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Why Are There Still So Few Women in Science?

By EILEEN POLLACK

Last summer, researchers at Yale published a study proving that physicists, chemists and biologists are likely to view a young male scientist more favorably than a woman with the same qualifications. Presented with identical summaries of the accomplishments of two imaginary applicants, professors at six major research institutions were significantly more willing to offer the man a job. If they did hire the woman, they set her salary, on average, nearly $4,000 lower than the man's. Surprisingly, female scientists were as biased as their male counterparts.

The new study goes a long way toward providing hard evidence of a continuing bias against women in the sciences. Only one-fifth of physics Ph.D.'s in this country are awarded to women, and only about half of those women are American; of all the physics professors in the United States, only 14 percent are women. The numbers of black and Hispanic scientists are even lower; in a typical year, 13 African-Americans and 20 Latinos of either sex receive Ph.D.'s in physics. The reasons for those shortages are hardly mysterious — many minority students attend secondary schools that leave them too far behind to catch up in science, and the effects of prejudice at every stage of their education are well documented. But what could still be keeping women out of the STEM fields ("STEM" being the current shorthand for "science, technology, engineering and mathematics"), which offer so much in the way of job prospects, prestige, intellectual stimulation and income?

As one of the first two women to earn a bachelor of science degree in physics from Yale — I graduated in 1978 — this question concerns me deeply. I attended a rural public school whose few accelerated courses in physics and calculus I wasn't allowed to take because, as my principal put it, "girls never go on in science and math." Angry and bored, I began reading about space and time and teaching myself calculus from a book. When I arrived at Yale, I was woefully unprepared. The boys in my introductory physics class, who had taken far more rigorous math and science classes in high school, yawned as our professor sped through the material, while I grew panicked at how little I understood. The only woman in the room, I debated whether to raise my hand and expose myself to ridicule, thereby losing track of the lecture and falling further behind.

In the end, I graduated summa cum laude, Phi Beta Kappa, with honors in the major, having excelled in the department's three-term sequence in quantum mechanics and a graduate course in gravitational physics, all while teaching myself to program Yale's mainframe computer. But I didn't go into physics as a career. At the end of four years, I was exhausted by all the lonely hours I spent catching up to my classmates, hiding my insecurities, struggling to do my problem sets while the

boys worked in teams to finish theirs. I was tired of dressing one way to be taken seriously as a scientist while dressing another to feel feminine. And while some of the men I wanted to date weren't put off by my major, many of them were.

Mostly, though, I didn't go on in physics because not a single professor — not even the adviser who supervised my senior thesis — encouraged me to go to graduate school. Certain this meant I wasn't talented enough to succeed in physics, I left the rough draft of my senior thesis outside my adviser's door and slunk away in shame. Pained by the dream I had failed to achieve, I locked my textbooks, lab reports and problem sets in my father's army footlocker and turned my back on physics and math forever.

Not until 2005, when Lawrence Summers, then president of Harvard, wondered aloud at a lunchtime talk why more women don't end up holding tenured positions in the hard sciences, did I feel compelled to reopen that footlocker. I have known Summers since my teens, when he judged my high-school debate team, and he has always struck me as an admirer of smart women. When he suggested — among several other pertinent reasons — that innate disparities in scientific and mathematical aptitude at the very highest end of the spectrum might account for the paucity of tenured female faculty, I got the sense that he had asked the question because he genuinely cared about the answer. I was taken aback by his suggestion that the problem might have something to do with biological inequalities between the sexes, but as I read the heated responses to his comments, I realized that even I wasn't sure why so many women were still giving up on physics and math before completing advanced degrees. I decided to look up my former classmates and professors, review the research on women's performance in STEM fields and return to Yale to see what, if anything, had changed since I studied there. I wanted to understand why I had walked away from my dream, and why so many other women still walk away from theirs.

In many ways, of course, the climate has become more welcoming to young women who want to study science and math. Female students at the high school I attended in upstate New York no longer need to teach themselves calculus from a book, and the physics classes are taught by a charismatic young woman. When I first returned to Yale in the fall of 2010, everyone kept boasting that 30 to 40 percent of the undergraduates majoring in physics and physics-related fields were women. More remarkable, those young women studied in a department whose chairwoman was the formidable astrophysicist Meg Urry, who earned her Ph.D. from Johns Hopkins, completed a postdoctorate at M.I.T.'s center for space research and served on the faculty of the Hubble space telescope before Yale hired her as a full professor in 2001. (At the time, there wasn't a single other female faculty member in the department.)

