JEM Journal of Experimental Medicine

VIEWPOINT

JEM women in STEM: Unique journeys with a common purpose

Anne O'Garra[1], Yasmine Belkaid[2], Arlene Sharpe[3], Susan Kaech[4], Sara Cherry[5], and Emmanuelle Passegué[6]

Before one can think of the challenges that face women in science and the hurdles that impair their development into leadership positions, it is worth considering the diversity within the collective of women scientists at the level of culture and past experience and life events.

This is exemplified here by female scientists who are Academic Editors at the *Journal of Experimental Medicine*. As a group, we have each first outlined our individual journeys through science, discussing the unique challenges and rewards that we have encountered in our journey through science.

Collectively, we finish with just some of the challenges facing women in science, and the difficulties in their reaching senior scientific research leadership positions. We all agree that in order for this to change, there must be buy-in from men and women at all levels. Also, to make change, support and investment from senior management at all scientific institutions, often male dominated, together with support from governments and funders, are needed.

Anne O'Garra: Senior Group Leader, The Francis Crick Institute, London, Academic Editor at *JEM*

I grew up in Gibraltar (population 29,000) when it was annexed from Spain. I attended a convent school which taught only one rudimentary science subject which only continued for pupils until the age of 16 yr. After a brief stint at the boys' school in Gibraltar to try and take "A-Level" high school–level science, my parents agreed I could go to England to obtain the science qualifications I required for university entry. This demonstrates that in the culture I grew up in, it was deemed that science was not for girls. But I was passionate about science and keen to follow this career. My mother—who ran one of the first day-care centers in Gibraltar and was the main bread-winner, since my father was ill—encouraged me and was inspirational in that she thought women could and should go forward in their careers. To afford to go to university, I had to work for 3 yr in the UK. This worked out well, as I worked in science laboratories and got some experience. I also realized pharmacology was not for me, but instead immunology. During this period, I attended science courses part time, which were offered to young people working in the science industry. There, I experienced cliques of young males who took pleasure in belittling their female colleagues, only to fail exams themselves. This was not a pleasant culture, testing my confidence but ultimately teaching me a lot. I was glad at last to get to university at the University of London, where attitudes towards women in science were better. Fast-tracking, driven by my passion for science, I pursued microbial biochemistry as a PhD student and then moved to immunology at the MRC National Institute for Medical Research (NIMR), where I developed a great passion for research on cytokines in the immune response. The Immunology Division was headed by the late Brigitte (Ita) Askonas,

Top (left to right): Anne O'Garra, Yasmine Belkaid, Arlene Sharpe. Bottom: Susan Kaech, Sara Cherry, Emmanuelle Passegué.

who became my friend and mentor through the years after that, until, sadly, her death in 2013. One of the many obituaries written for Ita stated, "It is difficult for immunologists to think of a world without Ita. We will miss her—as a force in immunology and as a dear friend" (O'Garra, 2013). Ita mentored many researchers, from postdocs to directors alike, both in science and in how to handle difficult situations. My time in the Immunology Division at NIMR, Mill Hill, empowered me to take up a senior postdoc position at the DNAX Research Institute in California, where I had a great time pursuing my research in a very non-gender-biased environment and was awarded a

[1]The Francis Crick Institute, London, UK; [2]The National Institute of Allergy and Infectious Diseases, National Institutes of Health, Bethesda, MD; [3]Department of Immunology, Harvard Medical School, Boston, MA; [4]NOMIS Center for Immunobiology and Microbial Pathogenesis, The Salk Institute for Biological Studies, La Jolla, CA; [5]Program for Chemogenomic Discovery, University of Pennsylvania, Philadelphia, PA; [6]Columbia University Irving Medical Center, New York, NY.

