GENDER

Jenna Tonn – *Boston College*

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Despite recent gains in the numbers of women in Science, Technology, Engineering, and Mathematics (STEM) fields, pressing concerns about gender in the modern sciences remain. These concerns are intertwined with the role gender has historically played in the practice of science. Research in this field takes up two broad and overlapping sets of questions. First, historians have explored *who* scientists were (often referred to as the "women in science" problem). Second, historians have examined how gender as a system of ideas, ideologies, and practices has informed the culture and content of science. Scholarship in gender studies of science comes from a variety of disciplines, including women and gender history, the history of science, technology, and medicine, science and technology studies, feminist studies, and the philosophy of science. The earliest literature sought to recover women from the historical record as scientific practitioners and to make their intellectual contributions visible to modern readers. More recent scholarship revisits these questions with attention to how scientific practitioners have been marked by gender as well as by race, class, sexuality, and disability. Similarly, foundational inquiries into how traditional gender stereotypes structure research frameworks are being revised to include more robust analyses of how intersectional forms of difference influence knowledge production. As in many historical fields, gender is understood as impossible to separate from other analytical frames; nevertheless, attending to histories of gender in science reveals how gender has framed not just participation in science, but the construction of the field itself.

WOMEN IN SCIENCE

Pioneering work in the field of gender studies of science focused on reconstructing histories of women working in scientific communities. Writing about women's contributions to science dates back to Christine de Pizan's work in the fifteenth-century, early modern encyclopedias of women's accomplishments, and late nineteenth- and early twentieth-century histories of barriers to women's participation in science.[1] Scholarly attention to women and gender in science developed in the twentieth century as more women started entering into the academic professions. Sparked by the women's movement in the 1960s and 1970s, the

[1] Schiebinger 1989.

growing field of women's history in the 1970s and 1980s, and the establishment of feminist studies programs in the 1980s and 1990s, historians of science including Margaret Rossiter, Marilyn Bailey Ogilvie, and Londa Schiebinger argued that women practitioners were present and active in science almost everywhere you looked.[2]

Scientific publications rarely acknowledged women's contributions, but archival records documented the presence of women in poorly remunerated, low-skilled positions in male-dominated fields or clustered in feminized subfields such as botany, public health, and home economics.[3] While we often think of science as conducted in public institutions such as laboratories and museums, historians have shown how domestic spaces like the family home and the private laboratory played significant roles in sustaining scientific cultures. Within the household, women had an opportunity to advance their intellectual interests in science and a domestic responsibility to work as highly competent—if rarely acknowledged—managers and collaborators for their husbands, fathers, and brothers.[4]

Tracing women's contributions to science has taken various forms. Some historians of science have generated lively biographical accounts of women in science, including Ada Lovelace, Marie Curie, Rosalind Franklin, and Barbara McClintock. Understanding how "women worthies" navigated scientific communities at different historical moments reveals women with uncommon minds and at times enviable connections and resources.[5] More recently, others have turned to the social history of scientific practice, which reveals women's often-unacknowledged labor. Women worked as technicians, museum assistants, artists and illustrators, educators, managers, fieldworkers, patent clerks, and agricultural experimenters (among other roles).[6] This research underscores science as an enterprise that has engaged a wider variety of practitioners than we once imagined.

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[2] Rossiter 1974; Keller 1977; Kohlstedt 1978; Rossiter 1982; Ogilvie 1986; Schiebinger 1989. See also: Keller 1995; Kohlstedt 1995.

[3] Rossiter 1982. See also: Rossiter 1995 and Rossiter 2012.

[4] Van Tiggelen, Bergwick, and Opitz 2016; Lykknes, Opitz, and van Tiggelen 2012; Harkness 1997; Chadarevian 1996; Abir-Am and Outram 1987.

[5] Wirtén 2015; Maddox 2002; Winter 1998; Davis 1995; Keller 1983; Sayre 1975.

[6] Swanson 2017; Muka 2016; Sleeper-Smith 2015; Kohlstedt 2013; Madsen-Brooks 2013; Opitz 2013; Kohlstedt 2010; Parish 2006, Ch. 5; Richmond 2006; Tolley 2003; Gates 1998; Bix 1997; Gould 1997; Richmond 1997; Shteir 1996; Pang 1996. See also: Shteir and Lightman 2006; Kohlstedt and Longino 1997; Laslett et. al. 1996.