In recent years, Urry has become devoted to using hard data and anecdotes from her own experience to alter her colleagues' perceptions as to why there are so few women in the sciences. In response to the Summers controversy, she published an essay in The Washington Post describing her gradual realization that women were leaving the profession not because they weren't gifted but

because of the “slow drumbeat of being underappreciated, feeling uncomfortable and encountering roadblocks along the path to success.”

Although Urry confessed in her op-ed column that as a young scientist she interpreted her repeated failures to be hired or promoted as proof that she wasn’t good enough, anyone who meets her now would have a hard time seeing her as lacking in confidence. She has a quizzical smile and radiant eyes and an irreverent sense of humor; not one but five people described her to me as the busiest woman on campus.

Before we met, Urry predicted that the female students in her department would recognize the struggles she and I had faced but that their support system protected them from the same kind of self-doubt. For instance, under the direction of Bonnie Fleming, the second woman to gain tenure in the physics department at Yale, the students sponsor a semiregular Conference for Undergraduate Women in Physics at Yale. Beyond that, Urry suggested that with so many women studying physics at Yale, and so many of them at the top of their class, the faculty couldn’t help recognizing that their abilities didn’t differ from the men’s. When I mentioned that a tea was being held that afternoon so I could interview female students interested in science and gender, Urry said she would try to attend.

Judith Krauss, the professor who was hosting the tea (she is the former dean of nursing and now master of Silliman College, where I lived as an undergraduate), warned me that very few students would be interested enough to show up. When 80 young women (and three curious men) crowded into the room, Krauss and I were stunned. By the time Urry hurried in, she was lucky to find a seat.

The students clamored to share their stories. One young woman had been disconcerted to find herself one of only three girls in her AP physics course in high school, and even more so when the other two dropped out. Another student was the only girl in her AP physics class from the start. Her classmates teased her mercilessly: “You’re a girl. Girls can’t do physics.” She expected the teacher to put an end to the teasing, but he didn’t.

Other women chimed in to say that their teachers were the ones who teased them the most. In one physics class, the teacher announced that the boys would be graded on the “boy curve,” while the one girl would be graded on the “girl curve”; when asked why, the teacher explained that he couldn’t reasonably expect a girl to compete in physics on equal terms with boys.

The only members of the audience who didn’t know what the rest were talking about were the women who had attended all-girls secondary schools or had grown up in foreign countries. (The lesbian scientists with whom I spoke, at the tea and elsewhere, reported differing reactions to the gender dynamic of the classroom and the lab, but voiced many of the same concerns as the straight women.) One student — I took her to be Indian or Pakistani — said she arrived on campus having taken lots of advanced classes and didn’t hesitate to sign up for the most rigorous math course.

Shaken to find herself the only girl in the class, unable to follow the first lecture, she asked the professor: Should I be here? "If you're not confident that you should be here" — she imitated his scorn — "you shouldn't take the class."

After the tea, a dozen girls stayed to talk. "The boys in my group don't take anything I say seriously," one astrophysics major complained. "I hate to be aggressive. Is that what it takes? I wasn't brought up that way. Will I have to be this aggressive in graduate school? For the rest of my *life*?" Another said she disliked when she and her sister went out to a club and her sister introduced her as an astrophysics major. "I kick her under the table. I hate when people in a bar or at a party find out I'm majoring in physics. The minute they find out, I can see the guys turn away." Yet another went on about how even at Yale the men didn't want to date a physics major, and how she was worried she'd go through four years there without a date.

After the students left, I asked Urry if she was as flabbergasted as I was. "More," she said — after all, she was the chairwoman of the department in which most of these girls were studying.

In the two years that followed, I heard similar accounts echoed among young women in Michigan, upstate New York and Connecticut. I was dismayed to find that the cultural and psychological factors that I experienced in the '70s not only persist but also seem all the more pernicious in a society in which women are told that nothing is preventing them from succeeding in any field. If anything, the pressures to be conventionally feminine seem even more intense now than when I was young.

For proof of the stereotypes that continue to shape American attitudes about science, and about women in science in particular, you need only watch an episode of the popular television show "The Big Bang Theory," about a group of awkward but endearing male Caltech physicists and their neighbor, Penny, an attractive blonde who has moved to L.A. to make it as an actress. Although two of the scientists on the show are women, one, Bernadette, speaks in a voice so shrill it could shatter a test tube. When she was working her way toward a Ph.D. in microbiology, rather than working in a lab, as any real doctoral student would do, she waitressed with Penny. Mayim Bialik, the actress who plays Amy, a neurobiologist who becomes semiromantically involved with the childlike but brilliant physicist Sheldon, really does have a Ph.D. in neuroscience and is in no way the hideously dumpy woman she is presented as on the show. "The Big Bang Theory" is a sitcom, of course, and therefore every character is a caricature, but what remotely normal young person would want to enter a field populated by misfits like Sheldon, Howard and Raj? And what remotely normal young woman would want to imagine herself as dowdy, socially clueless Amy rather than as stylish, bouncy, math-and-science-illiterate Penny?

