Hearsay, Not-So-Big Data and Choice: Understanding Science and Maths Through the Lives of Men Who Supported Women

Chapter 10

Hearsay, Not-So-Big Data, and Choice: On Understanding Science by Looking at the Past, Present and Future of Men Who Support Women

Paola Govoni[1]

Abstract

In the last 2000 or more years, a great deal and large variety of quantitative data and biomedical research on women has been conducted, collected, classified and interpreted. How is it that some scholars read this same data and research, including of course evolutionism – today, just as in the past – as indicating that women are *inferior* to men while others see an ambiguous form of *diversity* and still others *equality*? Following the invitation extended by this project's editors that we build a bridge between women's past and present in maths, in this chapter I move forward and back in time to discuss how, by interweaving arguments about present-day data with a gendered history of experts in maths (and science), we might achieve a better understanding of both the history of men and women in maths and science, and maths and science as socially constructed cultures. To face the problems lying in wait for humanity, from migrations in a climate-changed world to the challenge of providing energy for billions of people, we need good, abundant maths, science and technology embedded in good, abundant politics. It would appear that the only way forward is to train young people – men and women – to reason freely about science as, in addition to its other traits, a social culture, and this is probably the same pathway that will allow us to overcome gender – and race – in science.

1 Introduction: Betting on numbers

In the last 2000 or more years, a large amount of a variety of quantitative data has been collected, classified and interpreted regarding women. From Aristotle's time (384-322 BCE), when there were only four data points at play – hot and cold, wet and dry – to Francis Galton (1822-1911) and his "law of the deviation of averages"[2] or Cesare Lombroso (1835-1909) and his tragically famous

[1] Paola Govoni, Department of Education Studies, University of Bologna, via F. Re, 6, I-40126 Bologna, e-mail: p.govoni@unibo.it

It is my great pleasure to thank Renate Tobies, Tinne Hoff Kjeldsen, and in particular Nicola Oswald and Eva Kaufholz-Soldat, for inviting me to join this project. The week we spent in January 2017 in the snowy silence of the Oberwolfach Institute was simply perfect, both for the inspiring discussions we sheared and our nightly work in the Institute's dream library. As always, my exchanges with Giuliano Pancaldi have been important.

[2] Charles Darwin. 1981. *The Descent of Man, and Selection in Relation to Sex*, with an Introduction by J.T. Bonner and R.M. May, 327. Princeton University Press. (1st orig. edition London 1871).

book brimming with quantitative data on criminal and 'normal' women,[3] countless (male) natural philosophers and scientists have investigated and measured women's nature. In the modern age, data on women's cranial circumference and brain weight were collected without normalizing the data, not even in relation to height: I have the impression that this research is still being conducted even today, for example in neuroscience or endocrinology, without a proper awareness of the social and cultural issues at stake. In contrast, an increasing number of scientists both male and female, such as the geneticist Steve Jones or cognitive neuroscientist Gillian Einstein, to name just a few I shall address in this chapter, are well aware of these critical issues. Many contemporary scientists are aware that our postal code - which reflects a person's economic and social status - is more decisive than DNA in shaping our destiny, for example in terms of life expectancy; however, many scientists in the past shared this awareness. As early as the second half of the 19th century, besides data on women's bodies and their (allegedly backword) position in the history of human evolution, some experts were collecting data on women's education, including maths and science training. I believe that the history of that quantitative data on women's nature, culture and social roles can be useful today, allowing us to investigate a question that remains largely unexplored, even in studies on science, technology and society: Why and how is it that – today as in the past – the exact same data and research, including studies on human evolution, lead some scholars to conclude that women are *inferior* to men while other scholars see an ambiguous form of *diversity* and still others the same data suggest *equality*?

Indeed, even today there are sometimes individuals prepared to declare that, if women continue to face difficulties in achieving top professional positions in maths, science and technology even in countries such as the United States that have been supporting women scholars for decades, we simply must accept that the causes lie in their "aptitude", i.e. biology. Unfortunately, I am not referring to so-called locker-room talk. This conclusion was reached in 2005 by a (democratic) economist and President of Harvard,[4] and again in 2017 by a Google software engineer,[5] people who know how to wrangle data; people who might address – if only they chose to do so – the controversial issue of women in science using the same quantitative data and research that the

[3] The first English translation was Lombroso Cesare, and Ferrero, William.1895. *The female offender*, with an introduction by W.D. Morrison. New York: Appleton. Lombroso and Ferrero's book (1st orig. Italian ed. 1893) immediately achieved international circulation.

[4] Lawrence H. Summers. 2005. *Remarks at NBER Conference on Diversifying the Science & Engineering Workforce* (Cambridge, Mass., January 14, 2005) at the address http://www.harvard.edu/president/speeches/summers_2005/nber.php

[5] The 10-page anti-diversity manifesto (2017) by former Google software engineer James Damore is easy to find on the Web.

authors of this and other books on gender and science use.[6] Evidently, in the age of algorithms and big data mystique, just as in the times of Aristotle with his four data points and the age of Charles Darwin (1809-1882) when science and sociology were just beginning to employ statistics, quantitative data describing women, their bodies as well as their social roles, are imbued with something we might call world view, social culture or politics. The good news is that this is true for misogynists as well as feminists, for those who care little about this issue or consider themselves "objective": face to face with quantitative data, all of us have to make a choice, or perhaps a gamble, calling into question – at times without realizing it – both our values and our backgrounds. As the last few decades of history and sociology of science have shown, this interweaving of science and values impacts both the process through which experts collect and fine-tune data and the process through which these data are interpreted.[7] Being aware of those interactions with the goal of critically investigating them helps us understand what science is and how it works. As I shall show in this chapter, long before historians, philosophers or sociologists of science, it was the best scientific minds themselves who developed an awareness of this fact: suffice to cite the idea of "guesswork" as argued by Richard Feynman (1918-1988), a great scientist open-minded enough to admit that, when facing natural phenomena, sooner or later scientists are obliged to engage in guesswork.[8] A process of guesswork which is, naturally, composed of observation, experimentation, data and deep thinking. Not to mention hearsay, as in the case of male science on women.

Typically, in order to understand how society with its values (including gender-based values) interacts with the making of science about women, we as historians are accustomed to recalling the many (male) scientists who have used quantitative data to explain women's social marginality in biological terms.[9] To highlight the political role of the choice we all end up making when engaging data describing the nature and culture of women, in this chapter I shall instead focus on several evolutionary scientists who opted to support women. I suspect that the gamble that, in the 21st century, leads me to interpret the abundant, highly polished data demonstrating girls' disadvantages in maths and women's challenges in science through a social and cultural lens is

[6] By now the literature on this issue is extraordinarily extensive, I limit my citations to Margaret W. Rossiter's three volumes: 1982. *Women Scientists in America: Struggles and Strategies to 1940*. Baltimore: Johns Hopkins University Press; 1995. *Before Affirmative Action, 1940-1972*; 2012. *Forging a New World since 1972*.

[7] For a landmark anthology of writings on science studies see Biagioli, Mario, editor. 1999. *The Science Studies Reader*. New York: Routledge. For an autobiographical point of view on this issue, see Fox Keller, Evelyn. 2014. Pot-holes everywhere: How (not) to read my biography of Barbara McClintock. In *Writing about lives in science: (Auto)biography, gender, and genre*, eds. Paola Govoni and Zelda A. Franceschi, 33-42. Göttingen: V&R Unipress.

[8] Richard Feynman spoke about this point in one of his well-known 1964 lectures. See Richard Feynman Messenger Lectures, Cornell University, available at http://www.cornell.edu/video/playlist/richard-feynman-messenger-lectures (this and following sites were last accessed 12 November 2017).

[9] Similarly, early modern historians have often emphasized the anti-feminist role played by medical argument in the so-called Querelle des Femmes. For an important and fresh perspective on the crucial role that medicine played on the pro woman side, see Pomata, Gianna. 2013. Was there a Querelle des femmes in early modern medicine? In *Arenal. Revista de Historia de las Mujeres*, 20:3: 213-241.

similar to the move made by the 19th century Darwinian experts I quote in this chapter: faced with scare, uncertain data, they wagered in favour of women's rights and equality with men. In the so-called age of science, when women began to make their first, stubborn strides in universities throughout the western world, it is an established fact that many Darwinian scholars sustained women's inferiority. In fact, it is well known that, although Darwin went on to act inconsistently in his own private life, he argued that women were intellectually inferior.[10] However, Darwinians such as John Dewey (1859-1959) and other evolutionary Italian scientists I shall cite here, passionate Darwin supporters for both political and scientific reasons, diverged from their hero's position on the woman question.

In the first part of the chapter, I assert the importance of asking ourselves every now and then about the risks but also advantages of projecting our values and personal interests onto the making of science or its history: the goal is to keep these forms of interference under control, identifying them in our own and others' research. Above all, I believe that that working on these issues can have considerable educational value. Indeed, to successfully curb gender disparities in maths and science, we need a stronger alliance between scientists, social scientists and humanists, and this can only be achieved if we first agree on the meaning of the data on girls and maths and women and science. I will thus go on to briefly outline contemporary data on girls, women and mathematics, highlighting certain controversial aspects of the Italian case. I then take a step back in time, to the period between the 19th and 20th centuries, when women began accessing higher education and men, on becoming aware of this surprising – and frightening, for many of them – new social phenomena, reacted in various ways: not only by relegating women to the lowest rungs of the evolutionary ladder, but in many cases by taking the side of women instead. Keeping in mind this longstanding alliance between male scientists and women, I conclude by returning to the present to offer some suggestions about how we might conceive of a future gender-free science – an expression coined by Evelyn Fox Keller in the 1980s but still inspiring today[11] – by inviting young people to gamble on science as culture. To face the problems lying in wait for humanity, from new migration patterns in a world transformed by climate change to the challenge of providing energy for billions of people, we need good, abundant maths, science and technology embedded in good, abundant politics. And vice versa. It would appear that the only way forward is to train young people, and in particular future scientists both men or women, to reason freely about science as a social culture, among its many other traits: most likely, this is the same pathway that will allow us

[10] See articles by Evelleen Richards, instant classics cited in the following notes, and in particular her definitive 2017. *Darwin and the Making of Sexual Selection*. Chicago: Chicago University Press. These sources are also valuable for the extremely rich bibliography they provide.
[11] Keller, Evelyn Fox. 1985. *Reflections on gender and science*. New Haven: Yale University Press.

to overcome gender – and race – in science. Or, at least, this represents a pragmatic bet, the result of a choice.