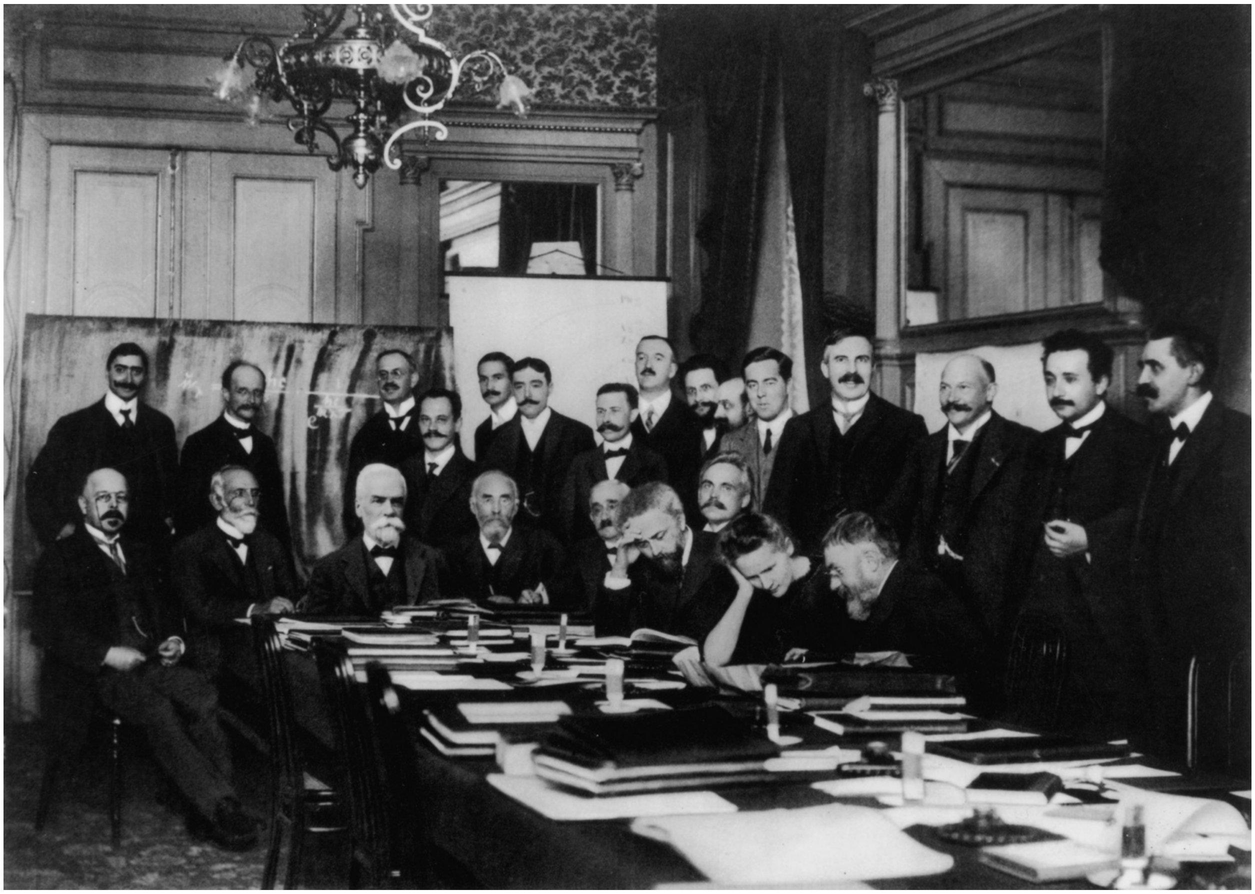

Image 1: Marie Curie at the 1911 Solvay Conference. Source: Wikimedia Commons

Many of the social and cultural norms that historically welcomed certain men into Anglo-European scientific communities excluded most women.[7] Medieval and early modern academic institutions developed in the absence of women. Tied to clerical traditions and the education of the social elite, German and Oxbridge university cultures emerged as models for training privileged men in the life of the mind.[8] In the seventeenth-century, the "scientific revolution" took place in these centers of learning as well as in the private quarters of gentlemen scientists, at the tables of public coffee houses, and within organizations like the Royal Society. While some women engaged at the margins of this milieu as patrons or

[7] Keller 1995; Jordanova 1993; Keller 1992.