Although Americans take for granted that scientists are geeks, in other cultures a gift for math is often seen as demonstrating that a person is intuitive and creative. In 2008, the American Mathematical Society published data from a number of prestigious international competitions in

an effort to track standout performers. The American competitors were almost always the children of immigrants, and very rarely female. For example, between 1959 and 2008, Bulgaria sent 21 girls to the International Mathematical Olympiad, while the U.S., from 1974, when it first entered the competition, to 2008, sent only 3; no woman even made the American team until 1998. According to the study's authors, native-born American students of both sexes steer clear of math clubs and competitions because "only Asians and nerds" would voluntarily do math. "In other words, it is deemed uncool within the social context of U.S.A. middle and high schools to do mathematics for fun; doing so can lead to social ostracism. Consequently, gifted girls, even more so than boys, usually camouflage their mathematical talent to fit in well with their peers."

The study's findings apply equally in science. Urry told me that at the space telescope institute where she used to work, the women from Italy and France "dress very well, what Americans would call revealing. You'll see a Frenchwoman in a short skirt and fishnets; that's normal for them. The men in those countries seem able to keep someone's sexual identity separate from her scientific identity. American men can't seem to appreciate a woman as a woman *and* as a scientist; it's one or the other."

That the disparity between men and women's representation in science and math arises from culture rather than genetics seems beyond dispute. In the early 1980s, a large group of American middle-schoolers were given the SAT exam in math; among those who scored higher than 700, boys outperformed girls by 13 to 1. But scoring 700 or higher on the SATs, even in middle school, doesn't necessarily reveal true mathematical creativity or facility with higher-level concepts. And these were all American students. The mathematical society's study of the top achievers in international competitions went much further in examining genius by analyzing the performance of young women in other cultures. The study's conclusion? The scarcity of women at the very highest echelons "is due, in significant part, to changeable factors that vary with time, country and ethnic group. First and foremost, some countries identify and nurture females with very high ability in mathematics at a much higher frequency than do others." Besides, the ratio of boys to girls scoring 700 or higher on the math SAT in middle school is now only three to one. If girls were so constrained by their biology, how could their scores have risen so steadily in such a short time?

In elementary school, girls and boys perform equally well in math and science. But by the time they reach high school, when those subjects begin to seem more difficult to students of both sexes, the numbers diverge. Although the percentage of girls taking high-school physics rose to 47 percent in 1997 from 39 percent in 1987, that figure has remained constant into the new millennium. And the numbers become more alarming when you look at AP classes rather than general physics, and at the scores on AP exams rather than mere attendance in AP classes. The statistics tend to be a bit more encouraging in AP calculus, but they are far worse in computer science. Maybe boys care more about physics and computer science than girls do. But an equally plausible explanation is that boys are encouraged to tough out difficult courses in unpopular subjects, while girls, no matter

how smart, receive fewer arguments from their parents, teachers or guidance counselors if they drop a physics class or shrug off an AP exam.

That cultural signals can affect a student's ability to perform on an exam has long been known. In a frequently cited 1999 study, a sample of University of Michigan students with similarly strong backgrounds and abilities in math were divided into two groups. In the first, the students were told that men perform better on math tests than women; in the second, the students were assured that despite what they might have heard, there was no difference between male and female performance. Both groups were given a math test. In the first, the men outscored the women by 20 points; in the second, the men scored only 2 points higher.

It's even possible that gifts in science and math aren't identifiable by scores on tests. Less than one-third of the white American males who populate the ranks of engineering, computer science, math and the physical sciences scored higher than 650 on their math SATs, and more than one-third scored below 550. In the middle ranks, hard work, determination and encouragement seem to be as important as raw talent. Even at the very highest levels, test scores might be irrelevant; apparently, Richard Feynman's I.Q. was a less-than-remarkable 125.

The most powerful determinant of whether a woman goes on in science might be whether anyone encourages her to go on. My freshman year at Yale, I earned a 32 on my first physics midterm. My parents urged me to switch majors. All they wanted was that I be able to earn a living until I married a man who could support me, and physics seemed unlikely to accomplish either goal.

