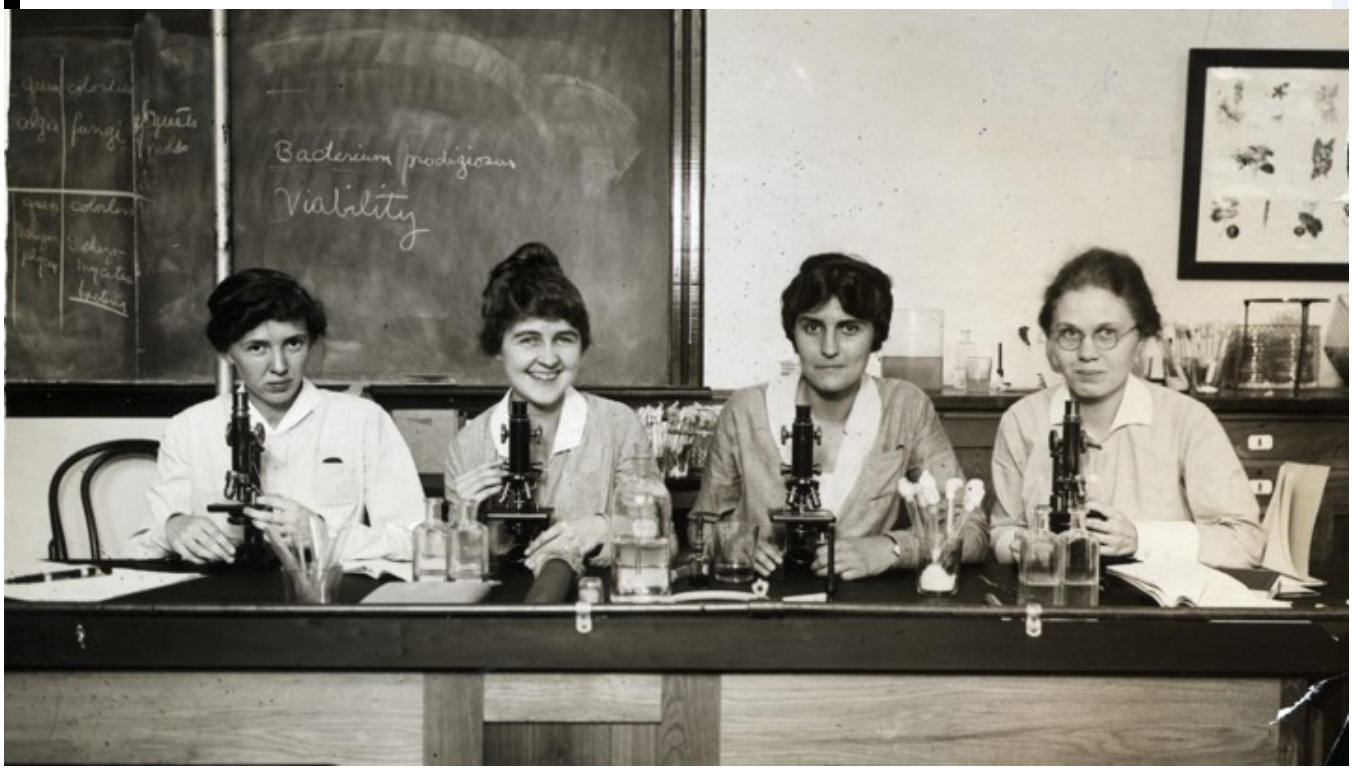
SCIENCE

The Women Who Contributed to Science but Were Buried in Footnotes

In a new study, researchers uncovered female programmers who made important but unrecognized contributions to genetics.

ED YONG FEB 11, 2019



The names of the women seated before microscopes in this undated photo were not recorded. (BETTMANN / GETTY)

In science, the question of who gets credit for important work—fraught in any field—is set down on paper, for anyone to see. Authorship, given pride of place at the top of scientific papers, can advance reputations and careers; credits buried in the rarely read acknowledgments section do not.

Over the past few years, a team of students led by Emilia Huerta-Sánchez from Brown University and Rori Rohlfs from San Francisco State University has been searching through two decades' worth of acknowledgments in genetics papers and discovering women who were never given the credit that would be expected for today's researchers. They identified dozens of female programmers who made important but unrecognized contributions. Some were repeatedly thanked in the

acknowledgments of several papers, but were never recognized as authors. They became literal footnotes in scientific history, despite helping make that history.

"When Emilia and I look at our elders in population genetics, there are very, very few women," says Rohlfs. "But there were women and they were doing this work. To even know that they existed is a big deal to me."

The project started with *Hidden Figures*, the 2016 movie about three black female mathematicians who helped NASA win the space race in the 1960s. After seeing the film, Huerta-Sánchez and Rohlfs felt surprised that they had never heard of its three protagonists. How many other historical female scientists were they similarly unaware of, they wondered?