[8] Warwick 2003, esp. Ch. 4; Noble, D. 1992.

organizers of intellectual salons, trusted networks of gentlemen dominated the new mode of empirical investigations.[9]

Enlightenment notions of sexual complementarity, a gender-based ideology that naturalized sex differences between men and women, served as a foundational rationale for limiting women's equal participation in modern science. In the early nineteenth-century, women followed their interests in science independently and recreationally, botanizing at the margins of scientific communities or privately studying natural science.[10] As science as an enterprise started to professionalize and women began to enter into institutions of higher education in the 1870s, women were educated in the sciences but barred from pursuing scientific careers. Universities and other institutions of science refused to hire women for a number of gendered reasons: women's biology made them unfit to do science; women's natural roles as wives and mothers precluded them from professional careers in science, except for in low-paying gender-appropriate subfields; hiring women required precedents and there were no precedents; and in the case of academic couples, university nepotism laws forbade employing both partners, often to the detriment of women.[11]Thus, while women actively worked in the sciences, often in unpaid or under-recognized capacities, entrenched stereotypes that one could not be both a woman and a scientist remained difficult to overcome well into the twentieth century.

Understanding historically how women have been excluded from mainstream scientific careers provides a useful vantage point for making sense of ongoing diversity gaps in science. Despite extensive attention paid to the underrepresentation of women in STEM fields in the 1970s and 1980s by scholars and scientific funding bodies, STEM fields today still struggle to attain gender parity. Questions about gender equity are field and culture dependent. In the U.S. 2017 National Science Foundation data demonstrates that individuals who identify as women earn over half of PhDs in the biosciences. By comparison, women earn less than twenty percent of doctoral degrees in computer science and physics. Even more striking, underrepresented minority women and men receive less than eight percent of PhDs in science and engineering (although this number has been slowly rising).[12] In the past several years, the women in science problem has transformed into the genders and sexualities in science problem. For instance, LGBTQA individuals report greater feelings of openness in STEM fields with higher gender parity, suggesting that gender equity contributes

[9] Shapin 1988. See also: Ray 2015; Park 2006.

[10] Kohlstedt 1978.

[11] Rossiter 1982.

[12] National Science Foundation, "Women, Minorities, and Persons with Disabilities in Science and Engineering," January 2017. (https://www.nsf.gov/statistics/2017/nsf17310/digest/about-this-report/)

to feelings of inclusivity for individuals across the sexualities spectrum.[13] It is important to underscore that this data seems to be confined to STEM cultures in the United States and Britain. A 2018 study indicates that countries with lower overall gender equality have higher reported numbers of women in science.[14] Transnational comparisons of women in STEM show that while women represent around twenty-nine percent of researchers globally, some regions have lower rates of women scientists (e.g. South Asia at 18%) while others have much higher rates (e.g. South East Asia at 42% and Latin America and Caribbean at 46%).[15] One key to thinking about how to increase women's representation in STEM fields is to adopt a transnational framework, acknowledging that scientific cultures are in some ways universal and in many ways culturally idiosyncratic.[16]

GENDERED SCIENCE

Understanding how science is gendered goes beyond tallying up the number of women at scientific society meetings or on the pages of *Science* and *Nature*. Science itself is a gendered institution. Scholarship in scientific masculinities connects the history of science as a history of (mostly) men doing science with changing cultural constructions of manliness and masculinity, opening up new avenues for addressing how scientists are marked by gender, race, and class.[17] In short, gender applies to men, too.

Feminist historians and philosophers of science have had a longstanding interest in examining how science itself has been associated with gendered representations of objectivity. Since the early modern period, classic gender binaries – male/female, masculine/feminine, mind/body, public/private, universal/individual, objective/subjective – have functioned as conceptual tools for making sense of who can be a man of science and what science as an endeavor aims to do.[18] During the scientific revolution, constructions of nature as a feminized object open to domination by masculine science formed the foundation of a new working language for empiricism.[19] For instance, as Francis Bacon described the practice of science in *The Masculine Birth of Time*: "I am come in very truth leading to you Nature with all her children to bind her to your service and make her your

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[13] Yoder and Mattheis 2016.

[14] Stoet and Geary 2018.

[15] Kumar 2012, pp. 293-97.

[16] Rosser 2012 and 2004; Margolis and Fisher 2002; Etzkowitz, Kemelgor, and Uzzi 2000.