I trudged up Science Hill to ask my professor, Michael Zeller, to sign my withdrawal slip. I took the elevator to Professor Zeller's floor, then navigated corridors lined with photos of the all-male faculty and notices for lectures whose titles struck me as incomprehensible. I knocked at my professor's door and managed to stammer that I had gotten a 32 on the midterm and needed him to sign my drop slip.

"Why?" he asked. He received D's in two of his physics courses. Not on the midterms — in the *courses*. The story sounded like something a nice professor would invent to make his least talented student feel less dumb. In his case, the D's clearly were aberrations. In my case, the 32 signified that I wasn't any good at physics.

"Just swim in your own lane," he said. Seeing my confusion, he told me that he had been on the swimming team at Stanford. His stroke was as good as anyone's. But he kept coming in second. "Zeller," the coach said, "your problem is you keep looking around to see how the other guys are doing. Keep your eyes on your own lane, swim your fastest and you'll win."

I gathered this meant he wouldn't be signing my drop slip.

“You can do it,” he said. “Stick it out.”

I stayed in the course. Week after week, I struggled to do my problem sets, until they no longer seemed impenetrable. The deeper I now tunnel into my four-inch-thick freshman physics textbook, the more equations I find festooned with comet-like exclamation points and theorems whose beauty I noted with exploding novas of hot-pink asterisks. The markings in the book return me to a time when, sitting in my cramped dorm room, I suddenly grasped some principle that governs the way objects interact, whether here on earth or light years distant, and I marveled that such vastness and complexity could be reducible to the equation I had highlighted in my book. Could anything have been more thrilling than comprehending an entirely new way of seeing, a reality more real than the real itself?

I earned a B in the course; the next semester I got an A. By the start of my senior year, I was at the top of my class, with the most experience conducting research. But not a single professor asked me if I was going on to graduate school. When I mentioned shyly to Professor Zeller that my dream was to apply to Princeton and become a theoretician, he shook his head and said that if you went to Princeton, you had better put your ego in your back pocket, because those guys were so brilliant and competitive that you would get that ego crushed, which made me feel as if I weren’t brilliant or competitive enough to apply.

Not even the math professor who supervised my senior thesis urged me to go on for a Ph.D. I had spent nine months missing parties, skipping dinners and losing sleep, trying to figure out why waves — of sound, of light, of anything — travel in a spherical shell, like the skin of a balloon, in any odd-dimensional space, but like a solid bowling ball in any space of even dimension. When at last I found the answer, I knocked triumphantly at my adviser’s door. Yet I don’t remember him praising me in any way. I was dying to ask if my ability to solve the problem meant that I was good enough to make it as a theoretical physicist. But I knew that if I needed to ask, I wasn’t.

Years later, when I contacted that same professor, the mathematician Roger Howe, he responded enthusiastically to my request that we get together to discuss women in science and math. We met at his office, in a building that still has a large poster of famous mathematicians (all male) in the lobby, although someone has tacked a smaller poster of “famous women in math” on the top floor beside the women’s bathroom. Howe appeared remarkably youthful, even when you consider that when I studied with him, he was the youngest full professor at Yale. He suggested we grab a sandwich, and as we sat waiting for our panini, I told him that one reason I didn’t go to graduate school was that I compared myself with him and judged my talents wanting. After all, I’d had such a difficult time solving the problem he had challenged me to solve.

He looked puzzled. “But you solved it.”

“Yeah,” I said. “At the end I really understood what I was doing. But it took me such a long time.”

“But that’s just how it is,” he said. “You don’t see it until you do, and then you wonder why you didn’t see it all along.”

But I had needed to drop my class in real analysis.

Howe shrugged. There are a lot of different math personalities. Different mathematicians are good at different fields.

I asked if he had noticed any differences between the ways male and female students approach math problems, whether they have different “math personalities.” No, he said. Then again, he couldn’t get inside his students’ heads. He did have two female students go on in math, and both had done fairly well.

I asked why even now there were no female professors on Yale’s math faculty. No *tenured* women, Howe corrected me. Just recently, the department had voted to hire a woman for a tenure-track job. (That woman did not receive tenure, but this year the faculty did hire a senior female professor.) Well, I said, that’s still not very many. He stared into the distance. “I guess I just haven’t seen that many women whose work I’m excited about.” I watched him mull over his answer, the way I used to watch him visualize n-dimensional toruses cradled in his hands. “Maybe women are victims of misperception,” he said finally. Not long ago, one of his colleagues at another school admitted to him that back when all of them were starting out, there were two people in his field, a woman and a man, and this colleague assumed the man must be the better mathematician, but the woman has gone on to do better work.