2 On the Role of Values and Self in Science and its History

The large body of available quantitative data on girls and maths, women and science raise interesting questions, such as: What distinguishes countries in which girls perform as well as boys or even better in maths – as in Sweden, Norway, and Island, Qatar or some parts of China, according to PISA data – from countries in which girls still show persistent difficulties in maths? Do the data allow us to say that, in those contexts in which girls perform in maths at the same level as boys, women in mathematics have the same chances as their male colleagues of reaching the top of the university career ladder? In considering these phenomena, we should seek to avoid, not only the risks of misogynist hearsay, obviously, but also the risks of superficial politically correctness; indeed, this might give us the advantage in moving beyond the disappointing results achieved to date both in terms of education (girls in maths) and the professional sphere (women in maths and science). Naturally, we must first establish whether or not we agree that, among human minds developed in comparable social and educational contexts, intelligence tends to be distributed regardless of sex and race. If we can agree on this, then it follows that we also agree that having departments and research centers full of women discriminated against on the basis of their sex (and race) clearly represents a serious problem not just for those women, but for global society as a whole, especially given the enormous challenges we are currently facing. It goes without saying that this argument can only convince those who are ready to accept the fact that the vast amounts of data on girls and women in maths and science collected over the course of the last century demonstrate that their disadvantaged position stems from thousands of years of non-inclusive social culture and not hundreds of thousands of years of biological evolution.

Girls underperform in mathematics compared with boys in 37 of the 65 countries and economies that participated in PISA 2012 and it is clear that, the more the Global Gender Gap (GGG, the index edited by the World Economic Forum) is reduced, the less divergence there is – judging from the OECD's PISA data – in boys' and girls' performance in mathematics.[12] Generally speaking, in countries that have by GGG measures nearly eliminated social discrimination against women, girls perform even better than boys in maths. Yet we know that there are countries in which this rule does not apply: there are countries (such as certain areas of China, for example, or Qatar[13])

[12] World Economic Forum. 2016. *The Global Gender Gap Report 2016*, http://reports.weforum.org/global-gender-gap-report-2016/; OECD. 2017. *Mathematics performance (PISA)*, https://data.oecd.org/pisa/mathematics-performance-pisa.htm

[13] OECD. 2015. *Qatar. Student performance (PISA 2015)*, see at http://gpseducation.oecd.org/CountryProfile?primaryCountry=QAT&treshold=10&topic=PI

where women do not enjoy the rights considered fundamental in so-called western countries but girls still do better in maths than boys. Shifting the focus from girls to women in mathematics, however, the situation appears to be different. The data I outline here demonstrate – as has been observed – that women in the academia likewise face significant difficulty in reaching top career positions in almost every country. Female mathematicians occupy a difficult position in Italy, a country which the 2016 GGG ranked 50th out of 144 countries worldwide,[14] but the same is true of countries such as Denmark, which holds 19th place in the same ranking, as Lisbeth Fajstrup and Tinne Hoff Kjeldsen discuss in their chapter. In my opinion, if we examine these data in relation to others, such as sociology of education or social psychology research on performance anxiety – there is no doubt that the reasons girls, just like minorities, have trouble in maths arise from sociocultural and psychological factors that could be overcome in the right circumstances.[15] Professional female mathematicians and scientists are likely to face hurdles which are not only social and psychological but also institutional and corporative, supranational and long-term and, consequently, much more complex: in order to understand that, integrate history with other approaches seems necessary.

My inquiries into the present, such as the one introduced here and which in my professional life I engage in connection with my teaching, are formulated in the service of the historiographical questions I pose as a historian of science. And vice versa. One particular question I have asked of late is whether the biographies of successful – or unsuccessful – women in math and science are useful tools for attracting girls to and sustaining women in maths and science: the issue at the heart of the project that gave rise to this book. After years of research on science and society – and in line with a consolidated approach[16] – I have concluded that it is simply impossible to craft history without adopting the present as a research objective. And yet, when political commitments – feminism, in my case – intertwine with research-related concerns, how can we – as historians of science – overcome the risk of projecting our personal values onto the lives of people in the past? Scientists can be aware of the risks of personal and political issues contaminating their data but decide nonetheless to pursue the best science possible, and evidently the same is true of historians

[14] The GGG Report 2016, data on Italy, at http://reports.weforum.org/global-gender-gap-report-2016/economies/#economy=ITA

[15] Some of the many studies on this subject, coming from diverse fields, include S. J. Ceci, W. M. Williams and S. M. Barnett. 2009. Women's underrepresentation in science: Sociocultural and biological considerations. In *Psychological Bulletin* 135: 218–261; S. E. Carrell, M. P. Page and J. E. West. 2010. Sex and science: How professor gender perpetuates the gender gap. In *The Quarterly Journal of Economics 125*: 1101-1144; J. G. Stout, N. Dasgupta, M. Hunsinger and M. McManus. 2011. STEMing the tide: Using ingroup experts to inoculate women's self-concept and professional goals in science, technology, engineering, and mathematics (STEM). In *Journal of Personality and Social Psychology 100*: 255–270; E. A. Gunderson, G. Ramirez, S. C. Levine and S. L. Beilock. 2011. The role of parents and teachers in the development of gender-related math attitudes. In *Sex Roles 66*: 153-166.

[16] Always useful and inspiring are: Bloch, Marc. *Apologie pour l'histoire ou Métier d'historien* (1949), translated as *The Historian's Craft* (1953); and Carr, Edward H. 1961. *What is history?* Cambridge: Cambridge University Press.

or sociologists: the first step for curbing this phenomenon that so many scholars have evidently interrogated is openly admitting that it exists.

I recently worked on a project about (auto)biography in the history of science. This represented an opportunity to delve a bit deeper into the complexity inherent in working on historical issues that can be traced back to personal – including gender – matters.[17] Apart from attempts between the two world wars in which Virginia Woolf experimented with biography writing, the biographical genre began to be considered a scholarly genre in the 1960s, following second wave feminism's discussions of the interrelations between the personal and the social. It was then, and following autobiographical endeavours focused on gender, that scholars began to ask how a biographer might capture the essence of a creative mind in its context. Roughly speaking, this explains why there are generally more women than men among scholars who raise questions about these issues: this represents an example of what we call group cultures.[18] All of us decide to or happen to be – or not be – part of a group, but when the network in question intersects with that of female (feminist) scholars, there is always a risk that members of other groups will tend to *naturalize* these women's cultural traditions and use them as the basis for marginalization.

These considerations led me, in the end, to shift the initial focus I had chosen for this chapter. At first, I had planned to delve into long-term history to identify what women who were able to succeed in maths had in common in the last three hundred years. Taking the Italian context as an example to be compared with other national cases, my idea was to look across time from the Enlightenment case of mathematician Maria Gaetana Agnesi (1718-1799),[19] a fervent catholic from a wealthy but not noble family, to the present-day example of Emma Castelnuovo (1913- 2014),[20] a Jewish educator, maths populariser, and the daughter and niece of famous – of course, male – mathematicians. This has been a classic approach in the history and sociology of science since the time of Robert K. Merton's (1910-2003) research on the Royal Society.[21] It remains helpful even today for understanding how social and cultural elements interact with science through the lives of experts. And, of course, constructing prosopography helps in granting a voice to those who have been forgotten by history. Yet, when the people in question are women, the research results are *perceived* – speaking of the importance of including social psychology in our professional toolbox –

[17] *Writing about lives in science*, eds. Govoni and Franceschi. Evelyn Fox Keller, Londa Schiebinger, Paula Findlen and Georgina Ferry also contributed autobiographical essays to this volume.
[18] For a bibliography on this point, see Govoni, Paola. 2014. *Crafting scientific (Auto)biography*. In *Writing about lives in science*, 7-30.
[19] Mazzotti, Massimo. 2007. *The world of Maria Gaetana Agnesi, mathematician of God*, Baltimore: Johns Hopkins University Press.
[20] Furinghetti, F. *Emma Castelnuovo*, MacTutor History of Mathematics Archive, School of Mathematics and Statistics, University of St Andrews at http://www-history.mcs.st-andrews.ac.uk/Biographies/Castelnuovo_Emma.html
[21] Merton, Robert K. 1938. *Science, Technology and Society in Seventeenth Century England*. In *Osiris*, 4: 360-632.

differently, and there is a tangible risk that authors will offer biased readers evidence supporting the idea that women are *different* from men: this occurs because there is still a tendency to treat the lives and work of male scientists as a point of reference. The concept of 'difference' has always been imbued with ambiguity and I believe this ambiguity continues even today to complicate the women's conditions in terms of achieving equal rights. The conflict between equality and difference in feminism was resolved (theoretically, at least) several decades ago; after all, it is clear that the political notion of equality depends on acknowledging that differences do exist.[22] Yet, in real life the issue is clearly not easy to resolve.[23] Still today, in the vast academic world of hearsay, inside and outside the circle of gender experts, the issue proves to be complicated: in many cases, simply evoking the concept of difference raises the specter of ambiguity, as in the case of the above-mentioned former Harvard President and his – often silent, but nonetheless very numerous – followers: after all, at this point there are not many who still label women 'inferior' (although they do exist, and may include Nobel prize scientists, as I shall show); usually, they settle for calling women 'different'.

I definitively changed my mind after re-reading an essay which had a good international reception and has become a classic of the history of women in maths: a lecture delivered in 1901 by the Italian mathematician Gino Loria (1862-1954) and published soon after, first in French then in Italian.[24] An interesting point in Loria's analysis is the constant that he identifies in the biographies of women mathematicians over the long term. He argues that the few women who (may) deserve a place in the history of mathematics owe this place to their fathers and brothers, or to the husbands, teachers and colleagues who helped them in their research. Loria uses this common element to demolish the scientific achievements of women in maths, from Hypatia (c. 350/370-415 BCE) to his contemporary Sofia Kovalevskaia (1850-1891). By themselves, Loria assures us, women could not have achieved anything, because "provident Nature seems to call [women] to other destinies".[25] Beyond the unfounded allegations that led Loria to assert that all of women's scientific achievements in mathematics must actually be attributed to the men around them, there is a part of Loria's discourse that I imagine anybody would agree with. In order to succeed in science and mathematics, women just like men must grow up in a family that – at the very least – does not

[22] Scott, Joan W. 1988. Deconstructing equality-versus-difference: Or, the uses of poststructuralist theory for feminism. In *Feminist Studies*, 14: 32-50.
[23] Hirsch, Marianne and Evelyn Fox Keller, editors. 1990. *Conflicts in Feminism*. New York and London: Routledge.
[24] Loria read the original text at the R. Accademia Virgiliana in Mantova on 28 December 1901. Loria, Gino. 1903. Les femmes mathématiciennes. In *Revue scientifique*, 4:385-892; Id. 1904. Encore les femmes mathématiciennes. In *Revue scientifique*, 5: 338-340; Id. 1936. *Donne Matematiche*, in Id., *Scritti, Conferenze, Discorsi sulla Storia delle Matematiche*, collected at the behest of and published under the auspices of the Liguria chapter of the "Mathersis" Association. Padova: Cedam: 447-466. The English translation of some passages from the lengthy article can be found in Michèle Audin. 2011. *Remembering Sofya Kovalevskaya*, 230 and following. London: Springer, 2011.
[25] Loria, *Donne Matematiche*, 465.

