic coalitions, rather

than competing individually.

There is evidence that female scientists band together, and that trend has increased slightly over the past decade. In 2019, evolutionary biologist Luke Holman at Edinburgh Napier University, UK, and his colleagues found that life-science researchers co-authored papers with others of their gender more often than expected by chance, given the gender proportions within their field⁹. Holman says it's unclear why this bias exists. Positive motivations could include women's efforts to support each other, or students' desire to work with a mentor with a similar mindset. Alternatively, male-scientist networks could be excluding women, or women might avoid working with men owing to fear of harassment, he adds.

For Lara Mahal, a chemist at the University of Alberta in Edmonton, Canada, collaborating with women from other institutions has allowed her to enter into large networks of scientists whose research interests and needs overlap with her own. Mahal works with an uncommon piece of lab equipment that can analyse sugars on viruses and cells – an analysis that many researchers seek out. Although she's had fruitful collaborations with male researchers, Mahal's longest-standing relationships have been with several women whom she calls “kindred spirits”. Their scientific interests and personalities mesh well, she says, making the work particularly enjoyable. “When you have a lot of fun working together, you tend to want to do more of it,” she says.

Women might benefit from more turnover in their collaborations, according to a 2016 study by Luís Amaral, a chemical engineer at Northwestern University in Evanston, Illinois, and his colleagues¹⁰, which analysed collaborations between 4,000 researchers. In heavily male-dominated fields, such as genomics, women collaborated more often with other women. Female researchers had as many collaborators as males, but they were less likely to collaborate with the same people over time.

Although the reasons for these trends are unclear, Amaral suggests that switching up collaborators might be a winning strategy for women. “Teams who bring in new blood tend to be more creative,” he says.

Mentorship's gender landscape

To access networks of scientists who can serve as mentors or collaborators, it can be helpful for junior scientists to collaborate with a well-resourced senior scientist. “There is good evidence for decades that when you collaborate with people who are well-networked, it has career benefits,” Sugimoto says. Although the gap is narrowing, those well-known people still tend to be men. In the United States, for instance, only 18% of full professors in biology are female. In Europe, on average, less than 15% of senior researchers in 2016 were female.

But the gender dynamics of mentorship

can be complex. Mahal was discouraged from choosing her female PhD adviser, biochemist Carolyn Bertozzi at the University of California, Berkeley, because her undergraduate mentor was also a woman – so it might have seemed as if Mahal was avoiding working with men. Mahal ignored the advice, and both she and Bertozzi benefited from the collaboration: Mahal's graduate research led to Bertozzi's first paper in *Science*.

In 2020, computational social scientist Bedoor AlShebli at New York University Abu Dhabi and her colleagues published a now-retracted study in *Nature Communications* analysing the gender and seniority of 215 million authors on 222 million papers in several fields over 100 years. The team designated senior authors as ‘mentors’ to junior co-authors¹¹.

Having a female mentor, they found, decreased junior researchers' citations by up to 35%, and having a female protégée decreased mentors' citations by 18%. Women in academia, the authors concluded, should work with men if they want to be successful.

The blowback was swift. Scientists harshly criticized the study's use of co-authorship as a proxy for mentorship and citations as a measure of success, among other aspects.

For many, the bigger problem was the mes-

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sage the study sent to women, many of whom said its maths didn't add up to their experiences. “To suggest women trainees would be better with men than women was deeply untrue,” says Christine Jacobs-Wagner, a molecular biologist at Stanford. Soon after the paper was published, about 7,600 researchers expressed concern about its implications and affirmed support for female scholars in an open letter organized by Jacobs-Wagner and her colleagues (see go.nature.com/3y3tap).

AlShebli and her co-authors retracted the paper owing to the criticisms, acknowledging that post-publication expert reviewers found their methodology problematic. They wrote: “We feel deep regret that the publication of our research has both caused pain on an individual level and triggered such a profound response among many in the scientific community.”

Not everyone agreed with the retraction. “I was really appalled,” says Benenson, who studies gender in group dynamics. She felt that the paper was retracted more because of its implications than its merit, and points out that the conclusions correlate with other research on gender-based socializing and collaboration.

For instance, Benenson's own research with primary-school children suggests that girls of

the same social status will play together, but they tend to avoid interacting with girls of a different ‘rank’ – such as those who are more or less skilled at art or sport. Boys, by contrast, constantly compete with one another and create ever-shifting social hierarchies that work well together. “The old boys' network is old because boys have been doing it since they were three,” she says.

Both Benenson and Sugimoto say that, retracted or not, the study had important lessons for women's collaborations. Benenson says scientists should examine why female mentors are so disadvantaged in a system that has been designed by and for men. “We should look at how to do it better,” she says.

Sugimoto points to institutional structures that might prevent women from accessing networks. For instance, men are more likely than women to lead large teams and collaborate internationally – factors that help to predict career success. For many women, who are more likely to bear more childcare and family obligations, a requirement to move or travel internationally could be disenfranchising. She praises initiatives such as NIH grant schemes that provide funding for scientists to keep their lab running while they take care of family responsibilities, and that provide childcare stipends for travelling scientists.

More and more, Doudna says, learning to collaborate is essential in modern science because so many fields have become interdisciplinary. She maintains that personalities and complementary research interests are the most important contributors to a successful collaboration, but acknowledges that gender can have a role – particularly in career advancement.

“I'm certainly honoured to serve as a mentor for everybody, maybe in particular for women because I feel there are barriers for women advancing,” she says. Doudna hopes that the Nobel that she and Charpentier share can be a symbol for female scientists – evidence that women can achieve the ultimate success through collaborations. “It was the pure joy of finding things out together.”

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