



Women in Science

To celebrate the diverse perspectives represented in this issue and to acknowledge that there are still barriers to women's full participation in scientific research, we asked each of our featured researchers the following two questions:

“ WHY DO YOU THINK THAT WOMEN ARE STILL UNDERREPRESENTED IN THE WORLD OF SCIENTIFIC RESEARCH? ”

“ WHAT NEEDS TO BE DONE TO TACKLE THIS? ”

Dr Audrey Moores
McGill University

Q1: This is a very important question and one that many have attempted to study, understand and solve. I do not have the expertise to provide definitive answers to this question, but I can give some ideas based on my own experience and what I see around me. I think the problem is a combination of factors. Maternity typically imposes constraints in the life of women at a very critical time in their career, especially in academia when the ramping period for launching a research programme is typically 30–45 years old. This imposes direct and obvious consequences in terms of physical and emotional availability, but also induces indirect consequences, in terms of both employers' decisions regarding women employees, and in terms of self-consciousness on the women's part.

Q2: One of the actions we have taken at McGill University was to consider family care at large, a concept including child, dependant adult and elder care, as a topic of action in the context of equity. A university-wide sub-committee, which I have been chairing for three years, was created to address this question and use policy making and awareness development to help promote concrete solutions to student, staff and faculty concerned with the question. While the question of family care is one which affects primarily women, there is merit in externalising the issue outside of a pure gender equity context, because we now have a generation of fathers who are more involved in caring for their family and they need to be supported too. The general hope is to make academic life friendlier to all workers to improve representation across the board.

Professor Catherine Beaudry
Polytechnique Montréal

Q1: A number of factors influence the low representation of women. First, establishing one's name/career is perceived to clash with the period when women want to have children. Second, the perception of the university as an ivory tower is linked with low socio-economic impact, or the sense that the university is disconnected from society. Third, there is not a critical mass of women in universities to act as role models. Women should represent at least 40% of university professors.

Q2: The focus on bibliometric performance measures needs to be dampened down to the benefit of more appropriate socio-economic impact measurements. Thankfully, several grant awarding bodies are moving in this direction and a greater diversity of research will be funded as a consequence. Finally, training for all peer-review committee members regarding possible biases in the evaluation of articles, grants, etc., needs to be made compulsory. Researchers are not aware that they are perpetuating numerous gender biases.

Dr Bipasha Baruah
Western University

Q1: I would say that there are three major reasons for women's underrepresentation in scientific research. First, there is systemic misperception and devaluation of women's scientific and technical abilities. Women in scientific and technical fields are deemed less competent than men even when they are better qualified than their male peers. Second, public policies and corporate policies to enable equity in training and employment in STEM are either very weak or absent in many contexts. And finally, the persistence of patriarchal social norms and assumptions about sexual harassment and assault make it difficult for women to assert themselves at par with men in these fields.

Q2: Women can gain optimal traction in scientific careers only within the context of wider socially progressive policies, as well as more transformative shifts in societal attitudes about gender roles and hierarchies. This is as true for developing countries and emerging economies as it is for industrialised nations. Since some women's ability to take advantage of careers in science is, to begin with, often constrained by social barriers imposed by race and class, for example, it is crucial that we take structural constraints into consideration to optimise women's entry into and advancement in scientific careers.

Dr Danie Meyer Parlapanis
University of Konstanz

Q1: Just as assumptions about women's natures led to an underrepresentation of women investigated in aggression research, so do gender stereotypes and the individual and systemic implementations of those prejudices continue to negatively impact women working to conduct research. Men in science outnumber, out earn, receive more grants and at higher values, are more likely to be collaborated with, published and cited than women. Furthermore, women researchers are reporting ever more cases of sexual harassment and assault in the workplace. A woman's motivations to work in science must outweigh her desires for a more inviting career field.

And this is only the topic of gender! Discrimination is breathtakingly intersectional, doubling and tripling down on women from further underrepresented groups with the burden often stemming from systemic and individual racism, homophobia, ableism etc. #MeToo

Q2: The disadvantages for women are clear and the implementation of effective strategies is difficult. Educational systems and institutions need to utilise the ever-growing body of research on women in STEM and the possible solutions to the problems plaguing them.