I finally came straight out and asked what he thought of my project. How did it compare with all the other undergraduate research projects he must have supervised?

His eyebrows lifted, as if to express the mathematical symbol for puzzlement. Actually, he hadn’t supervised more than two or three undergraduates in his entire career. “It’s very unusual for any undergraduate to do an independent project in mathematics,” he said. “By that measure, I would have to say that what you did was exceptional.”

“Exceptional?” I echoed. Then why had he never told me?

The question took him aback. I asked if he ever specifically encouraged any undergraduates to go on for Ph.D.’s; after all, he was now the director of undergraduate studies. But he said he never encouraged *anyone* to go on in math. “It’s a very hard life,” he told me. “You need to enjoy it. There’s a lot of pressure being a mathematician. The life, the culture, it’s very hard.”

When I told Meg Urry that Howe and several other of my professors said they don’t encourage anyone to go on in physics or math because it’s such a hard life, she blew raspberries. “Oh, come on,” she said. “They’re their own bosses. They’re well paid. They love what they do. Why not

encourage other people to go on in what you love?" She gives many alumni talks, "and there's always a woman who comes up to me and says the same thing you said, I wanted to become a physicist, but no one encouraged me. If even one person had said, 'You can do this.' " She laughed. "Women need more positive reinforcement, and men need more negative reinforcement. Men wildly overestimate their learning abilities, their earning abilities. Women say, 'Oh, I'm not good, I won't earn much, whatever you want to give me is O.K.' "

One student told Urry she doubted that she was good enough for grad school, and Urry asked why — the student had earned nearly all A's at Yale, which has one of the most rigorous physics programs in the country. "A woman like that didn't think she was qualified, whereas I've written lots of letters for men with B averages." She won't say that getting a Ph.D. is easy. "It is a grind. When a young woman says, 'How is this going to be for me?' I have to say that yes, there are easier things to do. But that doesn't mean I need to discourage her from trying. You don't need to be a genius to do what I do. When I told my adviser what I wanted to do, he said, 'Oh, Meg, you have to be a genius to be an astrophysicist.' I was the best physics major they had. What he was really saying was that I wasn't a genius, wasn't good enough. What, all those theoreticians out there are all Feynman or Einstein? I don't think so."

Not long ago, I met five young Yale alumnae at a Vietnamese restaurant in Cambridge. Three of the women were attending graduate school at Harvard — two in physics and one in astronomy — and two were studying oceanography at M.I.T. None expressed anxiety about surviving graduate school, but all five said they frequently worried about how they would teach and conduct research once they had children.

"That's where you lose all the female physicists," one woman said.

"Yeah, it's even hard to get your kid into child care at M.I.T.," said another.

"Women are just as willing as men to sacrifice other things for work," said a third. "But we're not willing to do even more work than the men — work in the lab and teach, plus do all the child care and housework."

What most young women don't realize, Urry said, is that being an academic provides a female scientist with more flexibility than most other professions. She met her husband on her first day at the Goddard Space Flight Center. "And we have a completely equal relationship," she told me. "When he looks after the kids, he doesn't say he's helping me." No one is claiming that juggling a career in physics while raising children is easy. But having a family while establishing a career as a doctor or a lawyer isn't exactly easy either, and that doesn't prevent women from pursuing those callings. Urry suspects that raising a family is often the excuse women use when they leave science, when in fact they have been discouraged to the point of giving up.

All Ph.D.'s face the long slog of competing for a junior position, writing grants and conducting

enough research to earn tenure. Yet women running the tenure race must leap hurdles that are higher than those facing their male competitors, often without realizing any such disparity exists.

In the mid-1990s, three senior female professors at M.I.T. came to suspect that their careers had been hampered by similar patterns of marginalization. They took the matter to the dean, who appointed a committee of six senior women and three senior men to investigate their concerns. After performing the investigation and studying the data, the committee concluded that the marginalization experienced by female scientists at M.I.T. "was often accompanied by differences in salary, space, awards, resources and response to outside offers between men and women faculty, with women receiving less despite professional accomplishments equal to those of their colleagues." The dean concurred with the committee's findings. And yet, as was noted in the committee's report, his fellow administrators "resisted the notion that there was any problem that arose from gender bias in the treatment of the women faculty. Some argued that it was the masculine culture of M.I.T. that was to blame, and little could be done to change that." In other words, women didn't become scientists because science — and scientists — were male.