destroy their potential. In addition, or alternatively, they need teachers, friends, colleagues or partners who support them as equals. If they choose to conduct research professionally, women as well as men need to be admitted into that select circle that the founders of the Royal Society called the invisible college. The invisible college is a powerful image, recovered at the beginning of the 1960s by sociologist of science Derek J. de Solla Price (1922-1983) and analysed in depth by Diana Crane.[26] Without being accepted into this college or network – a network which is personal, institutional, and political as well as scientific – it is impossible to make science and/or have a place in its history. Roughly speaking, the positive concept of invisible college lies at the origins of the Republic of Letters, a supranational space in which women in the 18th century – and Italian women in particular[27] – were able to play a recognized role. Between the 19th and 20th centuries, however, while natural philosophers were evolving into professional scientists, women from the petty and middle bourgeoisie began to access higher education and the labour market. Along with this rise in women's participation, the women-friendly Republic of Letters evolved into the same old boys' network that is still in force today. In Loria's time, women and men in Italy were beginning to compete for the few resources available for research, a competition many men enacted explicitly after the First World War using any means available, including Lombroso's already disproven but nonetheless republished science on women.[28] This is what brought women in universities South of the Alps to face the same kind of career obstacles that women in northern Europe and overseas were facing in the same period.[29] Identifying women as competitors but treating them with a combination of disdain and condescension succeeded in relegating women to the margins, a state of affairs that prevailed in university settings between the two world wars and during the Cold War and remains in place today despite the fact that, during the 1990s, female graduates began to outnumber male ones nearly everywhere: since Margaret Rossiter's 1982 first volume on women in science in the United States, this phenomena backlash has been known as.[30] If we as scholars aim to use available data to

[26] Crane, Diane. 1972. *Invisible Colleges: Diffusion of knowledge in scientific communities.* Chicago: University of Chicago Press.

[27] The best-known case is that of Laura Bassi, but in reality many Italian women savants achieved international prominence. Cavazza, Marta. 2009. *Women and Science in Enlightenment Italy*. In *Italy's Eighteenth Century. Gender and culture in the Age of the Grand Tour*, Paula Findlen and Catherine M. Sama eds., 275-302. Stanford: Stanford University Press.

[28] Lombroso and Ferrero's volume was reprinted in 1915, 1923 and again in 1927.

[29] Govoni, Paola. 2013. The Power of Weak Competitors: Women Scholars, 'Popular Science' and the Building of a Scientific Community in Italy, 1860s-1930s. In *Science in Context* 3: 405-436.

[30] Rossiter, *Women Scientists in America: Struggles and Strategies to 1940*, 122. For conditions in other countries, see: Dyhouse, Carol. 1995. *No Distinction of sex? Women in British universities, l870-l939*. London: Routledge; Rowold, Katarina. 2010. *The Educated Woman: Minds, Bodies, and Women's Higher Education in Britain, Germany, and Spain, 1865-1914*. London: Routledge; P. Govoni, Paola. 2015. *Challenging the Backlash: Women Science Students in Italian Universities (1870s-2000s).* In *Sciences in the Universities of Europe, 19th and 20th century,* ed. A. Simões, K. Gavroglu, M. P. Diogo, 69-88. Boston: Springer. For a discussion of the fierce resistance mounted against women during 1970s second wave feminism, see Malkiel, Nancy Weiss. 2016. *"Keep the Damned Women Out". The Struggle for Coeducation.* Princeton: Princeton University Press.

understand the present and even perhaps guide it, to avoid the kind of backlash against women currently occurring in universities all over the world we need to change our perspectives frequently. This is why I decided to put aside the issue of successful women in maths from the Enlightment to the present and instead focus on uncovering cases in which men from the 19th century chose to support women in science. I focus in particular on evolutionist scientists who gambled on women even though doing so went against the claims of the scientist they most esteemed, Charles Darwin, and his equally popular political counterpart, Thomas H. Huxley (1825-1895), who famously claimed that "five-sixths of women will stop in the doll stage of evolution".[31] To explore this story, however, we must linger a moment longer in the present, the space in which we live.

3 A Snapshot of the Present and the Case of Women in Computer Science

For many years, scholars as well as national and international agencies have been producing data on every aspect of the relationship between women and science: their education, research and careers as well as personal and familial aspects. Coming from both sides of the Atlantic, data produced by the National Science Foundation and European Commission have helped to spread an awareness that treating women and men with equal levels of education, commitment and scientific productivity in disparate ways has negative consequences for the production of innovative knowledge.[32] Discriminating against women in science is an enormous waste of creativity and, consequently, a waste of money.[33] To provide an example, let us consider the data for Italy, where women currently account for 59.2% of graduates and 52.4% of PhDs.[34] In Italian universities, however, women make up 45.9% of assistant professors, 35.6% of associate professors and 21.4% of full professors.[35] If we take into account the fact that this situation is relatively longstanding, given that female graduates overtook male graduates as early as 1991, there is evidently something in the university machine (the same machine that suffers the consequences) that does not function properly. As everyone is probably aware by now, this is a problem for many countries. Ever since the World Economic Forum began providing annual GGG data, there appears to be greater awareness at political and institutional levels throughout Europe that something must be done, although measures are not yet sufficient and lag decades behind the US's 1980 Women in Science

[31] Huxley to Charles Lyll, March 17, 1860, in Huxley, Thomas. 1901. *Life and Letters of Thomas Henry Huxley*, 228. Ed. by Leonard Huxley, vol. 1, New York: Appleton.
[32] European Commission. 2017. *Report on equality between women and men in the EU*. Brussels. doi:10.2838/52591; National Science Foundation. 2017. *Women, Minorities, and Persons with Disabilities in Science and Engineering*, https://www.nsf.gov/statistics/2017/nsf17310/static/downloads/nsf17310-digest.pdf
[33] Gaëlle Ferrant and Alexandre Kolev (OECD Development Centre). 2016. *The economic cost of gender-based discrimination in social institutions*, at the address https://www.oecd.org/dev/development-gender/SIGI_cost_final.pdf
[34] For a discussion of the Italian case in the long durée see Govoni, Challanging the Backlash,
[35] Istat. 2016. *Focus Le carriere femminili nel settore universitario*, 5, at http://ustat.miur.it/media/1091/notiziario_1_2016.pdf

and Technology Equal Opportunity Act.[36] So far the main consensus seems to consist in the importance of collecting data, and indeed there is no shortage of such data.

In general, the most positive data to emerge from the various surveys is widely known: women tend to be more studious than men in all the areas of the world where they have the right to education.[37] The negative side is that women all over the world who diligently pursue their studies and dedicate themselves to research struggle to reach top career rungs.[38] Another global trend shows that women have less interest than men in computer science, a field which for decades now has represented a crucial tool for every area of research, not to mention key markets.[39] The presentation of the latest GGG reminds us that:

> Talent and technology together will determine how the Fourth Industrial Revolution can be harnessed to deliver sustainable economic growth and innumerable benefits to society. However, if half of the world's talent is not integrated – as both beneficiary and shaper – into the transformations currently underway, we will compromise innovation and risk increased inequality.[40]

The stakes are indeed very high and as usual women, who as social actors remain fragile all over the world including countries with a lesser gender gap, are likely to end up marginalized. The history of the relationship between women and computer science is an interesting case. It is useful both for understanding relationships between men and women in science and for once again providing first-hand proof, if ever it was needed, that the history of women never progresses in a linear fashion, not even in historical moments of general development such as the 1960s and 1970s, during the so-called second wave of feminism.[41]

In the immediate post-war period, many women played a fundamental role in the pioneering phase of information technology. This participation stemmed from a lengthy period in which women worked as human computers, such the famous group of women at Harvard including astronomer Henrietta Swan Leavitt (1868-1921), those who participated in the Manhattan Project

---

[36] Public Law 96-516, 12/12/1980, https://www.gpo.gov/fdsys/pkg/STATUTE-94/pdf/STATUTE-94-Pg3007.pdf
[37] Max Roser and Esteban Ortiz-Ospina (2017) – 'Global Rise of Education'. Published online at University of Oxford, OurWorldInData.org. Retrieved from: https://ourworldindata.org/global-rise-of-education [Online Resource]
[38] For a summary of the latest data from Europe, see European Commission. 2017. *Eurydice Brief. Modernization of Higher Education in Europe. Academic Staff 2017*, doi:10.2797/806308
[39] *2017 Women, Minorities, and Persons with Disabilities in Science and Engineering*, 6-7; EC-DGR, European Commission, Directorate-General for Research and Innovation […], *She Figures 2015, Statistics and Indicators on Gender Equality in Science*, Brussels: European Communities, 5, available here: https://ec.europa.eu/research/swafs/pdf/pub_gender_equality/she_figures_2015-final.pdf
[40] Richard Samans, Saadia Zahida, Preface, World Economic Forum, *The Global Gender Gap Report 2016*, v, http://www3.weforum.org/docs/GGGR16/WEF_Global_Gender_Gap_Report_2016.pdf
[41] Noble, David F. 1993. *A World Without Women: The Christian Clerical Culture of Western Science*. New York: Knopf continues to represent a classic on this long durée issue.

and ENIAC program, and those who collaborated with the NASA during the space race.[42] Having been accustomed to working in certain niches of science men disdained for being insufficiently challenging, after the Second World War women acted as entrepreneurs and researchers in computer science. In the United States, women's enrolment in computer courses grew consistently until 1982 when – judging from National Science Foundation data – there was a sudden collapse.[43] It is impossible not to recognize the relationship between women fleeing computer science and the explosion of the male nerd culture characterising the Bill (Gates) and Steve (Jobs) generation. As historians (not only female but also male) have shown, nerd culture took shape in the public sphere as a *masculine* culture. Although much has obviously changed since then, nerd culture has remained masculine in the public sphere, informing academic policies and the business strategies of Silicon Valley firms[44] and even appearing in television series such as The Big Bang Theory.