[17] Tonn 2017; Milam and Nye 2015; Traweek 1988, Ch. 3. See also: Stein 2015.

[18] Longino 1990 and 1987.

[19] Merchant 1989.

slave....”[20] This masculinist mode of thought can be found in Baconian metaphors for nature as well as in early modern medical cultures which unveiled the secretive, feminine body through the practice of dissection.[21]

As Robert Nye has shown, masculine cultures of honor connected to feudal social rituals merged with a professionalizing scientific life in the eighteenth and nineteenth centuries. Scientific and medical societies reproduced traditions of gentlemanly sociability and, in doing so, tied priority disputes to ideals of competitive manliness. Associating the right kind of men with the right kind of technical knowledge bolstered the credibility of scientific communities and helped to fashion the popular image of the ideal male scientist: elite, sociable, brilliant, and competitive.[22]

Part of the feminist project in critiquing science is not only to identify how social and cultural ideas about gender provide conceptual resources for research programs but also to ask to what extent a feminist science might exist. If scientific epistemologies are so entangled with oppressive power structures is there a way of knowing in the natural sciences that is both credible and cognizant of power? Rethinking scientific objectivity from the positions of standpoint theory and strong objectivity has proved generative for the interdisciplinary field of feminist science studies, as pioneered by Sandra Harding, Donna Haraway, Helen Longino, and Anne Fausto-Sterling.[23] In this vein, hovering in the background of debates about women and gender in science is the question of whether women and men do science differently.

Asking this question presupposes that men and women are biologically distinct and that this biological difference somehow shapes women’s scientific abilities within the gendered world of science. On the one hand, there are examples of women entering into scientific subfields for the first time to ask entirely new research questions. For instance, the field of primatology transformed after the mid-century as women like Jeanne Altmann focused for the first time on the evolution of maternal and infant behavior in non-human primates.[24] On the other hand, there are examples of women such as the recent Nobel Prize in Physics recipient Donna Strickland, who advanced their fields in ways that seem delinked from gender.[25]

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[20] Keller 1985, p. 36.

[21] Jordanova 1989.

[22] Nye 1997.

[23] Hammonds and Subramaniam 2003; Fausto-Sterling 2000; Schiebinger 1999; Keller and Longino 1996; Haraway 1989; Haraway 1988; Harding 1986.

[24] Strum 2000; Haraway 1989.

[25] The reception of Strickland’s Nobel Prize has suggested the story is more complicated: Marina Koren, “One Wikipedia Page Is a Metaphor for the Nobel Prize’s Record With Women,” *Atlantic*, October 2, 2018

Barbara McClintock's life and work is often evoked as a case study for thinking through this problem. While some biographers have suggested that McClintock's gender marginalized her within the scientific community – and her research on genetic transposition in maize resulted from a particular gendered approach to her organism of study – others have suggested that McClintock's isolation as a woman in science might be more myth than reality.[26] All of this is to say that one almost never hears this query turned on its head — do men do science differently than women? — evidence that science is still an endeavor that remains, as Evelyn Fox Keller has described it, "both male and disembodied…."[27]

Other recent historical scholarship at the intersection of gender and science focuses intently on questions of power. For instance, it has become clearer how Anglo-European practitioners used women's knowledge and their bodies without attribution, and often without consent, in the process of knowledge production. Research on colonial botany demonstrates how enslaved and indigenous women in the West Indies used the "peacock flower" (*Poinciana pulcherrima* L.) as an abortifacient. Although the plant itself made its way back to Europe, this gendered knowledge did not always travel with it.[28] Enlightenment racial science relied on the non-consensual examination of the bodies of women of color in order to buttress ideologies of white supremacy.[29] Nineteenth-century physicians in the U.S. south performed non-consensual surgical experiments on enslaved women's bodies as part of the professionalization of gynecology.[30]

Historians have shown that against this backdrop of professionalized science, gendered forms of vernacular knowledge continued to circulate. In the antebellum United States, enslaved women used their expertise as herbalists, healers, and midwives to care for their communities. On both sides of the Atlantic, women continued to rely on traditional remedies and culturally distinct forms of knowledge about hygiene, food preparation, and the natural world well into the twentieth-century.[31] In addition, gender and its intersections with race, ethnicity, class, and disability have become important axes for reevaluating the consequences of twentieth-century eugenic policies, including forced sterilization and state-

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(https://www.theatlantic.com/science/archive/2018/10/nobel-prize-physics-donna-strickland-gerard-mourou-arthur-ashkin/571909/).