The committee's most resonant finding was that the discrimination facing female scientists in the final quarter of the 20th century was qualitatively different from the more obvious forms of sexism addressed by civil rights laws and affirmative action, but no less real. As Nancy Hopkins, one of the professors who initiated the study, put it in an online forum: "I have found that even when women win the Nobel Prize, someone is bound to tell me they did not deserve it, or the discovery was really made by a man, or the important result was made by a man, or the woman really isn't that smart. This is what discrimination looks like in 2011."

Not everyone agrees that what was uncovered at M.I.T. actually qualifies as discrimination. Judith Kleinfeld, a professor emeritus in the psychology department at the University of Alaska, argues that the M.I.T. study isn't persuasive because the number of faculty members involved is too small and university officials refuse to release the data. Even if female professors have been shortchanged or shunted aside, their marginalization might be a result of the same sorts of departmental infighting, personality conflicts and "mistaken impressions" that cause male faculty members to feel slighted as well. "Perceptions of discrimination are evidence of nothing but subjective feelings," Kleinfeld scoffs.

But broader studies show that the perception of discrimination is often accompanied by a very real difference in the allotment of resources. In February 2012, the American Institute of Physics published a survey of 15,000 male and female physicists across 130 countries. In almost all cultures, the female scientists received less financing, lab space, office support and grants for equipment and travel, even after the researchers controlled for differences other than sex. "In fact," the researchers concluded, "women physicists could be the majority in some hypothetical future yet still find their careers experience problems that stem from often unconscious bias."

Jo Handelsman spends much of her time studying micro-organisms in the soil and the guts of insects, but since the early 1990s, she also has devoted herself to increasing the participation of women and minorities in science. Although she long suspected that the same subtle biases documented in the general population were at work among scientists, she had no data to support such assertions. “People said, ‘Oh, that might happen in the Midwest or in the South, but not in New England, or not in my department — we just graduated a woman.’ They would say, ‘That only happens in economics.’ ” Male scientists told Handelsman: I have women in my lab! My female students are smarter than the men! “They go to *their* experience,” she said, “with a sample size of one.” She laughed. “Scientists can be so unscientific.”

In 2010, Handelsman teamed up with Corinne Moss-Racusin, then a postdoctoral associate at Yale, to begin work on the study that was published last year, which directly documented gender bias in American faculty members in three scientific fields — physics, chemistry and biology — at six major research institutions scattered across the country.

Moss-Racusin, along with collaborators in the departments of psychology, psychiatry and the School of Management, designed a study that involved sending out identical résumés to professors of both sexes, with a cover page stating that the young applicant had recently obtained a bachelor’s degree and was now seeking a position as a lab manager. Half of the 127 participants received a résumé for a student named John; the other half received the identical résumé for Jennifer. In both cases, the applicant’s qualifications were sufficient for the job (with supportive letters of recommendation and the coauthorship of a journal article) but not overwhelmingly persuasive — the applicant’s G.P.A. was only 3.2, and he or she had withdrawn from one science class. Each faculty member was asked to rate John or Jennifer on a scale of one to seven in terms of competence, hireability, likability and the extent to which the professor might be willing to mentor the student. The professors were then asked to choose a salary range they would be willing to pay the candidate.

The results were startling. No matter the respondent’s age, sex, area of specialization or level of seniority, John was rated an average of half a point higher than Jennifer in all areas except likability, where Jennifer scored nearly half a point higher. Moreover, John was offered an average starting salary of $30,238, versus $26,508 for Jennifer. Handelsman told me that whenever she and Moss-Racusin show the graph to an audience of psychologists, “we hear a collective gasp, the significance is really so big.”

I asked Handelsman if she was surprised that senior female faculty members demonstrated as much bias as male professors, regardless of age, and she said no; she had seen too many similar results in other studies. Nor was she surprised that the bias against women was as strong in biology as in physics or chemistry, despite the presence of more female biologists in most departments. Biologists may see women in their labs, she says, but their biases have been formed by images and attitudes they have been absorbing since birth. In a way, Handelsman is grateful

that the women she studied turned out to be as biased as the men. When she gives a talk and reveals the results, she said, "you can watch the tension in the room drop. I can say: 'We all do this. It's not only you. It's not just the bad boys who do this.' "

I asked Handelsman about the objection I commonly heard that John is a stronger name than Jennifer. She shook her head. "It's not just a question of syllables, believe me," she said. "There have been studies of which names convey the same qualities to respondents in surveys, and John and Jennifer are widely seen as conveying the same level of respectability and competence." That faculty members reported liking Jennifer more than John makes the covert bias all the more insidious. As the authors make clear, their results mesh with the findings of similar studies indicating that people's biases stem from "repeated exposure to pervasive cultural stereotypes that portray women as less competent by simultaneously emphasizing their warmth and likability compared to men."