[Read: Hidden Figures and the appeal of math in an age of inequality]

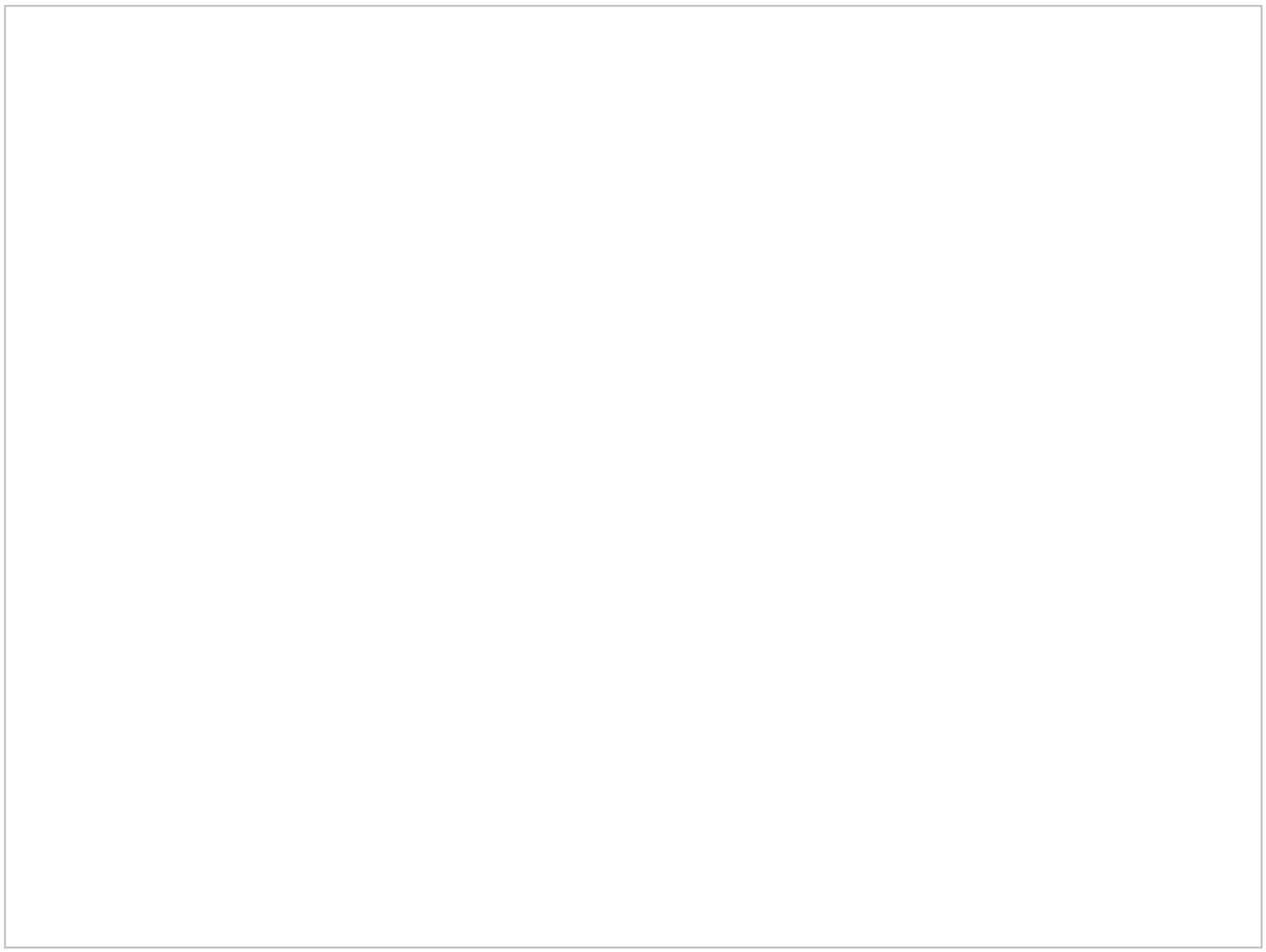
One name sprang readily to mind: Jennifer Smith. Huerta-Sánchez remembered reading a classic, decades-old paper in which Smith was thanked in the acknowledgments "for ably programming and executing all the computations." That seemed odd. Today, programming is recognized as crucial work, and if a scientist did all the programming for a study, she would expect to be listed as an author. "It was weird to me that Smith was not an author on that paper," Huerta-Sánchez says. "[Rori and I] wanted to see if there were more women like her."

The duo recruited five undergraduate students, who looked at every issue of a single journal—*Theoretical Population Biology*—published between 1970 and 1990. They pored through hard copies of almost 900 papers, pulled out every name in the acknowledgments, worked out whether they did any programming, and deduced their genders where possible. Rochelle Reyes, one of the students, says that she was "extremely motivated" to do this work, having grown up on stories of under-recognized pioneers like Rosalind Franklin, who was pivotal in deciphering the structure of DNA, and Henrietta Lacks, whose cells revolutionized medical research. "I was fortunate to grow up in a diverse environment with a passion for science as well as social justice," Reyes says.