Anne O'Garra: anne.ogarra@crick.ac.uk.

group leader position there to continue working on new exciting avenues. At DNAX, a mentor and scientific advisor to me was Bob Coffman, with whom we had joint laboratory meetings every other week for over 10 yr; our laboratories interacting at many levels, from science to social. I then started to be invited to conferences. The shock at that time was that I was often the only woman speaker; this was surprising to me and tested my confidence. Giving talks at meetings as a PhD student or postdoc, there had always been a 50:50 gender mix, so being the only female invited speaker in the early 1990s was unnerving. In meetings and conferences, this has since been addressed to a great extent. However, the ratio of women to men in senior leadership positions still remains very low, often 20:80. Women face many hurdles as they try to progress in their careers through science. As a group leader, I have witnessed many of these, and experienced some. I myself did not have children at that time, since Paulo Vieira (my partner at the time, and now my husband) had returned to Lisbon to set up a group. I was going to follow, but things did not work out for a position for me there. So, for 5 yr we "commuted" between Palo Alto, California, and Lisbon—no mean feat. We felt that we could not bring up kids under these circumstances. Paulo and I now commute between Paris and London, following our passion for science across two great cities.

In 2004, I was invited to be the first woman to join the *Journal of Experimental Medicine* Editorial Board as "full" editor by Ralph Steinman, which has been a great experience. Ralph became my friend and mentor through the years and I am lucky to have benefitted—as many others have—from his wisdom, generosity, and enthusiasm for science. Ralph would be pleased to know that six of *JEM*'s Academic Editors are now women. Some years ago, I was privileged to co-organize a number of Keystone Conferences with Ralph and Jacques Banchereau. Ralph was committed, of course, to excellence and was the most diligent of leaders, but in addition to this, he was always attentive that we had enough women speakers and speakers from less represented countries.

Through my 30 yr of running a group, a division, and then in a senior management role, it became clear to me that not enough support is provided to women, and young men, as they try to juggle a scientific career while raising a family. As an advocate of Women-In-Science, working as a Senior Group Leader and Head of Division of Immunoregulation at NIMR, I chaired the Athena SWAN Institute Pilot Bronze award for the NIMR, awarded in 2014, which helped to implement support that included the 1-yr extension of contracts for female group leaders after maternity leave, regardless of the length of their maternity leave. The institute cast the recruitment net for group leaders wide to ensure that at least 50% women who applied were selected for interview, aiming to get a higher level of female group leaders recruited. The Athena SWAN Charter was established in the UK in 2005 to encourage and recognize commitment to advancing the careers of women in science, technology, engineering, maths, and medicine (STEMM) employment in higher education and research (https://www.ecu.ac.uk/equality-charters/athena-swan/). As Associate Research Director, when the NIMR became part of the new Francis Crick Institute, I continued to contribute to matters of gender and ethnicity in science and also set up a mentoring scheme for early-career group leaders. A large group, now working toward an Athena SWAN Award received by the Crick in 2019, has continued to raise awareness on gender matters in science, and actions have been implemented and will continue to be worked on to encourage a larger number of women leaders in science. Among the Crick's achievements to date toward women in science are: the introduction of a childcare support allowance for parents of children under 3 yr; increased recruitment of female early-career group leaders; support of flexible working hours, including part-time work schedules, for successful candidates and their families; automatic extension of fixed-term contracts for postdocs and group leaders to compensate for time lost due to extended periods of leave (usually to due maternity leave); unconcious bias training and investment in career development, leadership training, and mentoring for postdocs and group leaders.

Although progress has been made, there is still a lot to do at many levels to support women to continue in science towards leadership positions, which will undoubtedly lead to higher quality research globally.

Yasmine Belkaid: National Institutes of Health (NIH) Distinguished Investigator, The National Institute of Allergy and Infectious Diseases (NIAID), NIH, Director NIAID Microbiome Program, Academic Editor at *JEM*