And when you combine that subconscious institutional bias with the internal bias against their own abilities that many young female scientists report experiencing, the results are particularly troubling. Of all the data her study uncovered, Handelsman finds the mentoring results to be the most devastating. "If you add up all the little interactions a student goes through with a professor — asking questions after class, an adviser recommending which courses to take or suggesting what a student might do for the coming summer, whether he or she should apply for a research program, whether to go on to graduate school, all those mini-interactions that students use to gauge what we think of them so they'll know whether to go on or not. . . . You might think they would know for themselves, but they don't." Handelsman shook her head. "Mentoring, advising, discussing — all the little kicks that women get, as opposed to all the responses that men get that make them feel more a part of the party."

Some critics argue that no real harm is done if women choose not to go into science. David Lubinski and Camilla Persson Benbow, psychologists at Vanderbilt University, spent decades studying thousands of mathematically precocious 12-year-olds. Their conclusion? The girls tended from the start to be "better rounded" and more eager to work with people, plants and animals than with things. Although more of the boys went on to enter careers in math or science, the women secured similar proportions of advanced degrees and high-level careers in fields like law, medicine and the social sciences. By their mid-30s, the men and women appeared to be equally happy with their life choices and viewed themselves as equally successful.

And yet the argument that women are underrepresented in the sciences because they know they will be happier in "people" fields strikes me as misdirected.

The problem is that most girls — and boys — decide they don't like math and science before those subjects reveal their true beauty, a condition worsened by the unimaginative ways in which science and math are taught. Last year, the President's Council of Advisers on Science and Technology

issued an urgent plea for substantial reform if we are to meet the demand for one million more STEM professionals than the United States is currently on track to produce in the next decade.

But beyond strengthening our curriculum, we need to make sure that we stop losing girls at every step as they fall victim to their lack of self-esteem, their misperceptions as to who does or doesn't go on in science and their inaccurate assessments of their talents.

As daunting as such reform might be, it is far from impossible. A book called "Math Doesn't Suck," by the actress Danica McKellar (who starred as Winnie Cooper on "The Wonder Years" before earning her bachelor's degree in math at U.C.L.A.), along with her follow-up books, "Kiss My Math," "Hot X: Algebra Exposed" and "Girls Get Curves: Geometry Takes Shape," may well have done more to encourage girls to stick with math than any government task force. McKellar's math books might go a little far in pandering to adolescent girls' stereotypical obsessions (the problems involve best friends, beads and Barbies rather than baseballs and speeding cars), but the wildly enthusiastic response they have received speaks to the effect that can be achieved by reworking the contents of standard math and science problems and countering the perception that boys won't like girls who are smart.

The key to reform is persuading educators, researchers and administrators that broadening the pool of female scientists and making the culture more livable for them doesn't lower standards. If society needs a certain number of scientists, Urry said, and you can look for those scientists only among the males of the population, you are going to have to go much farther toward the bottom of the barrel than if you also can search among the females in the population, especially the females who are at the *top* of their barrel.

In addition, she said, her colleagues need to recognize the potential of women who discover a passion for science relatively late. Studies show that an early interest in science doesn't correlate with ability. You can be a science nut from infancy and not grow up to be good at research, Urry said, or you can come to science very late and turn out to be a whiz.

With a little practice and confidence, girls can even make up for an initial disadvantage working with machines, tools and electronic equipment. While boys consistently outperform girls in tests that measure the spatial skills essential for lab work and engineering, studies also show that spatial aptitude is a function of experience. At Olin College of Engineering in Massachusetts, the administration is dedicated to making sure that half the students in each entering class are women. All of Olin's incoming students are required to take a machining course the first semester. According to Yevgeniya Zastavker, a faculty member who conducts research in biophysics and studies the role of gender in science: "Everyone is faced straight on with gender differences in the lab. We set them up in coed teams and ask them to design a tool or a product. If the gender dynamics get weird, we intervene, and that one intervention early on has a ginormous effect."

Back at Yale, Urry laughed at my own stories of how inept I had been in lab — drizzling acid on my stockings, which dissolved and went up in smoke, getting hurled across the room by a shock from an ungrounded oscilloscope, not being able to replicate the Millikan oil-drop experiment. Even she had been a disaster in lab in college. Only when she took a more advanced lab and spent hours poring over a circuit diagram, figuring out that her fellow students had set up an experiment wrong, did she realize she knew as much as they did.