However, there are changes underway in the generation of computer scientists in their thirties, those associated with Facebook, Twitter and so on. In the Silicon Valley, women but also Latinos and African Americans have brought cases for discrimination, and this resistance is being enacted using new languages and strategies.[45] Beyond labels – such as that of intersectional feminism, which has become quite widespread by now – I have the impression that we ought to seek new ways to support women in science and mathematics in Europe as well, focusing more on new ways of encouraging and advocating for minorities. The new migratory flows reshaping Europe are raising issues of gender, class and culture more generally, issues that have a tangible effect on Europe's social and cultural physiognomy. I believe it is important to consider women's rights in general, and the rights of women in science in particular, in the context of these new and profound changes. If not, we face the risk that women will lose part of the ground they have gained in favour of new social emergencies judged to be more pressing, as occurred for example after the First and then Second World Wars. Indeed, the history of relations between women and computer science in the United States shows that women might abandon a given field of study very quickly as a result of changing cultural, even pop cultural conditions, even more so than economic changes.[46] On the contrary, if the new emergencies introduced by migration flows in Europe are managed by

[42] For several different approaches see: Light, Jennifer S. 1999. When Computers Were Women. In *Technology and Culture*, 40, 3: 455-483; *Gender codes: Why women are leaving computing*, ed. by Thomas J. Misa. Hoboken, N.J., 2010; Jordynn Jack. 2014. *Autism and gender from refrigerator mothers to computer geeks*. Urbana: University of Illinois Press; Nathan Ensmenger. 2015. Beards, Sandals, and Other Signs of Rugged Individualism: Culture & Identity within the Computing Professions. In *Osiris*, 30:1: 38-65.
[43] Ensmenger, Beards, Sandals, and Other Signs of Rugged Individualism, see figure 3 on page 63.
[44] Mundy, Liza. 2017. Why Is Silicon Valley So Awful to Women? In *The Atlantic*, April issue, https://www.theatlantic.com/magazine/archive/2017/04/why-is-silicon-valley-so-awful-to-women/517788/
[45] Josephine Lister. 2017. Crossing Boundaries: The Future of Science Education. In *Scientific American*, 15 August.
[46] Brand, Stewart. 1972. SPACEWAR. Fanatic Life and Symbolic Death Among the Computer Bums. In *Rolling Stone*, 7 December, http://www.wheels.org/spacewar/stone/rolling_stone.html

policies informed in part by gender history, these flows could instead become a great resource. In Italy, the (now very low) percentage of foreigners among PhDs is on the rise: from 2.2% of PhDs in 2004 to 6% in 2010. These degrees are quite evenly distributed between women (46.8%) and men.[47] Among those who migrate and are able to educate their children, gender discrimination evidently does not hold much weight: policy makers should make a point of working on these data using an intersectional approach.

In light of this point, another interesting finding emerges from the PISA data regarding assessment in mathematics. How can we explain why girls are better than boys in mathematics in Qatar, a country ranked 119th in the 2016 GGG, as well as in Sweden, a country ranked 4th in the GGG?[48] The classic interpretation associating girls' success in mathematics with social contexts characterised by equality between women and men is clearly not enough to explain these cases. It is undoubtedly true, as we can easily verify by comparing PISA data on girls' and boys' performances in maths with those of the GGG, that there is a close correlation between girls' performance in maths and equal cultural-social contexts, as already mentioned as one of the findings of social psychology research. As usual, however, matters are much more complex: under certain circumstances, discrimination based on gender, as well as racial or social class, may under certain conditions be turned into an opportunity and tool for overturning the status quo in many areas, including mathematics. In contexts characterized by the new migration flows mentioned above, if these phenomena were studied and discussed freely with young people in schools and universities on the basis of concrete data it might lead to interesting changes, especially for women and minorities. This is even more true in cultures such as Italy which, as already mentioned, the 2016 GGG ranks 50st out of 144 countries worldwide. In Italy, the 2015 edition of PISA found that Italian students did not deviate significantly overall from their colleagues as represented by the OECD average. However, Italy is the OECD country with the third-highest degree of gender disparity after Lebanon and Austria: boys are 20 points above girls (500 vs 480), while the average difference internationally is 8 points in favour of boys.[49] Besides and consequently, PISA has also found that girls report a statistically significant higher levels of anxiety in relation to mathematics than boys

[47] Istat. 2015. *L'inserimento professionale dei dottori di ricerca*, 2, see at https://www.istat.it/it/files/2015/01/Dottori-di-ricerca_DEF.pdf?title=Inserimento+professionale+dei+dottori+di+ricerca+-+21%2Fgen%2F2015+-+Testo+integrale.pdf

[48] Math data, PISA 2012, analysed in *Education at a Glance 2014*, http://www.oecd-ilibrary.org/docserver/download/9614031e.pdf?expires=1483004034&id=id&accname=guest&checksum=201186F0848C0D63A13BCAF5187BD896; The GGG 2016 Report http://reports.weforum.org/global-gender-gap-report-2016/

[49] For a detailed analysis of Italian data, see INVALSI. *Presentazione Indagine internazionale 2015 OCSE- PISA Principali risultati Italia*, at the http://www.invalsi.it/invalsi/doc_evidenza/2016/061216/Sintesi_Indagine_PISA2015.pdf

do.[50] As many studies have shown, the same is true of the weight, both negative and positive, relationships between girls and female teachers can assume in relation to mathematics performance. In moments of intense migration like today, it is likely – indeed, desirable – that young male and female second-generation migrants' aspirations for personal freedom trigger positive competitive processes in the spheres of education and research. This is why I consider it important for those of us dealing with equal opportunities between women and men in science and mathematics to broaden our scope, focusing on gender issues in order to move beyond them. This already occurred in the 19th century in the United States during the first wave of feminism, when women and black people came together as allies in the struggle for rights and access to education,[51] in the so-called age of science.

4 Men Supporting Women in the Victorian and Liberal Ages

From a contemporary perspective, it seems clear that the processes definitively transforming women's physical and mental inferiority into what we would call a science fact took place in the so-called age of science, the Victorian era (Liberal age in Italy), in particular with the 1871 publication of another long-awaited work by Darwin, *The Descent of Man, and Selection in Relation to Sex*. In this book Darwin of course talks about woman and their place in human evolution, a topic that has obviously been the object of a great many publications. [52] Darwin's position is well-known, but it is still worth recalling his specific words:

> The chief distinction in the intellectual powers of the two sexes is shewn by man attaining to a higher eminence, in whatever he takes up, than woman can attain-whether requiring deep thought, reason, or imagination, or merely the use of the senses and hands.[53]

Women are distinguished by some cognitive capabilities, Darwin reassures us, such as "power of intuition, or rapid perception, and perhaps imitation".[54] These traits are, however, "characteristic of the lower races, and therefore of a past and lower state of civilisation".[55] The scientific fact of "women's inferiority" Darwin argued systematically if rather weakly was also supported by the campaign carried out by his supporter and friend Huxley. Not to mention the vast corpus of

[50] OECD, *The ABC of Gender Equality Education*, 77, see at https://www.oecd.org/pisa/keyfindings/pisa-2012-results-gender-eng.pdf
[51] This took place in particular in certain co-educational colleges where science held a crucial place in the curriculum. See Noble, *A World without Women*, chapter 10.
[52] Darwin, *The Descent of Man*; for the section dedicated to women, see cap. XIX, vol. II. For an interesting discussion and rich bibliography on this issue, see Richards, *Darwin and the Making of Sexual Selection*.
[53] Darwin, *The Descent of Man*, 327.
[54] Darwin, *The Descent of Man*, 326.
[55] Darwin, *The Descent of Man*, 327.

literature of a more or less philosophical and sociological nature, quantitative data from physiology and anthropology, and an incredible volume of journalistic literature, this latter being the uncontested realm of hearsay as evidenced by the case of Herbert Spencer (1820-1903).[56] For more than a century that fact – women's inferiority – functioned quite tidily to explain and justify a number of social issues and resolve difficulties in the familial sphere as well as in science. For some, there was no end to the need to prove that women, who had been confined to the domestic sphere in every society, were obliged to remain there: naturalistic research on women continued steadily from Galen, Aristotle and Hippocrates up to Darwin, and many readers saw his concept of sexual selection as putting a definitive end to the discussion.[57] And yet the trouble with women was that, from Hypatia to Christine de Pizan, Madame du Chatelet to Laura Bassi, Maria Gaetana Agnesi to Mary Sommerville and countless other Victorian-age women, their achievements called all of this authoritative naturalistic research into question. In the early and late modern period, the phenomenon of *Femmes Savantes* was explained using the flexible concept of 'exception': yes, a woman might sometimes be a good natural philosopher or excellent mathematician, but these are the kind of bizarre, outlying phenomena also found in nature. In short, the argument went, these women were monsters. This was in fact the label pinned on Bassi, the first woman – and only woman for over a century – to hold a paid professorship in a university.[58] When a woman managed to engage with Newton, as did Bassi and Chatelet, or with Laplace, as did Sommerville, she could be explained away fairly easily as the classic exception that confirms the rule. Periodically the debate would reignite, but for several centuries it remained limited to specific circles of elites; that is, until the question of women's intellectual capacity become an urgent social issue in 1870s-public debate, when Darwin's timely book was published. It was during the first wave of feminism that the natural philosophers who had begun to call themselves scientists lost control of the issue: even as scientists put themselves forward as new professional figures at the centre of public debate, they were obliged to face a strange new competitor in women. The women in question were not even aristocrats but, embarrassingly, women of the petty and middle bourgeoisie who wanted to study and do science and mathematics. They did not want to amuse themselves and men in the sitting

[56] Richards, Evelleen. 1997. "Redrawing the Boundaries: Darwinian Science and Victorian Women Intellectuals." In *Victorian Science in Context*, ed. Bernard Lightman, 119-142. Chicago: Chicago University Press. Richards, Evelleen. 1998. "Huxley and Woman's Place in Science: The 'Woman Question' and the Control of Victorian Anthropology." In *History, Humanity and Evolution: Essays for John C. Greene*, ed. James Richard Moore, 253-284. Cambridge: Cambridge University Press. Regarding Spencer's controversial figure and international impact and appropriation, see Bernard Lightman (ed.), *Global Spencerism. The Communication and Appropriation of a British Evolutionist*, Boston and Leiden: Brill, 2016.

[57] Schiebinger, Londa. 2004. *Nature's Body: Gender in the Making of Modern Science*. New Brunswick: Rutgers University Press (1st ed. 1993).

[58] Findlen, Paula. 1993. Science as a Career in Enlightenment Italy: The Strategies of Laura Bassi. In *Isis* 84: 441-469.

room but to study and work, alongside men, in laboratories and professional scientific societies with an eye to enjoying themselves and earning glory and money. Just like men. How to make sense of this phenomenon in view of the arguments about women presented in the work of Darwin, one of the most insightful theories ever penned about life on earth?