It is crucial that we take structural constraints into consideration to optimise women's entry into and advancement in scientific careers – Dr Bipasha Baruah



Prof Olfa Nasraoui
University of Louisville

Q1: This is a tough question that has recently attracted a lot of attention. There are many reasons but not all apply to every woman or every circumstance. In order for women or men to be able to fully participate in research, they need to be employed in a scientific research track, particularly in academia. Unfortunately, recruitment and retention of women in STEM fields has been lagging and this is particularly true in some fields like computer science and physics. Advancement of women to full professorship has also been lagging compared to men. Many reasons are hypothesised ranging from unconscious bias to lack of networking opportunities, not to forget systemic issues that affect full equity, participation, and advancement in the careers of women in academia and industry research labs. Some systemic issues can be administrative pertaining to institutional policies, while others can be societal (e.g. motherhood demands and the toll it places on women at a much more pronounced rate compared to men). In addition, there are entire leaky pipeline issues in the representation of women in the STEM fields, particularly in engineering and computer science. For instance, not enough girls remain interested and engaged in STEM subjects starting from the middle school level in the United States and several other countries. Another reason is that women are active and capable but they are perceived to be less active and they are not credited at the same rate as men for many reasons, mainly because of implicit bias. Women, unlike men, also are kept at bay from the opportunities for collaboration and recognition that are afforded by networking and mentoring.

Despite this, women have made significant discoveries in all research fields.

Q2: All of the above issues need to be identified and recognised at an institutional and governmental level and addressed by implementing proven interventions that, for instance, try to curb down implicit bias in institutions or try to implement equity enhancing policies for the recruitment, promotion and professional development and mentoring of women in all stages of their education and career, from preschool to the top leadership stages.



Professor Joy Hirsch
Yale School of Medicine

Q1: I have great respect for this question because the answer is so multi-faceted. The underrepresentation of women is not because institutions and universities have not tried to solve the problem. Further, there are some women who are very successful in science, confirming the proof-of-principle that it is possible for women to be world-class and leading scientists. I think that a model for the problem may be described as “accumulated handicap”. This model predicts that if men and women start at the entry levels of the academic ladder with equal representation, and a handicap is assigned to one gender (say female), then at every small decision point along the way involving things like space, students, grants, publications, teaching, service to the university, family obligations, invitations to symposia and named lectures, etc., the small handicap has a subtractive effect relative to the male counterparts. As the years progress the accumulated effects are measurable. One of the predicted outcomes is the progressive underrepresentation of women with increasing academic rank. This prediction is repeatedly confirmed by the volumes of descriptive data.

Q2: Although most universities have made notable and sincere efforts to increase the representation of women in science, it is stunning that the last two or more decades of various socially-engineered top-down strategies including quotas, mandates, and gender-related goal enforcements have been largely unsuccessful. However, as a result of these efforts, the problem is well-documented and the genuine efforts of institutions have confirmed the sustainability of the problem as well as established a legal framework for a solution. Clearly, it is time to add new approaches. I like bottom-up empowerment strategies that encourage creative and talented women to perfect their skills at hypothesis-based investigation. These skills include bravery for taking a calculated risk, and laughing with the excitement of an advance. Unstoppable drive and fierce passion are useful personal qualities for success in science, and expectations of “fairness” are often misguided and a distraction. However, focussing on achieving the highest standard in science is usually a lifeline. Although there is no magic pill to cure the chronic condition of underrepresentation, it is worth considering that we might expand our representation with a woman-by-woman approach focusing on the art of doing science within the institutions that we have rather than modifying the institutions by gender-based regulations.



Dr Cornelia Fermüller
University of Maryland at College Park

Q1: I believe that, even if in recent decades there has been much improvement, stereotyping, i.e. the belief that boys are better at sciences and math, still exists in society, and affects how girls are educated, and how girls are motivated, and it affects their beliefs about their capabilities. Females usually are less confident and more shy in making decisions, and defending their work. Females, often because of their ability to see things from different directions and see much better pros and cons, do not appear as confident as their male peers. While their way of thinking actually could be considered an advantage, it often puts them at a disadvantage, as employers/ advisors may choose the confident over the unconfident person.

Even if females reach the level of education to do science (get a PhD), they then find themselves confronted with having to juggle both job and family. Usually, women take on most of the family duties from raising the children, coordinating the family, to taking care of the household. Men instead often have the luxury to focus mostly on their research work. Most scientists do not work a forty hour week. Progress in all fields is so fast and, to keep up, a scientist has to invest many more hours. For once, most scientists have a large workload (writing proposals, travel, teach, supervise). They need to constantly learn, ask questions and engage. For many scientists, it is difficult to separate work from a private life. I believe many women, if they do not have sufficient support, simply because of the large work demands, find it impossible to combine family and job, or they are not interested in putting that large effort into their work.