I was born and raised in Algeria. My Algerian father was involved at a very young age in the Algerian war of independence and, as was the case for many of his generation, never had the opportunity to finish school. He spent the rest of his life fighting for his country. My French mother moved to Algeria as a young academic to teach in an effort to help the country recover from the damages imposed by colonization. Her mother—my grandmother—inspired my earliest dreams of a career in science. She was one of the rare women of her generation to earn a scientific degree, and she briefly did research before becoming a pharmacist. What I remember from my childhood was the pure joy of being in her laboratory while visiting during the summer, and the magic of the place filled with brass scales, tubes, and jars with mysterious names. I completed my biochemistry degree at the University of Science and Technology Houari Boumediene in Algiers while working at the Pasteur Institute during the academic year and at the World Health Organization in Switzerland during the summers. Being exposed to research, both applied and fundamental, on infectious diseases started a lifelong fascination for host–microbe interactions. This led me to pursue a PhD at the Pasteur Institute in Paris in the laboratory of a wonderful scientist, Dr. Genevieve Milon, who introduced me to the concept (at the time, poorly appreciated) of tissue-specific immunity. At the completion of my PhD, I remember feeling lost and unclear about my next step, but an opportunity to work at the NIH opened. I moved to Bethesda, without having visited the laboratory, as a single mother and barely speaking English. I was met there by an extraordinary research environment within the laboratory of parasitic diseases (NIAID) and started to explore the mechanisms underlying microbial persistence. At the completion of my postdoctoral fellowship, once again, I had no clear path. The department was exclusively composed of male PIs, which provided me with no role models. A lack of mentorship, poor self-confidence, and the challenge of raising

children while managing bench work are past experiences I share with many other women in science. I eventually decided to take a nonindependent position at the NIH. Starting to think about my next step was left to a random encounter. Steve Katz, who sadly passed away recently and whom I had just met, came to me after I gave a talk and said, "What are you doing? You need to get your own lab." This was one of the first times anyone had expressed trust in my ability to move forward. I decided to give it a try. Starting my own group and having the privilege to pursue a career in science would not have been possible without my highly supportive companion, my family, and the exceptional mentors (one of them, Anne, now my colleague as an editor at *JEM*), who adopted me along the way. I am here today because of them, but what my life experience taught me is that the scientific path of our trainees, and in particular women trainees, should not be subjected to extreme and fragile circumstances. My scientific career could have derailed at so many junctures and this indeed happened to many of the extraordinarily talented women I met during my journey.

My experience being a mother during both my PhD and postdoc training also gave me a profound understanding for the enormous financial and logistic hurdles encountered by young families in science. As further discussed below, it is time that all scientific institutions provide adequate financial and logistic support to our trainees and early-stage investigators trying to raise families. Some concrete and necessary actions are severely overdue.

As we previously discussed, women in science should not be lumped into an amorphous group. We are diverse and so are the circumstances. While there is some commonality of experiences (and challenges), our cultural and life experience differences can also have a profound impact on our ability to self-advocate, develop critical mentorship relationships, and position ourselves for the next step of our career. As a community, we need to acknowledge and respect these differences and develop a more proactive approach. We need to become advocates and actively promote women at all stages of their career. While signs of positive change can be seen in all institutions, much remains to be done to significantly change the culture of science and the current leadership landscape. This is a task that cannot be accomplished by women alone but as a true scientific community.

Arlene Sharpe: George Fabyan Professor of Comparative Pathology at Harvard Medical School, Chair, Department of Immunology at Harvard Medical School, Academic Editor at *JEM*

I grew up in Indiana in the post-Sputnik era when there was a great push for science education. I fondly remember in second and third grade arriving early to school or staying late to do simple experiments. This experience resonated with me and sparked my interest in science. My parents were supportive and encouraged my participation in elementary school science fairs, putting up with my less-than-successful hydroponics experiments when all I managed to grow was mold. Though research opportunities were limited in northwest Indiana, I was grateful to work at the local water company on an environmental biology project as a high school student.

I entered Harvard University unsure whether I would pursue a degree in science or anthropology. I was equally drawn to both disciplines and enjoyed learning about different cultures and foreign languages. A defining moment for me came the summer after my sophomore year when I had the opportunity to work in Jack Strominger's laboratory. It was in Jack's laboratory that I first experienced the joy of scientific discovery and was immediately hooked! The amazing scientists in his group were very kind, took time to talk with me about their work, and their enthusiasm was infectious. Jack has remained a wonderful mentor throughout my career. I earned my MD and PhD at Harvard Medical School where I was fortunate to have another amazing mentor, Bernard Fields. Bernie created a marvelous laboratory environment with a family atmosphere, equally supportive of female and male trainees. He was an amazing role model for how to balance research and family life. My PhD thesis research on reovirus pathogenesis sparked my interest in pathology as well as immunology and led me to a residency in anatomical pathology at Brigham and Women's Hospital (BWH). Following my residency, I did postdoctoral research with the inspiring and supportive Rudolf Jaenisch at the Whitehead Institute. I was most fortunate to receive a Lucille Markey Scholar Award, after being nominated by Rudolf and David Baltimore, at a critical time in my career. The Markey Award provided research and salary support, which allowed me to contemplate starting a family. I was able to hire a technician and afford high-quality childcare.