She and her colleagues found that in the 1970s, women accounted for 59 percent of acknowledged programmers, but just 7 percent of actual authors. That decade was a pivotal time for the field of population genetics, when the foundations of much modern research were laid. "Based on authorship at the time, it seems that this

research was conducted by a relatively small number of independent individual scientists, nearly all of whom were men," the team writes. But that wasn't the case.

"It's hard to know what sort of contributions people in the past have made behind the scenes," says Jessica Abbott, a geneticist at Lund University. But this study "shows that it's possible to get the right kind of data if you think creatively."



Ezequiel Lopez Barragan, Rochelle-Jan Reyes, Samantha Kristin Dung, Andrea López, and Ricky Thu present their work. Credit: Mayra Banuelos

Margaret Wu, for example, was thanked in a 1975 paper for "help with the numerical work, and in particular for computing table I." She helped to create a statistical tool that scientists like Huerta-Sánchez still regularly use to estimate how much genetic diversity there should be in a population of a given size. That tool is called the Watterson estimator, after the 1975 paper's one and only author—G. A. Watterson. The paper has since been cited 3,400 times.

Skeptics might argue that the programmers listed in these old papers were just doing menial work that wasn't actually worthy of authorship. Rohlfs says that's

unlikely, especially in the cases of Wu, Jennifer Smith, and Barbara McCann, who were repeatedly name-checked in many papers. "They were doing work that was good enough that they were being called back again and again," she says. The team even talked with William Hill, Smith's former supervisor at the University of Edinburgh, who described her work as both technical and creative. (He didn't, unfortunately, know where Smith ended up, and the team never managed to track her down.)

They had better luck with Margaret Wu, who finally responded to repeated emails and phone calls. She told them that she was a research assistant when she worked on the Watterson-estimator paper, and taught herself programming on the job. "I think people think that, back then, women were just secretaries, who typed code, punched cards, and didn't do intellectual work," Huerta-Sánchez says. "But when [Wu] described her work, it was what grad students and postdocs do nowadays."

Afterwards, Wu didn't consider trying for a Ph.D., although she told the team that "had someone suggested that I do it, I possibly would have found that an attractive idea." She only got her doctorate in her 40s, after two decades working as a statistician and a math teacher. Now, she's a faculty member at the University of Melbourne, where she develops statistical methods to analyze educational data. Wu didn't return my request for an interview, but apparently has no regrets about the 1975 paper, Huerta-Sánchez tells me. She didn't even know how heavily cited it had become. "She smiled," says Huerta-Sánchez. "There was a little laugh. I felt like I was more upset than she was."

In the 1980s, the practice of shunting programmers to the acknowledgments section declined. That's partly because the task steadily fell more to graduate students and postdocs, who were rewarded with authorship. But also, programming began changing from a "pink collar" job, done largely by low-paid women, to the male-dominated profession it remains today. Programmers, essentially, only became rewarded with authorship when they started becoming male.

[Read: When will the gender gap in science disappear?]

"This is an opportunity for us to think about the norms we use in authorship and other metrics of academic success," says Rohlfs. Even today, there are no clear rules about how much work someone must do to become an author. A professor

could email some data to a colleague and become an author. A lab technician could do enormous amounts of labor, without which experiments could never be done, and be ignored. "There's no standard, and surely the way we deal with authorship will be exclusive to some groups of people," says Rohlfs. "If I look around at lab technicians, I'll see a lot of women and people of color who aren't being given authorship for creative work."

Even when women *do* become authors, the systemic biases that pervade modern science can work against them. For a start, they're outnumbered: One recent study found that, given current trends, it would take 16 years for the number of male and female authors to equalize across the sciences, and 258 years for fields like physics. That discrepancy is especially stark in the highest-profile journals, where women account for just 25 to 35 percent of people in the coveted first-author slot. And at least in some fields, studies authored by women tend to be cited less frequently than those authored by men.

For these reasons and others—less training, lower salaries, less mentoring, fewer speaking opportunities, more negative stereotypes, and more harassment and abuse compared with men—many women leave scientific careers early. Those who stay are judged more harshly and less favorably than equally qualified male peers. Some are forgotten.

But there's growing awareness of these problems, and several best-selling books have recently resurfaced the stories of unrecognized women in science, technology, engineering, and mathematics. Both *Hidden Figures* (Margot Shetterly's book that inspired the film of the same name) and Nathalia Holt's *Rise of the Rocket Girls* tell of the elite mathematicians of NASA's history. *Broad Band*, by Claire L. Evans, reveals the tales of the women whose computing and engineering skills helped to create the internet. Liza Mundy's *Code Girls* is about the women who broke German and Japanese codes during World War II.

Rohlfs hopes that scientists in other fields will do similar work to rediscover the contributors whose work has been obscured for so long. "Women have always been influential in science but their achievements have simply not been given the recognition they deserve," adds Ezequiel Lopez, one of the five students who worked on the project. "That can be changed."

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