“I’m soldering things, and I’m thinking, Hey, I’m really good at this. I know the principles. It’s like an art. It took me years to realize I’m actually good with my hands. I have all these small-motor skills from all the years I spent sewing, knitting and designing things. We should tell young women, ‘That stuff actually prepares you for working in a lab.’ ”

As the Yale study laid bare — scientists of both sexes also need to realize that they can’t always see the way their bias affects their day-to-day lives. Abigail Stewart, director of the University of Michigan’s Advance program, which seeks to improve the lives of female and minority faculty members, told me in an e-mail that Handelsman’s study shakes the passionately held belief of most scientists that they are devoted to accurately identifying and nurturing merit in their students. “Evidence that we are not as likely to recognize and encourage talent (even modest talent, as in this study) shakes our confidence and (I hope) will make us more attentive to our limitations in recognizing talent where we don’t expect to find it.”

Like Stewart, Urry thinks Handelsman’s study might catalyze the changes she has been agitating to achieve for years. “I’ve thought for a long time that understanding this implicit bias exists is critical. If you believe the playing field is equal, then any action you take is privileging women. But if you know that women are being undervalued, then you must do something, because otherwise you will be losing people who are qualified.”

Most of all, we need to make sure that women — and men — don’t grow up in a society in which they absorb images of scientists as geeky male misfits. According to Catherine Riegle-Crumb, an associate professor at the University of Texas at Austin, gender differences in enrollment rates in high-school physics tend to be correlated with the number of women in the larger community who do or do not work in STEM fields. Handelsman, who is awaiting Senate confirmation as associate director of science in the White House Office for Science and Technology Policy, told me that she would love to see murals of women scientists painted on the walls of Yale’s classrooms, “say, a big mural with Rosalind Franklin in the front and Watson and Crick in tiny proportion in the back.”

The good news is that, slowly and steadily, as more institutions acknowledge the bias against women and initiate programs to remedy it, real change is taking place. Peter Parker, who was director of undergraduate studies in physics when I was at Yale and for many years thereafter, told Urry that he wasn’t surprised that all the students and professors in the department were male. In his later years, Urry said, he would exclaim with glee that, say, 21 out of 49 of the physics majors in

the junior class that year were women. Not long ago, Roger Howe wrote me to say that he'd had a gifted female student, would I get in touch with her to offer some advice and support? At M.I.T., 19 years after those three senior women began comparing their experiences and demanding changes, the university now has a significant number of female administrators. Day care is more readily available. Faculty members find it more acceptable to have children before they achieve tenure. And deans and department chairs seem committed to increasing the number of female professors.

Urry, who stepped down as chairwoman of Yale's physics department this summer but will soon be president of the American Astronomical Society, wonders if her department's commitment to gender equality will continue or stall. One fall Friday, she invited me to attend a picnic the physics and astronomy departments were throwing to welcome back its graduate students and faculty. The professors were sipping wine from plastic cups and chatting with colleagues they hadn't seen all summer. Hungry graduate students surveyed tables crowded with bowls of salad, barbecue fixings, pies, cakes and a plate of brownies that Urry's husband baked that morning when he realized she had overslept. Four young women — one black, two white, one Asian by way of Australia — explained to me how they had made it so far when so many other women had given up.

"Oh, that's easy," one of them said. "We're the women who don't give a crap."

Don't give a crap about — ?

"What people expect us to do."

"Or not do."

"Or about men not taking you seriously because you dress like a girl. I figure if you're not going to take my science seriously because of how I look, that's your problem."

"Face it," one of the women said, "grad school is a hazing for anyone, male or female. But if there are enough women in your class, you can help each other get through."

The young black woman told me she did her undergraduate work at a historically black college, then entered a master's program designed to help minority students develop the research skills and one-on-one mentoring relationships that would help them make the transition to a Ph.D. program. Her first year at Yale was rough, but her mentors helped her through. "As my mother always taught me," she said, "success is the best revenge."

As so many studies have demonstrated, success in math and the hard sciences, far from being a matter of gender, is almost entirely dependent on culture — a culture that teaches girls math isn't cool and no one will date them if they excel in physics; a culture in which professors rarely encourage their female students to continue on for advanced degrees; a culture in which success in graduate school is a matter of isolation, competition and ridiculously long hours in the lab; a

culture in which female scientists are hired less frequently than men, earn less money and are allotted fewer resources.

And yet, as I listened to these four young women laugh at the stereotypes and fears that had discouraged so many others, I was heartened that even these few had made it this far, that theirs will be the faces the next generation grows up imagining when they think of a female scientist.

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