I returned to BWH and Harvard Medical School as an Assistant Professor in Ramzi Cotran's Department of Pathology at BWH. Ramzi helped me navigate my early days as a junior faculty member, caring about me as a person as well as my career. When I was eight months pregnant, Ramzi and I met to talk about balancing laboratory and family. Following that meeting, he introduced me to women physicians who had navigated motherhood while working in science—truly amazing and illustrative of his support for women in medicine.

In addition to having progressive and supportive mentors, I have been most fortunate to share my scientific journey with my husband, Gordon Freeman. I could never have imagined when we met as undergraduates how many opportunities we would have to collaborate. His support and encouragement continue to be invaluable in the pursuit of our shared scientific passions and our devotion to family.

My early exposure to science sparked a lifelong interest in scientific discovery enhanced by supportive family, caring mentors, and generous colleagues. My career experiences demonstrate how mentorship is a critical part of supporting women and promoting gender equality; collaborations between male and female scientists can change the landscape for women in STEM. Working together, we can provide early science education opportunities for girls, mentor women trainees, and address unconscious bias by developing new and effective strategies to support female scientists.

Susan Kaech: Professor and Director, NOMIS Center for Immunobiology and Microbial Pathogenesis, The Salk Institute for Biological Studies, Academic Editor at *JEM*

I am so thankful that 30 yr ago, I didn't have to write an individual development plan (IDP) to "plan" my career in science, as I probably wouldn't be where I am today if I had! Growing up in Olympia, WA, I developed the typical tree-hugging, free-thinking attributes of a Washingtonian. My mother

played an active role in the Democratic Party and volunteered a lot of her time in managing political campaigns, and my father taught high school biology. I am sure that my father's interest in biology and the physical sciences influenced and piqued my interest in science. For instance, I remember going to his school on the weekends and "playing" in his classroom with the scientific models, looking at all the chemicals and laboratory supplies. In high school, I certainly gravitated toward science classes, enjoying chemistry and physics, but there was no real "career guidance" for science in my high school. So when I entered college, I decided to major in engineering, the only science-related profession I really knew about at the time. However, during my freshman year, a moment of fate occurred when I walked into the University of Washington's financial aid office. Coming from a low-to-middle class family meant that I was eligible for a form of financial aid called "work-study," and so when I sat down in the office, they handed me a huge binder with literally hundreds of student jobs and asked me to pick one. Who would have guessed that over the next 20 min, my "IDP," so to speak, for a career in science would be written.

I selected a work-study job as a laboratory assistant in Dr. Paul Neiman's laboratory at Fred Hutchinson Cancer Research Center and was very fortunate to work with a postdoc, Dr. Richard To, who didn't just have me wash dishes, but actually involved me in his research project to develop antisense RNA to inhibit viral replication of Rous sarcoma virus. I loved it and spent nearly every afternoon and weekends at the laboratory, but unfortunately, my work-study aid ended a semester later and so I had to find a different job. But that first laboratory experience was perhaps the most pivotal moment of my scientific career—I was thoroughly hooked! Following that, I only looked for student jobs in laboratories, and was fortunate to work with Dr. Charles Laird, studying the genetics of fragile X mental retardation, for the remainder of college. With my growing love of genetics and biology, I switched majors from engineering to molecular and cellular biology. Dr. Laird was the first to tell me I should go to graduate school and helped me think about what schools and programs to apply to. I remember being awestruck when I was offered admission into some of the best PhD programs in the world. Because my undergraduate research experience was my entryway to becoming a scientist, I have always had undergraduate researchers in my laboratory to offer them the same opportunity.