Just as today big (or not so big) data enjoys a certain mystique, in those years as well some of the most interesting speeches made in support of higher education for women were based on quantitative research. One of the best known of these is a 1888 investigation of women and the university in Europe conducted by Helene Lange (1848-1930), one of the leading figures of the women's rights movement in Germany. The American edition of Lange's book, supplemented with an essay on female higher education in the United States, enjoyed wide success.[59] Lange's inquiry was a response to the 1878 decree in Germany that allowed women to attend only certain university courses, leaving it up to faculty to decide on a case-by-case basis if they should be admitted.[60] Lange's ambitions went far beyond the national setting, however: her quantitative data were a response to the hostility that had been expressed more or less everywhere at the idea of women studying at university. With her comparative data, Lange showed her readers that, in countries where women studied just like men, the world continued to spin on its axis just as it had before; there was no serious social upset, and the family continued to represent the foundational core of society. It was these fears that had prayed on the minds of opponents of women's higher education, aware as they were that, for women just as for men, education constituted a pathway to autonomy including but also going beyond economic independence. We must keep in mind that this was the atmosphere in which important figures from different generations of the international, multifaceted women's movement for emancipation developed their positions: these included Harriet Martineau (1802-1876) in Britain, Ellen Key (1849-1926) in Sweden, or the Italian physician and popular writer Gina Lombroso (1872-1944), daughter of Cesare Lombroso. For these and other intellectuals, not suffragists but emancipationists, it was crucial that women's education and social deliverance be restrained by domesticity, not only to avoid fuelling widespread fears but also to ensure a certain degree of freedom for women.[61] The battle against women seeking university educations was more heated in those countries with a more widespread awareness that education represents the key to emancipation for anyone: women, blacks or members of disadvantaged social classes. I believe this

[59] Lange, Helene. 1890. *Higher education of women in Europe*, Translated and accompanied by comparative statistics By L. R. Klemm. New York: D. Appleton and company (1st orig. ed. Berlin, 1888).
[60] Regarding women and higher education in Germany, see Mazón, Patricia. 2003. *Gender and the modern research university. The admission of women to German higher education, 1865-1914*. Stanford: Stanford University Press.
[61] For a discussion of this issue and further bibliographic resources, see Richards, *Darwin and the Making of Sexual Selection*. On the history of feminism, see Offen, Karen. 2000. *European Feminism, 1700-1950*: A Political History, Stanford: Stanford University Press.

is why in the United Kingdom and Germany, unlike Italy, there were long-lasting and fierce battles, fought with legal tools, to keep women – as competitors – out of the university. These struggles were waged to maintain a status quo that had been established in the Middle Ages when universities were founded on a monastic model: worlds without women.[62] While efforts to keep women from accessing higher education took on various legal forms in different national contexts, medical and scientific justifications were a constant across the board. The debate over the so-called woman question was a lively, prolific, and transnational one that largely revolved around the biological factors many claimed constituted an insurmountable obstacle to women's intellectual activity: as the worthy Loria reminded his listeners, pursuing formal education represented a challenge to women's very nature, a challenge that would lead to sterility, neurosis and social disorder.

It followed that, if women were to enter labs and university halls, it would have a detrimental effect on educational and research standards. As already mentioned, for many the answer to these and other hotly debated questions appeared in 1871 in Darwin's *The Descent of Man.* Many evolutionist scientists – although not all, as I shall show – embraced Darwin's explanation as to why women's roles must necessarily unfold in the home. There are several studies on this topic, matched by a body of research asserting the opposite perspective: indeed, it is known that women in a number of countries, including Italy, managed to combine their enthusiasm for evolutionary science with a commitment to women's rights.[63] However, as far as I know much less research has been conducted on those scientists and mathematicians who, while wholeheartedly agreeing with Darwin's science and Thomas Huxley's politics (as mentioned, Huxley's impressive political genius was also expressed in keeping women out of labs and professional societies),[64] preferred to make up their own minds about the woman question. After all, for anyone not suffering from an *ipse dixit* complex, the first few lines cited above sufficed to show that Darwin's writings on women in *The Descent of Man* had fallen into the trap of hearsay. That is, it is quite clear that his arguments were political (or moral) rather than scientific.

There were many men who supported women in their struggles to obtain the same rights as men. These included not only politicians, such as John S. Mill (1806-1873), who Darwin criticized in *The Descent of Man* specifically in the section dedicated to women[65] or, South of the Alps, republican Salvatore Morelli (1824-1880), who drafted several bills that would have given women

[62] Noble, *A World without Women.*
[63] On the United States, see Hamlin, Kimberly A. 2014. *From Eve to evolution. Darwin, science, and women's rights in Gilded Age America*. Chicago: Chicago University Press. On the Italian case, see Govoni, The Power of Weak Competitors.
[64] Richards, Evelleen. 1998. "Huxley and Woman's Place in Science: The 'Woman Question' and the Control of Victorian Anthropology." In *History, Humanity and Evolution: Essays for John C. Greene*, ed. James Richard Moore, 253-284. Cambridge: Cambridge University Press.
[65] Darwin, *The Descent of Man*, 328.

the vote, although obviously they failed to pass. The above-mentioned John Dewey wrote an article on women in education that began by posing some interesting considerations about statistical methods applied to the social sciences. *Science*, a periodical that had already garnered widespread attention in its few years of circulation, published an article by Dewey in 1885 questioning whether women's studying really caused the host of moral and health problems feared by critics on both sides of the Atlantic. To address this question, the Massachusetts labour bureau had collected data provided by the Association of College Alumnae in relation to twelve institutions that had produced 1,290 female graduates as of 1882. Of these, 705 had responded to a questionnaire designed to ascertain how intellectual labour and college life affected women's health. The collected data led Dewey to assert in the very first lines of the article:

> The general conclusion stated in the report is that the health of women engaged in the pursuit of a college education, does not suffer more than that of a corresponding number of other women in other occupations, or without occupations.[66]

This statement was followed by a presentation of his data analysis; it was only in closing that Dewey acknowledged that these data were unclear in some ways and that the matter required further investigation. By that point, however, the reader had already been guided in interpreting the data as arguing in favour of educated women, and perhaps Dewey managed to bring some readers, likely undecided individuals and hopefully many women, around to his position. Darwin is known to have had a profound influence on Dewey,[67] but evidently Dewey's choice to support women's education was dictated by his personal experiences and educational and social ideals, pragmatic and non-ideological; in other words, his political views. The same was true of a number of evolutionist scholars in that period who chose not to share Darwin's and Huxley's position on the woman question.

Some of the most interesting evolutionary scientists of the Liberal age, whether atheist and anticlerical such as the zoologist Michele Lessona (1823-1894) or Catholic such as the naturalist Paolo Lioy (1834-1911), wrote in support of women's education or collaborated with female colleagues. In some cases, such as the physicist Pietro Blaserna (1836-1918), men professionally supported some of the first female science graduates. Lessona and Lioy were not only evolutionists, they were actually the first to import Darwin into Italy, translating his books and describing them in glowing terms.[68] There is more to discover about this historical moment, but from my initial

[66] Dewey, John. 1885. Education and the Health of Women. In *Science*, 6, 141 (Oct. 16, 1885), 341 (pp. 341-342).
[67] Dewey, John. 1910. *The Influence of Darwin on Philosophy and Other Essays*. New York: Henry Holt.
[68] Pancaldi. Giuliano. 1991. *Darwin in Italy. Science across cultural frontiers*, rev. and exp. ed., Bloomington: Indiana University Press.

investigations I can already assert a few facts: despite Darwin's arguments, these evolutionists bet on women.

Physiologist Angelo Mosso (1846-1910) was one of the few Italian scientists of the time whose work enjoyed international visibility. Mosso was unquestionably materialist and positivist, and as early as 1887 he proposed that evolution be included in the school curriculum. He also penned some of the most beautiful writings of the period about women's freedom in relation to education and the professions. After a conference tour he held in the United States between 1900 and 1901, Mosso wrote that:

> The greater degree of freedom young ladies enjoy [in the United States] at first seemed to wound my old European sentiments, but afterwards, entering more deeply into the intimacy of family life, I changed my mind; now I am convinced that, without freedom, we cannot master ourselves, and I believe that we must grant absolute independence to woman, to curb and restrain all the impulses that seem to us most terrible.[69]

Mosso also noted that, while only twenty-five years earlier

> woman's opponents proclaimed that letting them teach would lower the standards [...] of teaching; [...] now everything has changed. What was forecasted did not come to pass; and the professors want women on school benches and in universities.[70]

Of course, matters were not as rosy for American women as they appeared to Mosso's European eye.[71] Nevertheless, his writings on women – only briefly mentioned here – deserve to be considered alongside those of other positivist scientists, Italian and non, and explored in future research. Just as recovering the stories of women in science previously censored by history has proved an essential step in understanding science, its history and institutions, I believe it is equally important that we uncover the voices of male scientists who cast their lot on the side of women. Telling the stories of men who supported women might hopefully contribute to curbing backlash, helping to smooth tensions with scientists both male and female who even now, for different reasons, prefer to ignore or deny the problem of gender discrimination. These stories help us to understand more about the role cultural and political values play in the processes of constructing or

---

[69] "La maggior libertà che hanno le signorine [negli Stati Uniti] da principio urtava un po' i miei sentimenti di vecchio europeo, ma dopo, entrando più addentro nelle intimità della vita famigliare, cambiai di parere; ora sono convinto che senza la libertà non esiste la padronanza di noi stessi, e credo che si debba concedere una indipendenza assoluta alla donna, per frenare e moderare tutti gli impulsi che a noi sembrano più temibili". Angelo Mosso. 1903. *Mens sana in corpore sano*, 325-326. Milano: Treves.

[70] "Gli oppositori della donna gridavano che mettendola ad insegnare si doveva abbassare lo *standard* […] dell'insegnamento; […] ora tutto è cambiato. Le previsioni non si verificarono; ed i maestri desiderano che sui banchi della scuola e nelle università vi siano delle donne". Mosso, *Mens sana in corpore sano*, 333.

[71] Rossiter, *Women Scientists in America: Struggles and Strategies to 1940*.

appropriating scientific facts. As for the scientific fact of "woman's inferiority", these historical cases are useful for highlighting the role that choosing – or guessing, in Feynman's words – plays at a certain point in dealing with experimental or mathematical data, because this choice takes on important educational value in the defence of science. This act of choosing shifts responsibility for the idea of "women's inferiority" from scientists as a professional group and science in general to individual scientists and society in general. In my opinion, reasoning about the contemporary situation on the basis of historical cases such as these can also contribute to supporting women in mathematics who, as the data show, have certainly been discriminated against in the past and still face discrimination today. This discrimination comprises a multiplicity factors that are social, cultural and anthropological but also economic, with different social actors competing for the same professional territory. Several mathematicians of the past, such as Klein – discussed by Renate Tobies in this volume – wagered on female mathematicians. Over a century later, what challenges do these women face?