Q2: Create efforts to make girls more confident. Possible solutions are: teach students about stereotyping; educate students about women's achievements to create role models for girls; help girls understand their skills, and encourage them to take advanced science and math classes in school; provide funds so all schools can create courses with real-life applications; colleges could do more to actively recruit women to science majors; faculty should be educated about the gender differences in thinking and mind.

For working women, create a better infrastructure so that women can combine family and science. Especially in the US, there is hardly any maternity leave, and good child care is expensive. Policy makers need to help provide better and cheaper day care and early education facilities. At universities and research centres, provide policies to give women more time to achieve research goals when having families (e.g. stop tenure-clock policies).



Dr Maria Bergemann
Max Planck Institute,
Heidelberg

Q1: Women have been under-represented in science for a variety of reasons, both strong cultural influences and the “standardised” requirements from the scientific job market. These core structures in science have solidified over thousands of years and, due to the lack of female voice, have been adapted to a predominantly male-dominated community. Having said that, I think it is not that much a problem of being female per se, but rather the problem of those who choose to combine research and family, which is extremely difficult, especially in a family where both partners work full-time. Research in the US showed that over 80% of female researchers are in partnership with a male researcher. Even in such couples, women are more strongly affected by this problem, because of the cultural perception of a female taking over the role of home-keeper and caregiver, whereas men typically take the role of money-earner. For example, one of the extremely family-unfriendly conditions, which has, nonetheless, a very high weight in a scientific career, is mobility – the need to change geographical location every couple of years, but also the demand to “be visible” in the community – i.e. to attend international conferences. We know that most females with career responsibilities do not withstand the pressure to quit or follow their partner at the expense of their own career. At most evaluation meetings that I have participated in, high mobility is associated with a positive career growth, whereas low mobility is a signature of a poor performance. Strikingly, the true reasons behind this are usually ignored, which leads to the “leaky pipeline” phenomenon: as soon as a female scientist gets her first child, there is about an 80% chance she will quit. Generally, continuity and productivity constitute one of the backbones of science, and career breaks, in most cases, imply failure and the lack of motivation, regardless of their causes. This is shocking and requires a radically new approach to enable female scientists, especially those with families, to have successful careers.

Q2: The first important way to tackle the issue is by increasing awareness. Society must acknowledge the unsuitability of current scientific structures for developing successful male and female researchers. This firstly requires new ways of evaluating the performance and scientific potential of individuals in science, taking a much greater consideration of personal conditions and an individual's responsibilities. Secondly, this requires much-improved support for families, both in terms of childcare, dual career, flexible working hours. I have often observed that in many places finding a suitable childminder becomes challenging, if not impossible; day-care facilities have working hours that are incompatible with research. Thirdly, active involvement of under-represented groups, i.e., females and people who *share carer responsibilities* (and who do not hand the burden of taking care of the kids to the partner) in important decisions, such as selection and evaluation committees, leadership, and scientific politics, in general. Finally, it requires role models and openness to alternative career paths, which do not fit in the current scientific structures (such as mobility, visibility, etc). We all want to help our dependants to succeed and everyone must realise that the future of the next generations is completely in our hands. It is pointless to sit and wait for another Lady Liberty to revolutionise the situation of females in science: it is fundamentally important to help improve the situation step by step in order to make progress and develop towards the ultimate goal of truly equal opportunities in science.



Dr Julie Hlavacek-Larrondo
University of Montreal

Q1: When I first started thinking about this question (during my undergraduate degree), I thought the answer would be simple. But, after having read much about the subject, it turns out the answer is not simple. It is probably because of a variety of factors, but it boils down to how our society thinks and acts (unconscious bias, stereotypes, etc.).

Q2: Research, some more research and then applying this research to make a difference. The past decade has seen tremendous progress in this field, and we are just beginning to understand why women are underrepresented in the world of scientific research. I don't have a definitive answer to this question yet (because we still need to study it more), but it seems that what really needs to be done is a change in how our society thinks and acts in general, from the way we raise our children to how we portray scientific research.



Dr Mareike Augsburger
University of Zurich

Q1: I often come across young female scientists with actually amazing results who are seeking reasons why their work findings are not that great and had major flaws, thus compromising their own work and preventing them from sharing with other scientists. Likewise, I have noticed male scientists presenting their far less impressive work in a much more self-confident manner. Guess, who will succeed?