Because I have always had so much fun doing research, I have never really felt like a "minority" in any of the environments I have worked in, even though I certainly was—such as in my very first laboratory experience, where I was the only woman working in the laboratory at the time. I have been extremely fortunate to have worked with male mentors at each stage of my career who were just as respectful to the women in their laboratories as they were to the males. And equally important was finding the right partner: an "enthusiastic" spouse who views my career and parental responsibilities as important as his own. Less than a century ago, in some institutes, women had to sneak into lecture rooms of seminars for which they were not allowed to enter and learn. I often wonder what I would have done in those times. Would I have still found my passion for science if the environment were that repressive? I like to think that I would have sought inspiration and courage from the pioneering women in science, just as I do today, to ignore professional stereotypes and to do what you want to do because it fascinates you. In fact, even to this day, a couple of times a year someone will ask me whose lab I work in, to which I usually chuckle and reply, "the Kaech lab," waiting for their reaction as they realize the implications of their question. And while trivial, these types of examples show us the societal perceptions still common today. Thus, as a mother raising two daughters, I constantly try to break down gender stereotypes, encouraging their confidence to try out and enjoy whatever interests and hobbies they like so that they will never think twice about their gender as they pursue their choice of careers. Similarly, with my trainees, especially the women in my laboratory, I encourage them to "lean in," speak up, and take ownership of their projects and collaborations, regardless of their stage. Little by little, day by day, I try to pay it forward, taking what my role models and past mentors provided to me to help create a more diverse and equitable environment for the next generation of talented and motivated scientists.

Sara Cherry: Professor of Pathology and Laboratory Medicine, Director, Program for Chemogenomic Discovery, University of Pennsylvania, Academic Editor at *JEM*

I am very lucky to have grown up in Brooklyn among a large number of immigrants who included my family; my mother was born in Germany in a displaced persons camp after World War II and came to America as a child. My father's family went through Ellis Island from Poland, at which point the name Cherry was created. Both of my parents were the first to attend college and were academics, both professors at Brooklyn College. My mother's role as both mother and Dr. Cherry, the Head of Audiology, had a huge impact on how I viewed women. She took me to conferences as a child where I saw her present her work, and I spent time with her students who spoke in awe of her, conveying how her critical approach was challenging, but that her thoughtfulness made them better clinically. I feel strongly that these experiences made me a more confident woman, in both my academics and in my view that I can accomplish what I strive for. My love and passion for science emerged as a child, and I was fortunate that my father had the wherewithal to find laboratories in New York City where I could work as a high school student. These experiences laid the groundwork for me to obtain a Bachelor's degree in Chemistry at the University of California, Berkeley. While I loved chemistry, it was clear from my classes that it was heavily male-dominated, and it was difficult for me to feel accepted. At the same time, working in Peter Schultz's laboratory, it became clear to me that women could be successful scientists. Altogether, these experiences led me to graduate work in David Baltimore's laboratory and to the field of biological sciences where I am today.

I started my independent laboratory at the University of Pennsylvania, where I have been fortunate to have had a large number of mentors and supporters, both men and women. My Chair, Bob Doms, and other senior faculty in the Microbiology Department not only read my grants and gave me practical advice, but they also tried to make me feel a part of the team and

included me in various professional and social events. And while there are few senior women in academia, the women at Penn have been a group of amazing individuals who have helped me throughout my career. I feel lucky to have had the opportunities I have had, interacting with a large number of positive individuals who have helped me to have the confidence to make it happen.

Unfortunately, many girls and women do not have the role models that I have had, and I feel that this makes it more difficult for women to have the level of self-confidence and the practical opportunities needed to make it in STEM fields. Moreover, I and many female scientists feel that when we exhibit self-confidence and assert our opinions, and when we don't conform to the expectations of our colleagues as to how women should behave, it can have detrimental consequences for our careers. I try to do as much as I can to be a role model and mentor for both my daughter and women in science. However, until we see a critical mass of women in major leadership positions in STEM fields, we may continue to face these challenges in the generations to come. Our goal should be to make it routine for girls to have STEM goals and for women to achieve them.

Emmanuelle Passegué: Professor of Genetics & Development, Columbia Stem Cell Initiative, Director, Columbia University Irving Medical Center, Academic Editor at *JEM*

My main take on the challenges that women in science are facing is that they are usually not empowered enough to take on important responsibilities and to shine in their own right due to a combination of social constraints and a lack of mentoring and role models. I speak from experience, having had to overcome some of the same issues.