5 Back to the Present and the Strange Case of Women in Maths in Italy

In general, in Italy as in many other European countries, girls decide more often than boys to continue their studies after high school: in 2015, 55.6% of newly-graduated girls enrolled in university as compared to 45.0% of boys.[72] Regarding enrolment in science in general, including mathematics, the overall situation seems to have improved over time: in 2000-2001, women made up 14.2% of those enrolled, in 2007-2008 they amounted to 17.4%[73] and now (2015-16 data) they comprise 37.6%.[74] If we break down the data, however, the enrolment numbers for computer science courses are worrying. In 2003-2004, Italian graduates in Informatics science and Technologies programs (in science departments) numbered 506 women and 1,837 men; graduates in Information engineering programs (in engineering departments) comprised 1,214 women and 5,838 men. In 2015-2016, 25 women and 174 men graduated in Informatics Science and Technologies, while 334 men and 79 women earned degrees in Information engineering.[75]

Data on math graduates also attest to a generalized and serious disinterest among young people in relation to both mathematics and computer science, which is a problem not only for research and innovation but also for schools in Italy that will be likely facing a shortage of math

[72] Statistical report. 2016. Focus. Gli immatricolati nell'a.a. 2015/2016 il passaggio dalla scuola all'università dei diplomati nel 2015, 6, http://statistica.miur.it/data/notiziario_2_2016.pdf
[73] Miur data regarding students enrolled in university during the 2007-2008 academic year, http://statistica.miur.it/Data/uic2008/Gli_Studenti.pdf
[74] Focus. Gli immatricolati nell'a.a. 2015/2016 il passaggio dalla scuola all'università dei diplomati nel 2015 http://statistica.miur.it/data/notiziario_2_2016.pdf data on p. 5 and p. 11.
[75] Ministero dell'Università e della Ricerca - Ufficio di Statistica. Processing of data from the Anagrafe Nazionale degli Studenti Universitari, published at http://anagrafe.miur.it/laureati/cerca.php (data updated as of July 4, 2017).

teachers. At the same time, however, the data regarding math graduates for the last twenty years or so Italy are debateable (Table 1).

Table 1. Maths graduates in Italy by sex, 1999-2016. Data kindly provided by DGICASIS, Ufficio Statistica e Studi, Ministero dell'Istruzione, dell'Università e della Ricerca (Statistics Division, Italian Ministry of Education, Universities, and Research).

Year	First degree				Master degree			
	W	M	W+M	%F	W	M	W+M	%W
1999	1.237	455	1.692	73%				
2000	1.054	398	1.452	73%				
2001	1.087	416	1.503	72%				
2002	1.056	414	1.470	72%				
2003	1.092	405	1.497	73%				
2004	1.089	507	1.596	68%	6	3	9	67%
2005	948	490	1.438	66%	41	20	61	67%
2006	880	479	1.359	65%	158	97	255	62%
2007	672	411	1.083	62%	235	140	375	63%
2008	633	403	1.036	61%	308	217	525	59%
2009	695	470	1.165	60%	374	229	603	62%
2010	801	584	1.385	58%	335	243	578	58%
2011	801	657	1.458	55%	480	295	775	62%
2012	813	612	1.425	57%	501	363	864	58%
2013	844	625	1.469	57%	588	402	990	59%
2014	846	695	1.541	55%	528	429	957	55%
2015	771	630	1.401	55%	554	415	969	57%
2016	708	636	1.344	53%	603	444	1.047	58%

Unlike engineering, physics and computer science, female graduates outnumber their male peers in mathematics as well as medicine, the humanities and the social sciences (including law). The data I received from the Ministry of Education, Universities and Research (table 1) show that, at the end of the 1990s, women actually made up 73% of graduates in maths. There has been a significant decline in women's interest in maths in the last few years, while men display increasing interest in this field: considering the role math with its algorithms plays in today's digital world, it is not difficult imagine a future in which women in Italy will follow the trend set by women in the computer science in United States in the 1980s, increasingly distancing themselves from maths.

Anyway, the current data show that women in Italian universities not only make up the most high-performing graduates in maths, but even among young people who decide to continue with their education in maths, women are in an interesting situation: 58% of graduates at the master's level are women. This finding should be interpreted within a broader context in which women are more interested in men in seeking education at all levels: the 2015 data confirm that women in Italy constitute 53% of all PhDs, with 63% female graduates in the life sciences, 41% in the basic

sciences (a field that includes graduates in mathematics) and, finally, 37% female graduates in engineering.[76] Let us examine the situation facing women who continue with their research after obtaining a PhD to pursue an academic career in mathematics.

Despite the decades-long trend of female graduates being more numerous and obtaining higher scores than male graduates, in Italian universities there are only 336 women as compared to 432 men working as assistant professors in mathematics. At the level of associate professor, the situation worsens dramatically: 389 women as compared to 720 men. At the top of the career ladder the disparity reaches surreal proportions: men in the position of full professors of mathematics number 654 while women number only 373.[77] Given the medium and long-term data on graduates, waiting for a generational changeover does not appear to represent a solution, neither for women in math nor for women in the humanities. In the humanities macro sector (so-called macro sector 11 - History, philosophy, pedagogy and psychology) which popular opinion considers a field in which women have less trouble pursuing a career than in other fields, the situation is as follows: among assistant professors there are 591 women and 509 men; among associate professor there are 790 women and 900 men; among humanities full professor there are currently 373 female full professors while their male colleagues number 652.[78] In Italy women make up 36% of full professors in the humanities: a shocking figure, given that today (2016 data) women make up 77% of overall humanities graduates and 63% of humanities PhDs.[79] Indeed, we must not forget that female graduates in the humanities were more numerous than male graduates long before the Second World War.[80]

Let us return to female researchers and professors in mathematics as compared with those in the humanities, conducting a search by year of birth. In Italian humanities departments (macro sector 11 - History, philosophy, pedagogy and psychology), there are 36 female full professors who were born in 1950 as compared to 64 male ones; female full professors who were born in 1960 number 10, while male ones number 21; there are no female full professors born in 1970, but there are two male ones. In mathematics and computer science (macro sector 01 - Mathematics and

[76] Almalaurea. *Indagine Almalaurea 2015 sui dottori di ricerca. Tra performance di studio e mercato del lavoro* https://www.almalaurea.it/sites/almalaurea.it/files/docs/info/cs_almalaurea_dottoridiricerca-ottobre-2015-def.pdf
[77] Source: Miur database at http://cercauniversita.cineca.it/php5/docenti/cerca.php search in the "Macrosector 0/1A – Mathermatics" (search conducted November 14, 2017).
[78] Source: Miur database at http://cercauniversita.cineca.it/php5/docenti/cerca.php search in the "Macrosector 11 – History, philosophy, pedagogy and psychology" (search conducted November 14, 2017).
[79] Miur, Ufficio Statistico. 2016. *Focus. Le carriere femminili nel settore universitario*, see at http://statistica.miur.it/Data/notiziario_1_2016.pdf
[80] In terms of enrollment, the phenomenon of women overtaking men was already evident in the 1920s: in the academic year 1921-1922, men enrolled in programs to graduate in literature and philosophy numbered 1,547 as compared to 1,300 women, the following academic year there were 1,387women enrolled in the same courses as compared to 1,257 men. Presidenza del Consiglio dei Ministri, Istituto Centrale di Statistica. 1926. *Annuario Statistico Italiano*, second series, v. IX, years 1922-1925, , 97-99. Rome: Stabilimento Poligrafico per l'Amministrazione dello Stato.

Informatics), 24 of the full professors born in 1950 are men and 10 women; of the full professors born in 1960, 45 are men and six are women; of those born in 1970, six are men and one is a woman.[81] These disturbing figures speak for themselves.

Judging from the overall data on the numbers of women working as researchers and teachers at Italian universities, I think we can conclude that the situation in Italian universities became significantly worse for women from one academic generation – the post war generation – to the next. This phenomenon is particularly evident if we focus on the generation of female scholars born between the 1960s and 1970s, women who spent the course of their professional careers in universities in which, in the 1990s, women outnumbered men among both undergraduates and PhDs. After a significant increase in female researchers and professors between the 1970s and 1980s, there was a marked deceleration that succeeded in curbing the push from below.[82] In Italy, 2016 marked the 25th anniversary since the year female graduates outnumbered male graduates. In view of this as well as the fact that female PhDs also outnumbered men, I would argue that the present situation represents a second backlash against female scholars in Italy. This current backlash is even more apparent than the one mentioned earlier which occurred – in Italy as in other countries – in the period between the wars, in response to women's achievements in the 19th and beginning of the 20th centuries.

The shocking data on women in both maths and humanities in Italy testify to the enduring nature of an incredibly complex phenomena that can only be addressed by simultaneously employing multiple tools. Indeed, the problem undoubtedly concerns men and their old boys' network, but it also has to do with institutions, which have proven themselves unable to understand the economic costs of discrimination and hence been much slower than broader society to understand and denounce instances of discrimination. Yet, the problem also concerns girls and women themselves. In Italy, these phenomena are often downplayed by the very women they affect in that the female professionals are concerned that they might end up being marginalized to an even greater extent. Furthermore, women who have reached the peaks of their careers over the past few decades have a substantial share of responsibility for this state of affairs: having arrived at the top, it is quite rare for female professors in Italy to denounce this situation with the degree of frankness this grave situation requires, as women have done for example in the United States.[83] What is

[81] Source: Miur database at http://statistica.miur.it/scripts/PersonaleDiRuolo/vdocenti1.asp (search conducted November 14, 2017).
[82] ISTAT. 2001. *Donne all'Università*, Bologna: il Mulino; Women and Men in Scientific Careers: New Scenarios, Old Asymmetries, Special issue. In *Polis. Ricerche e studi su società e politica in Italia*, 1, 2017. For a contextualising and long durée approach, see Govoni, Challanging the Backslash.
[83] See for example some outstanding presentations made as part of the Symposia Leaders in Science and Engineering: The Women of MIT (March 28, 2011 - Tuesday, March 29, 2011) and in particular Nancy H. Hopkins, Keynote: The Status of Women in Science and Engineering at MIT, at http://mit150.mit.edu/symposia/leaders-science-

needed is a new pragmatic alliance among women, among women and men in science, as well as between women and other discriminated minorities. As I have mentioned, this kind of alliance emerged at the dawn of feminism and as early as the end of the 18th century in battles against slavery. The alliance between different social actors then continued in the Victorian and Liberal ages and came to involve a number of evolutionist scientists who made up their own minds about the "woman question" rather than embracing the position supported by official evolutionist thinking. In view of new migratory flows, I believe that longstanding alliance – formalized in the 1980s as intersectional feminism – is needed even more urgently than ever.