Dr Céline Lévesque
University of Toronto

Q1: Gender bias is still prevalent so it is not surprising that women are underrepresented in science. Sadly, women and men are still in 2018 judged very differently for exhibiting similar behaviour. Gender inequality can be extremely demoralising and demotivating.

Q2: Our society urgently needs to give women more senior leadership positions. Everyone benefits from more women in leadership roles.



Professor Jennifer Rowsell
Brock University, Ontario

Q1: I think that there remains a stubborn myth that females have greater fluency and agency in ‘the softer subjects and disciplines’ such as English, history, and the arts. This of course is a myth and this is the beauty of the push for girls to engage in the learning sciences and to complete DIY, maker, and problem-solving activities to foster curiosity in the sciences, math, technology, and design.

Q2: There needs to be more interdisciplinary teaching and learning (blurring subjects and blending arts, science, design, and the humanities). This will go a long way in redressing gender gaps.



Professor Zahra Moussavi
University of Manitoba

Q1: I think the main reason that women are still under represented in science has to do with the fact that women, in general, have been told by their parents and society and the governing sector of the society that their role is to be a nurse, a teacher or a housewife. While there is nothing wrong with being any of those three, they should not be held as mutually exclusive of being a scientist. However, culturally they have been. When I talk about culture, I don't mean a specific culture. While there are many different cultures around the world, interestingly there are some universal features among all cultures. One of those universal features is the way women's role in the society is perceived. Of course, there are considerable variations in this too but they do share the same core, even though in recent years there have been movements to change that core perception of women's role in society.

Q2: I believe the most effective way to tackle this issue is to change the mindset of parents. I would put emphasis on both parents and not only fathers because some mothers (usually older generation) are so much against the idea of their daughter being in jobs similar to men. I have friends at my age who still struggle to get out of the mindsets that their mothers engraved in them when they were little. I was lucky that I had parents who treated me as equal to my brothers. I was a book worm as soon as I could read and I remember my mother referring to me as a "little scientist"! So, if I were in charge of making an initiative to tackle this issue, I would make programmes for young parents in the first place. I would also emphasise to young girls that being a scientist is not mutually exclusive of having a family or being a parent or doing any other traditional tasks that women usually do. I am myself an example in that I have always enjoyed doing all those traditional feminine tasks like cooking, knitting, sewing and I have had my children since my BSc programme (now I have grandchildren), and yet I've always been a scientist at my core. Maybe it is all because my mother called me "little scientist" when I was very young!



Professor Tanvi Banerjee
Wright State University

Q1: This is a really complex issue and we need to be careful to not oversimplify the problem. I think this has to do with conditioning of women as students as early as middle school or even elementary school; boys are stereotypically known to be interested in machines and video games while girls are inherently attracted to fields related to the biological sciences and human services (see https://nces.ed.gov/programs/digest/d16/tables/dt16_325.45.asp). Many female students aren't aware of the role of computer science and engineering in the exploration of biological and social phenomena. According to the National Center for Education Statistics, within engineering, the percentage of females conferred a bachelor's degree grew from 0.3% in the late 1940s to 18% in the early 2000s, but the percentage has not increased since then. This shows that we have reached an impasse where female students don't feel interested or welcome in stereotypical male fields like engineering.

Q2: For computer science, I think the solution lies in introducing coding to female students as early as elementary or middle school, and helping these students understand the wide range of sub-disciplines in computer science. Certain programmes like Girls Who Code are already initiating these types of interventions. However, like all challenging tasks, this will take time to produce measurable effects; I believe we will see the effect in the next five to ten years. Another aspect that I think is beneficial is the presence of strong female role models; having people like Shafi Goldwasser, Daphne Koller or Sheryl Sandberg to look up to can inspire young female students to pursue careers in currently male-dominated fields like computer science. I see serving as a strong female role model in computer science as part of my job as a professor, too. I want to help my students overcome stereotypes about computer science like its association with gaming, hacking, or staying up all night coding. For me, pursuing computer science for health care has not only allowed me to keep my identity as a woman, but has actually enhanced it. I want my students to understand that as computer science continues to become more discipline independent, there will be nearly limitless room for students to tailor computer science to their unique interests and value systems.