I grew up in rural France in a very artistic family. My parents were teachers by day but a painter and a science fiction writer by night. They thrived in a simple and close-to-nature life and were extremely supportive of the education and personal development of their children, regardless of where it led them. This quickly took me to the nearby university town and then to Paris to finish college, and it set me up to become a scuba diving instructor, which to this day remains one of my long-lasting passions. It also opened my eyes to science, having the opportunity to intern in several laboratories over the years, and drove my decision to embark on a PhD thesis at the Collège de France. The response of my parents was unconditional support; the rest of my family, not so much, with at least one grandparent wondering why I was still wasting my time at school. In contrast, my PhD advisor, Dr. Danielle Gourdji, a wonderful scientist and human being, always believed in me and both pushed and supported me through the highs and lows of graduate school. I credit her with giving me the confidence to decide to join much more challenging laboratories in countries where I did not speak the language or knew the rules, and for equipping me with the scientific rigor and mindset to conduce the best research that I was capable. This took me first to the laboratory of Dr. Erwin Wagner in Vienna (Austria) and then to the US and the laboratory of Dr. Irv Weissman (Stanford University) for a second postdoctoral training. Both were fantastic mentors in their own right, providing a terrific and rich scientific environment to grow as a researcher and nurturing my fascination with stem cell biology and my life-long interest in the inner working of the hematopoietic system. However, they also ran very competitive laboratories where everyone had to perform and figure out, largely on their own, how to be successful. It was clearly the environment that I needed at this stage of my career, but I am not sure that I would have managed it without having had other driven and successful women postdoc fellows around me as role models.

I joined the University of California at San Francisco to start my own independent laboratory. It was an exhilarating time, with many institutions in California and across the US starting new stem cell institutes and recruiting many talented junior faculty. I really enjoyed being surrounded by so many bright new colleagues, both men and women, learning together how to set up a laboratory, recruit people, write grants, and celebrate the ups and downs of running what I have come to define as a small business. I also came to realize the importance of having the right faculty mentors and supportive departmental structure to help develop both scientific connections and visibility within the institution. In this context, I have to say that I was, more often than my male colleagues, the one having to ask the difficult questions rather than being told the answers, and painfully learning that I did not know some important facts that were obvious for them. I also found it difficult to be part of what really matters in the life of the institution, or to have relaxed, more casual interactions with my leadership, which I mainly blamed on awkward social skills and a lack of female representation. On the bright side, it did force me to be more proactive in reaching out to people and seeking opportunities, and it was a big motivator for my recent decision to join Columbia University and become the director of my own stem cell program. I am very glad that this opportunity existed, which I see as a sign of progress. I also hope to become the role model and mentor that I needed so much as a young scientist, building up the confidence of my faculty members and their trainees regardless of gender, while also developing their resilience and success in navigating the complicate world of academic research. I see the lack of self-confidence in grabbing or asking for meaningful opportunities, which is so much more prevalent in women than in men, coupled with the difficulty of raising a family while having a career, which is still disproportionally affecting women, as major roadblocks to overcome for women in the STEM field. Otherwise, the sky is the limit.

Our collective thoughts on how to overcome the challenges that face women in science

Collectively, we all agree that although progress has been made, there is still a lot to do at many levels internationally. We also all agree that supporting women to continue in science to leadership positions will lead to higher quality research globally and will have a significant impact on the science culture. For this, we need to work as a community with our male colleagues and leaders, as well as institutions and governments both nationally and internationally.

Practical support of parents with young children in science

While the discussion below can be relevant to both men and women, raising a family as a young scientist has traditionally impacted the career of women in a more significant way. It is worth noting that the increased length and demand required to complete

and publish scientific work over the past few years makes actions related to this important issue ever more pressing. Successful initiatives have existed for some time in other countries but are sadly lacking in many countries where scientific research is conducted at the highest level. Paid parental leave is offered in Europe, the UK, Canada, and Australia, but not in most institutions in the US. Other resources which could help are offered spottily, including support in returning to work after having a child and affordable childcare (especially for trainees and early-career group leaders).