6 Attracting Boys and Girls to Maths and Science as Social Culture

Unlike Dewey, we have access to abundant, comparative and long-term data about the cultural, social and psychological aspects of the mathematics performance gap between girls and boys. And there is more. At this point we finally have access to the findings of integrated scientific research on genetics, human biology, culture and society. For example, studies which, bringing gender into genetics and biomedical research, investigate how the brains and behaviour of gender-diverse individuals react and respond when experiencing sex-specific health conditions, medical treatments or social practices are absolutely innovative.[84] Scientists are exploring how our genes, hormones and phenotypes change when interacting with our education, economic income, stress and much more: I like to think that these scientific findings that definitively overcome both scientism and radical constructivism have come about thanks in part to decades of laborious dialogue between scientists, social scientists and humanity scholars. And the fruits of that dialogue can be found in all areas of research. We have been asking how science and society interact at least since the era of scientists such as Ludwik Fleck (1896-1961) and sociologists such as Robert K. Merton (1901-2003), often in ways which were confused, but nonetheless effective in terms of opening up new paths of inquiry. Almost a century after that embarrassing question was first posed, all fields – science and science studies alike – are displaying considerable interest. At the end of the Human Genome Project, Steve Jones, the well-known geneticist referenced above, admitted that humans' health depends more on our postal code than our genes. In so doing, he offered us a view – couched in a joke – of the fact that, biologically speaking, we are a social and cultural species. Provocatively, Jones applies this integrated approach to the study of man, in the sense of the male

engineering.html . In relation to this point, see P. G. Abir-Am, Women Scientists of the 1970s: An Ego-Histoire of a Lost Generation. In *Writing about Lives in Science*, eds. Govoni and Franceschi, 223-259.

[84] This research has been carried out at the Cognitive Neuroscience, Gender and Health Laboratory coordinated by Gillian Einstein. For a discussion of these issues, see Einstein, Gillian (ed). 2007. *Sex and Brain: A Reader*. Cambridge: MIT Press. Besides see the recently launched (March 2017) journal *Gender and the Genome* edited by Marianne J. Legato.

of the species, studying men as woman were studied in the past but doing so by integrating genetics with anthropology, history, pop culture and more.[85] This focus is very similar to that of the historians and sociologists of science who investigate the overlapping of content and context in the making of science.[86]

Recalling these general interpretative questions helps us to admit that the elements at stake when interpreting data on men's and women's brains as well as data on the controversial relationship between girls and maths and women and science include, at least to some extent, a political choice similar to that once made by Dewey, Mosso and other evolutionist scientists who wagered on women. Lawrence Summers, the Harvard Principal mentioned at the beginning of this chapter who declared in 2005 in an educational context that woman have so much trouble reaching top positions in mathematics due to "issues of intrinsic aptitude" likewise made a choice.[87] All of us make political choices in dealing with data. These kinds of choices have conditioned several thousand years of natural and sociological research on women, not to mention race and other subjects. Exploring topics such as this in a class with boys and girls, topics that touch on the present but have also been investigated in a historical perspective, requires a great deal of effort, considerable modesty and a substantial pinch of courage. In my opinion, however, it has the potential to bring about an essential shift, that is, attracting more young people to science. It can also reveal the controversial reality of science, not its heroic or heroic myth; a reality which might be attractive to young people: this reality is made up of cognitive, mathematical, experimental and speculative challenges (leading to extraordinary achievements as well as blind alleys), not to mention political and personal challenges. From climate change to energy production for a human race numbering 7.5 billion individuals, humanity must face challenges that can only be overcome using science and technology guided by pragmatic and challenging politics, and vice versa. To succeed, in my opinion, we will need to train K-12 and university students, especially future scientists and mathematicians, both men and women, to be aware that science and its facts are thoroughly permeated by social, cultural, and political issues: since at least the invention of fire we have been immersed in contexts that, in varying proportions and ways, are simultaneously natural, technological, cultural and social. And now science has shown us that our social and cultural network influences our nature as well. I believe the challenge lies in maintaining an open dialogue

[85] Jones, Steve. 2002. *Y: The Descent of Man*. London: Little, Brown.
[86] Latour, Bruno. 1987. *Science in action. How to follow scientists and engineers through society*. Milton Keynes: Open University Press; Id. 1999. *Pandora's hope: Essays on the reality of science studies.* Cambridge, Massachusetts: Harvard University Press. For Latour's definitive declaration of peace in relation to scientists, see de Vrieze, Jop. 2017. Bruno Latour, a veteran of the 'science wars,' has a new mission. In *Science*, October 10. doi:10.1126/science.aaq1805
[87] Summers, *Remarks at NBER Conference*, at the address http://www.harvard.edu/president/speeches/summers_2005/nber.php

among experts - scientists, humanists and social scientists - and young people as well as the general public, discussing and debating both the potentialities and dangers of the effects of these interactions, whether we call them epigenetics or actor-network theory. In the process in which the "world […] writes on [our] body",[88] sex, gender and society, including technology, matter a great deal in that they change the context and circumstances. These issues lend themselves so easily to ideological positioning (scientist as much as social constructivist), but freely discussing them is the only way I see young people being able to decide how to bet with greater clarity, following in Dewey's pragmatic (and utopian) footsteps.

The public sphere typically presents a different image of science and mathematics than the culture Feynman describes in his writings. A scientific process calls for the kind of independent approach displayed by scholars such as Dewey and Mosso who, while enthusiastically supporting natural selection, read Darwin's hearsay about women and said, "no". The image of science and mathematics as special cultures characterized by certainty tends to drive away individuals who have historically been required to prove themselves, not only women but also social minorities. The report presenting the latest PISA assessment (data issued December 6, 2016) implicitly offers an ambiguous definition of science:

> In the context of massive information flows and rapid change, everyone now needs to be able to "think like a scientist": to be able to weigh evidence and come to a conclusion.[89]

Defining science as the ability "to weigh evidence and come to a conclusion" is the result of a consolidated and longstanding tradition, something I can certainly support. Yet, a historian's work is based on the same ability to weigh evidence in order to come to a conclusion. And I suppose the same is true for a plumber or an art historian, a literary critic or a lawyer. One of the problems that arises when we talk about the troubled relationship between young people and maths, and especially girls and maths, is the idea that science and maths represent special – *different* – cultures, the only cultures that involve weighing evidence to come to a conclusion: the tragically famous "scientific method". The image of a science practiced by *different* people who work in labs sealed off from personal, social, economic and cultural issues, not to mention gender and race, tends to drive away girls, as they fall victim of the so-called Marie Curie complex, but it drives away boys as well. As I have shown, in Italy there are too few graduates in maths and computer science for a world in

[88] Einstein, Gillian. 2012. Situated Neuroscience: Elucidating a Biology of Diversity. In Neurofeminism: Issues at the Intersection of Feminist Theory and Cognitive Science, eds. Bluhm, R., Maibom, H., and Jacobson, A.J. New York: Palgrave McMillan, 145–174. New York: Palgrave McMillan.
[89] OECD, *PISA 2015 Results Excellence and Equity in Education*, volume I (data published on December 6, 2016), quote on p. 3.

which everything from finance to romance travels through digital channels or social networks. Investigating the social dimension of science facts, instead, would reveal a fascinating side of science that might attract more young people, both men and women.

6 Some concluding remarks: Women, from hearsay to obstacles in the labour market

There is of course more than one explanation for the difficulties girls and women encounter in mathematics and science: this phenomenon is among the most complex we face and, as evidenced by the ample body of medium and long-term data, entails psychological, institutional and social factors.[90] It has been established that, if we look at girls who equal or even exceed boys in maths according to PISA data, it is clear that this situation is found in countries where, judging from World Economic Forum data, significant strides have been made in terms of achieving equal opportunity. However, as I have mentioned, matters are complicated all over the world. I began this chapter wondering if the data allow us to say that, in contexts in which girls' maths performance equals that of boys, women in mathematics have the same chances as their male colleagues of reaching the top of the university career ladder. The answer, at least judging by the Norwegian case described in another chapter of this book, appears to be no: girls in Norway do not have problems in maths, but women who go on to pursue careers as mathematicians at universities do. It seems obvious, as these cases prove, that the issue is sociocultural and not one of girls' or women's "intrinsic aptitude". And yet, many still believe in the latter explanation even today, and it is periodically re-presented in the public sphere by some authoritative name or other.

This position was championed by the controversial scientist James D. Watson (1928-), the 1953 co-discoverer of the structure of DNA along with Francis Crick (1916-2004), Rosalind Franklin (1920-1958) and Maurice Wilkins (1916-2004). Watson is known for his racist and sexist comments, and in a 2007 book he also had his say about the episode mentioned earlier which led to Summers to step down as Principal at Harvard University. In the book, Watson argues that Summers' comment about women in science ended up all over the international media, forcing him to resign, because of MIT molecular biologist Nancy Hopkins (1943-); indeed, Watson tries to keep Hopkins 'in her plac' by defining her as "my former student".[91] In describing how Hopkins fled from the lecture hall sickened by Summers' remarks, Watson asserts that:

[90] OECD. 2014. *PISA 2012: Results in Focus What 15-year-olds know and what they can do with what they know*, 23 http://www.oecd.org/pisa/keyfindings/pisa-2012-results-overview.pdf

[91] Watson, James D. 2007. *Avoid boring people: Lessons from a life in science*, 317. Oxford: Oxford University Press (italics added).

It did Nancy Hopkins no particular credit as a scientist to admit that the mere hypothesis that there might be genetic differences between male and female brains – and therefore differences in the distribution of one form of cognitive potential – made her sick. Anyone sincerely interested in understanding the imbalance in the representation of men and women in science must reasonably be prepared at least to consider the extent to which nature may figure, even with clear evidence that nurture in strongly implicated. To my regret, Summers, instead of standing firm, within a week apologized publicly three times for being candid about what might well be a *fact of evolution* that academia will have to live with.[92]

This passage is definitely interesting, especially for scholars who deal with popularizer scientists and the relationships between science and society. The phrase confirms Watson's infamous arrogance, but in my opinion what deserves to be highlighted is how roughly scientist and out of time the arguments the geneticist posits as scientific actually are. He is clearly making an autoreferential appeal to genetics which are by now more than half-a-century old: nonetheless, book is from 2007 and the Human Genome Project concluded in 2000, disappointing all those betting on its locating the gene of all genes, naturally one that would also code for differences between women and men. Above all, however, citing a supposed "fact of evolution" that supposedly explains why women end up blocked at a certain point in their careers is, of course, pure fantasy. A classic example of hearsay. This is exactly the kind of disastrous pit – both communicative and educational, not to mention scientific – that has pulled in hundreds of scientists, convinced as they were that scientist argumentation is the one capable of supporting and defending science. It is clear that this kind of approach usually produces the opposite effect in the medium and long term, especially among young people and women. This statement is not only the fruit of a centuries-old academic misogyny of which Watson represents one of the most authoritative spokesmen (it is known that he himself recounted his controversial relationship with Rosalind Franklin). Above all, it is the terrible habit of arguing through hearsay disguised as science and used to defend political beliefs. Many people – much less women and minorities – would balk at entering a profession whose prospects involve a perennial war with people of this sort.[93]

What is worse than the use of such hearsay is the fact that it circulates in the public sphere for decades, centuries or millennia: "Aristotle said ... a Nobel Prize winner said it … so it must be true". This is how hearsay – repeated dozens, hundreds, thousands of times – becomes scientific fact, fact deserving of being included in the writings of a scientist as extraordinary as Darwin.