Professor Elisa Bertino
Purdue University

Q1: In Computer Science research women are still under-represented. I believe that Computer Science is an exciting research field. Most likely the reason why women are under-represented is that perhaps this research field is not correctly perceived by the general public. Perhaps it is seen as a dull area focusing on programming and hacking into computer systems. However, Computer Science is much more than that. It is a very creative field where one can think broadly about novel applications of computer systems – for example in education, well-being, and communication. Today, the impressive advances in artificial intelligence, big data, cognitive devices and robotics will revolutionise human life and society. Novel research topics are emerging – for example how humans and cognitive devices can effectively and efficiently collaborate in many different tasks and activities. Women want to be part of all this.

Q2: We need to engage young girls in creative research activities in Computer Science and make them aware of the novel exciting opportunities of this field and also of the challenges.



Dr Andreana Haley
University of Texas at Austin

Q1: The roots of the patriarchy, which largely excluded women from participating in society, are deep and strong - 6000 years strong, according to some experts! We can hardly expect women to overcome 6000 years of systematic oppression and deprivation in just a few short decades. The institution which awarded my PhD degree, the University of Virginia, opened its doors to women in 1970. That is only 50 years ago! In many places in the world, girls are still actively prevented from obtaining even the most basic education. Women are underrepresented in the world of scientific research because they are still busy fighting to be recognised as fully fledged members of society.

Q2: We can start by promoting women into positions of leadership, providing role models and mentorship to women during their education, funding and promoting the work of female scientists. It would also be helpful if we support and encourage men to assume and maintain an equal role in child rearing. It is unfortunate that the career building years in academia coincide directly with the most active years of parenting. We would certainly retain more talented women in scientific research if they did not have to feel that they have to choose between their career and their family.



Professor Diana Brydon
St. John's College
University of Manitoba

Q1: We are still struggling with the legacy of a humanism that defined white men as the norm and all women (and many men) as not fully human. Everything else stems from that: the institutional and attitudinal barriers, including the failure to value women's perspectives and the inability to understand that only by including women can true excellence be achieved. Misogyny is so entrenched in most dimensions of our lives that it seems natural. It is hard for men and women to imagine a world designed to serve the interests of all its inhabitants.

Q2: We need to work on many fronts simultaneously. We can challenge assumptions about the appropriate roles of men and women, understand that involving more women pays off in increased value to any enterprise, and reform social services to recognise, for example, that childcare is a societal responsibility. We can change the stories we tell in fiction, media, and research publications. We can review books by women and cite women scholars. We need laws enshrining equality and encouraging diversity in all dimensions of public life, and we need them to be enforced. To combat sexual harassment, women need to trust they will be believed. We need to eliminate barriers and change the story. Publications such as yours can help with this.



Professor Isabelle J. Dionne
Université de Sherbrooke

Q1: I believe the reasons are numerous. As young girls, there are still a lot of gender disparities in interest and social pressure. Boys are encouraged to be strong and pragmatic while girls are urged to be caring and nurturing. This has a tremendous impact on interests but also on sense of competence. Eventually, it will influence career choices. Later on, even for women who have interests in science, the demands of a research career often appear incompatible with their personal aspirations (i.e. having a family, not being in constant competition).

Q2: A lot is done these days to encourage and stimulate young women to get interested in science but there is still much to do. We need to increase the opportunities for young girls to develop their interest for basic sciences. Later on, I believe the solution is to place young women scientists in contact with successful models i.e., women who are successful in science and happily conjugate career demands with personal aspirations. Mentoring in this context is also a great strategy.



Dr Medeva Ghee
The Leadership Alliance

Q1: The research community is still plagued with biases and stereotypes that impede women from realising their full potential. Disparities begin at the secondary level of education and the gap increases at subsequent stages of their education. A lack of encouragement to pursue math and science courses, lack of role models and a lack of critical mass contribute to the dearth of women in science. A departmental culture that does not adopt a multicultural perspective and embrace diversity prevents the recruitment, retention and advancement of women in scientific research.

Q2: The strategy calls for a multi-pronged, sustained approach to accelerate change. Intrusive or proactive recruitment of students at the undergraduate, graduate and postdoc levels is essential to creating a diverse and competitive talent pool for the academy and broader research workforce. As important, a community of mentors and peers would provide a supportive network to promote academic and professional development mentoring. Institutional leadership is critical to developing, implementing and monitoring supportive policies that value diversity and improve the departmental climate. Resources invested in these initiatives would be required to ensure sustainable change.

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