There is a need for a source of flexible and brief funding, targeted to young researchers at fragile pinch points in their career who also have family care responsibilities, usually associated with pregnancy and early infant care. The danger of potentially excellent, predominantly female researchers being lost to a career at those periods in their lives continues to be a major threat to international scientific research, as well as a dramatic source of inequality in career outcomes for young researchers. For postdocs on maternity or paternity leave, costs such as technician time, enabling the continuation of ongoing experiments and acquisition of pilot data for a grant proposal, would greatly encourage them to continue in science. Funding for extra personnel to enable research productivity/efficiency which could be technical, administrative support, or for household/childcare was pioneered as a pilot scheme by Laurie Glimcher when she was president of the American Association of Immunologists (Glimcher, 2004). For instance, within the intramural program of NIAID, a new program has been recently implemented that will help provide technical help to trainees with familial obligations. Such schemes should be encouraged worldwide. Additional childcare funds to facilitate travel to conferences or for research collaborations would also be a plus for support of postdocs and early-career group leaders.

In Germany, the Max Planck Society provides diverse support for their scientists, ensuring that the question of "children or career" does not become an "either/or" decision, especially for women. The respective measures include the Christiane Nüsslein-Volhard Foundation (http://www.cnv-stiftung.de/en/goals/), streamlined procedures for receiving extra funds for technicians/research assistants to fill in the gaps associated with pregnancy and maternity leave, and a recently established program providing funds for infant care. To quote Christiane Nüsslein-Volhard (http://www.cnv-stiftung.de/fileadmin/user_upload/pdfs/Infoblatt_en_20.pdf), who formed a foundation to support women in science, "To conduct research is a tremendously demanding task that bears its own set of challenges. Research requires motivation, passion, diligence, and the ability to work in a self-directed manner. Moreover, flexibility and mobility are essential in order to generate the conditions that foster high-quality research; in particular, a significant amount of time that can be dedicated to research is important. For female scientists who are also mothers the unavoidable lack of free time becomes a looming problem that invariably hinders professional progress. Breaks for any length of time or part-time positions are dangerous, since reentry into the field my not be successful. Lost time cannot be regained and previously acquired knowledge may have already become dated and thus useless. We would like to help highly qualified women who are serious in pursuing their careers to weather through this time of double responsibility and still be able to accomplish excellent research."

Culture change strategies that may realize the change we need to encourage more women into senior scientific positions and leadership roles

Change in institutions' culture and fair promotion of the careers of women and their role in leadership depends also on transparency. For instances, at the NIH, Gigi Storz and others recently initiated an equity committee, which seeks to improve equity and diversity across all the intramural programs by analyzing metrics (on resources, salary, space, etc.) and proposing concrete solutions. In response to this, institutions also need to develop a proactive approach to correct disparity in promotion, resources, or salary.

Efforts in various institutions are being made to encourage gender-conscious speaker selection committees and mitigate unconscious gender bias by educating search committees and grant review committees. To this end, it is now recognized that membership of committees needs to have female representation. At the level of senior scientific management committees, this can be difficult, since the ratio of women to men in senior leadership positions still remains very low, often 20:80. Hence, it becomes critical to increase the numbers of women continuing in science; otherwise, senior female scientists will become overburdened with committee or grant panel membership, to the detriment of their science and quality of life.

Many studies have demonstrated disparities in hiring, funding, and publishing, based on gender and ethnicity; doubtless, there are undocumented biases that need to be considered, which we need to understand to implement change. There are questions as to whether publishing, funding, and charitable activities suffer from gender disparities. But we need hard facts with respect to the numbers applying/submitting versus the numbers awarded/published, against the average ratio of women to men (Briscoe and Brown, 2020).

Initiatives are being developed to review gender equality at institutions and policies for paid family leave, tenure clocks, and efforts to recruit, retain, and promote women faculty, but is this being attended to globally at all institutions, and is this enough? Again, we need to increase the number of women who develop their careers as scientists. More opportunities to get science to schools and encourage more opportunities for girls in science in high school is vital to enlarge the pool of women pursuing a scientific career, which will lead to more inclusive and better science.

References

Briscoe, J., and K. Brown. 2020. *Development*. dev187591. https://doi.org/10.1242/dev.187591
Glimcher, L.H.. 2004. *J. Immunol*. https://doi.org/10.4049/jimmunol.173.5.2891
O'Garra, A.. 2013. *Nature*. https://doi.org/10.1038/494037a