[92] Watson, *Avoid Boring People*, 318.
[93] Keller, Evelyn Fox. 1977. The Anomaly of a Woman in Physics. In *Working it Out Working It Out: 23 Women Writers, Artists, Scientists, and Scholars Talk About Their Lives and Work*, ed. by Sara Ruddick and Pamela Daniels, 71-9. New York: Pantheon.

Perhaps the science that might be capable of attracting young people is the science of those who assert that:

> I can live with doubt and uncertainty and not knowing. I think it is much more interesting to live not knowing than to have answers that might be wrong. If we will only allow that, as we progress, we remain unsure, we will leave opportunities for alternatives. We will not become enthusiastic for the fact, the knowledge, the absolute truth of the day, but remain always uncertain … In order to make progress, one must leave the door to the unknown ajar.[94]

Naturally enough, these are the words of the perennially-useful Feynman. If we share this image of science, we admit that there will never be one single element – be it genetic or cultural – that explains girls' difficulties in math once and for all. Instead, we have many studies, including long-term ones, that provide quantitative data on educational, psychological and economic contexts. We also have data from cutting-edge research in genetics and biomedicine. These integrated data confirm that the problem of girls and maths and women in science must be tackled in the educational setting, alongside, obviously, familial, institutional and social spheres: because it is there, not in some fanciful fact of evolution, that the problem arises and is reproduced.

As mentioned above, my argument is that, in order to address the problems discussed in this book with any success, we will need a gender-aware educational system that is much more open to the inclusion of other forms of ethnic, cultural and social diversity than it is now. However, such an inclusive education will only be effective if we are able to strengthen the image of science as social culture, highlighting the contradictions inherent in the (political) positions taken by scientists, even one as great as Charles Darwin: and it is worth recalling that Darwin, in contrast to Watson, was also great on a human level.[95] Understanding the political nature of science facts, such as the fact of the "inferiority of woman", will help us overcome ideological barriers, both scientistic and constructivist. In my opinion, this change can only come from the bottom up, through the education of the younger generations, a mission scientists and mathematicians should commit to more often: although there remains a great deal to do all over the world, programs on science, technology and society (STS) have been particularly useful in this sense. In educational contexts of this kind, such as the STS program at MIT hosting scientists and social reformers like Nancy Hopkins, it is very effective to narrate lives, combining the lives and work of women in science with the role models provided by capable professors. There are many women who have contributed to science and

[94] Richard P. Feynman, The pleasure of finding things out, 1981-1982, interview for the BBC available at http://www.bbc.co.uk/programmes/p018dvyg/clips

[95] Desmond, Adrian and James Moore. 1992. *Darwin*. New York: Warner; Browne, Janet. 1995-2000. *Charles Darwin. A biography*, 2 volumes. New York: Knopf.

mathematics, and indeed – as the project that gave rise to this volume illustrates – historical accounts from recent decades have granted visibility to hundreds of them. It is certainly important to make their voices heard through articles, books and media and especially digital media, as this is our best tool for reaching boys and girls. At any rate, the subject is delicate, as there is always someone who takes advantage, just as in the past with "heroes of science" narratives, and uses these stories to feed the heroine, martyr and "first woman who…" rhetoric. Too much of the amateur feminist historiography flooding the internet in every language shares this weakness. Myths and rhetoric are harmful to science and, in my opinion, contribute to driving young people (and girls in particular) away: they produce the more or less conscious conviction that women or girls must be exceptionally gifted and prepared for heroism before they can dedicate themselves to science or mathematics. For boys, it is different not only because men have been depicted in a heroic guise from Ulysses to present-day super-heroes and characters such as Sheldon Cooper. We know all too well that in some countries more than others, it is common to encounter mediocre male scientists and mathematicians in university corridors who have reached the peak of their careers mainly thanks to their academic genealogies. Of course this is also the case of some female mathematicians and scientists, but it is definitely less common. When the individuals are women, however, the phenomenon is *perceived* in a different way because so much has been said about these women. The data instead show that what most frequently occurs– in Europe, but also in the United States with its Equal Opportunity Act and affirmative action – is that many brilliant women do not even attempt to reach top career positions.

In 2011, the *Proceedings of the National Academy of Sciences of the United States of America* (*PNAS*) published the results of a study and *Nature* immediately wrote in support of the study's conclusions.[96] With the quantitative data at hand, according to *PNAS*, the difficulties women encounter when undertaking a science career, especially in the technological and math sectors, can no longer be explained in terms of discrimination in the process of selecting papers for publication, funding or professional assignments. The study instead posited that the factors behind these inequalities were concealed in an "invisible web" deriving from the social and familial organization that structures the daily lives of female scientists. This network of personal and institutional forces leads women, especially mothers – sometimes unintentionally, sometimes deliberately – to invest more time and energy in their families than their male colleagues do, a choice which obviously has repercussions in the professional sphere. In contexts like the United States in which institutional choices are largely guided by merit and competitiveness and so-called

[96] Ceci Stephen J. and Wendy M. Williams. 2011. Understanding current causes of women's underrepresentation in science. In *PNAS*, vol. 108 no. 8: 3157–3162, doi: 10.1073/pnas.1014871108. Dickey Zakaib, Gwyneth. 2011. Science gender gap probed. In *Nature* 470, 153, Published online February 7, doi:10.1038/470153a.

positive action has been in place since the 1980s, men and women begin equally and keep pace with each other during the first phases of their careers. In time, however, women's careers begin to slow down, not because of prejudice and discrimination from inside the community (the classic glass ceiling), says PNAS, but because of this "invisible web" that female scientists apparently actively reproduce, however reluctantly or unintentionally. Communicated in a simplified manner by magazines such as *Nature* – and let us remember that "*Nature* said so, so it must be true…" – the conclusions of the PNAS research have become new scuttlebutt: women in science and mathematics do not struggle because of "issues of intrinsic aptitude" (Summers) or a "fact of evolution" (Watson), and neither because of an inflexible community or institutions that tend to reward members of the old boys' network. Women's difficulties are social and psychological as well, and therefore we must help them: suffice to cite the many so-called empowerment's projects in STEM launched in Europe. However, is it really women – who even in countries like Italy already outnumbered men as undergraduates and PhDs more than 25 years ago – who need help? Or should we instead focus on helping those who discriminate against them? At this point, I suspect that to support equal opportunities in science and maths – as in any other research area – we have to work much more on boys and men than on girls and women. Instead, contemporary measures designed to tackle this issue focus on women, such as the European Union's move to include "gender" in all its calls for funding, thereby draining or even completely undermining its significance and reducing everything to politically correct rhetoric, a situation that might potentially fuel the backlash. If we were to broaden our vision to move beyond gender, it might prove in many ways, including a better understanding of the data on the relationship between girls and maths, data which cannot be fully understood using only the category of gender. It is possible that the conclusions of the PNAS study hold true in some countries, but they certainly do not describe the countless national contexts addressed in this volume. For example, the Italian data confirm that there is a real glass ceiling in both mathematics and the humanities, a ceiling that is growing denser rather than more permeable. The more competition there is over resources, the more women are marginalized. You do not need to be a mathematician, I think, to grasp that this situation is very bad for universities and research in general, and not only for women. Matters will not change until everyone, men and women alike, take up data such as those outlined in this book and really think about what they mean.

Studies like those published in PNAS do, however, have the advantage of widening the scope of the discussion to address an often-neglected area: that of teaching young people about equal opportunities and equal obligations. As I have argued, we must broaden the policies of inclusion in new contexts characterised by migration and digital communication, integrating gender

and race more decisively. If not, I believe there is a risk that women will lose out as they have always lost out throughout history, as the above-mentioned last fifty years of women's history as (non)participants in computer science shows. In fact, all of this occurs within a more generally alarming context: after their first stage of professional activity in science and mathematics, young people, both men and women, struggle very hard to secure stable positions. Professional conditions are becoming increasingly precarious everywhere, as *Nature* and *Science* frequently report.[97] The data about female mathematicians' careers in Italian universities reflect these conditions, showing discrimination and competition over the generally scarce resources allocated to research. To avoid these kinds of situations, every university might consider setting up an efficient system of watch dogs (on rotation) to defend not only women but also the quality of research carried out by women, men, foreigners or others. The evaluation system in Italy, which increasingly relies more on algorithms than peer review, feeds deep neuroses on the part of both individuals and institutions. In the quantitative "publish or perish" atmosphere that threatens the quality of research everywhere, conditions are so competitive that they nearly qualify as psychological violence. In these circumstances, the result of a mix of institutional, social and personal tensions, women are often the first to give up, and not only women with families. To address these issues and support girls in science and mathematics, I believe it is crucial that we bring students into contact with contemporary women who enjoy satisfying careers in both universities and the private sector while maintaining "normal" personal lives. Women who, like many men, can provide positive role models for all young people, not just girls. That is the gender, class and race-free science behind the old dream of so many scientists and scholars, such as Robert K. Merton and Evelyn Fox Keller, a dream that is controversial and inspirational at the same time. We need a science capable of pursuing an ideal that many scientists, from Galileo[98] to Feynman and beyond, proclaimed but only very rarely practiced: the ideal according to which the only thing that matters in science are the results we achieve face to face with nature and experimental data. Scientists such as Feynman and many others know that this is simultaneously impossible and possible: a quantum phenomenon, perhaps. In the age of technoscience, we know all too well this is only an ideal to aim for. And yet, since Galileo's time it has been political ideas that helped shape the most interesting science facts humanity has developed, including, obviously, evolution itself.

[97] For the most recent editorial dedicated to this issue in *Nature*, see Many junior scientists need to take a hard look at their job prospects. In *Nature* 550, 429 (October 26, 2017) doi:10.1038/550429a

[98] Biagioli, Mario. 1993. *Galileo, courtier. The practice of science in the culture of absolutism*. Chicago, The University of Chicago Press; Heilbron, John. 2012. *Galileo.* Oxford: Oxford University Press.