[26] Comfort 2009; Keller 1983.

[27] Keller 1992, p. 19; See also: Oreskes 1996.

[28] Schiebinger 2005.

[29] Schiebinger 2004. For a popular biography of Saartjie Baartman, Holmes 2007.

[30] Owens 2017; Fett 2006; Schwartz 2006; Fett 2002, Ch. 5.

[31] Tomes 1998, Chs. 2, 6, 8; Ladd-Taylor 1997; Ewen 1985, Ch. 8.

sponsored population control initiatives.[32] This research underscores the importance of moving outside mainstream cultures of science to better understand alternate forms of knowledge and the consequences of scientific decision-making in everyday life.

THE SCIENCES OF GENDER

Histories addressing the problem of women in science and scholarship about the gendering of scientific cultures regularly wade into the murky waters of scientific approaches to sex difference. Nineteenth-century reservations about women's biological fitness for careers in science illustrated how biological essentialism functioned in practice. Meanwhile foundational inquiries in the field of feminist science studies focused on critiquing scientific studies of sex difference, many of which feature problematic methodologies, limited sample sizes, and circumscribed sets of results.[33] From this perspective, the very question of whether women and men practice science differently overlooks the spectrum of gender identities and gender expressions available to individuals and the complex layers of sex (chromosomal, gonadal, hormonal, genital, and metabolic) that make up an individual's biology.[34] Even the science of sex difference has a long history.

Within gender studies of science, there are a number of classic examples of how traditional gender stereotypes have influenced science and medicine. Traditional gender ideologies can be recognized by three patterns of thought: the existence of gender binaries or stereotypes; the representation of these gender binaries as inevitably in conflict; and the blurring of biological explanations of sex and social and cultural explanations for gender.[35] To take an example, Nelly Oudshoorn's research on sex hormones tracks how assumptions about sex difference in the gonads carried over into sex endocrinologists' research into dually sexed hormones in the 1910s and 1920s.[36] Not only were male and female sex hormones seen as binaristic, they were also characterized as being deeply antagonistic and emblematic of the battle between the sexes. As one popular writer noted: "the chemical war between the male and the female hormones is, as it were, a chemical miniature of the well-known eternal war between men and women."[37] By the 1930s, researchers acknowledged that males and females both had male and female sex hormones and that they were not as opposed as

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[32] Novak 2018; Hall 2011; Briggs 2002; Kline 2001. See also: Roberts 1997; Duster 1990.

[33] Fausto-Sterling 1992.

[34] Fausto-Sterling 2012.

[35] Richardson 2013, p. 13. See also: Laslett et. al. 1996; Spanier 1995; Hubbard 1990.

[36] Oudshoorn 1994.

[37] P. Kruif quoted in Oudshoorn 1994, p. 24.

previously thought. Despite this nuance, testosterone remains a cultural shorthand for aggressive masculinity and estrogen for excessive femininity.[38]

One of the aftereffects of how biological theories about sex and social notions of gender are invoked in hormone research can be found in contemporary debates about sex testing in women's athletics. Methods behind sex testing and gender verification analysis in elite sport have changed over time. They have included visual screening, physical exams, gynecological exams, chromosome tests, and hormone level analysis. In the past decade, the International Association of Athletics Federations (IAAF) and International Olympic Committee (IOC) have focused on androgen levels as markers of biological femaleness. This means that athletes with hypoerandrogenism have to take steps to alter their hormone levels to "normal" states. Women athletes are almost always the subjects of gender verification testing, demonstrating both the double standard in sport and the underlying assumption that women need careful biological regulation to ensure "fair play". Critics of these policies argue that factors such as height, weight, and access to top training regimes and facilities play an even more important role in ensuring athletes' competitive advantage. In addition, if the logic behind these positions was to be taken to its extreme (and applied to both men and women) then perhaps elite athletic events should be segregated not by gender but by hormone levels.[39]

Sex hormones are one of many examples of how the scientific community has reduced the spectrum of human sex differences into discrete, over-determined units of analysis since the early modern period. As Londa Schiebinger has shown, eighteenth-century anatomists drew representations of female and male skeletons that confirmed widespread assumptions about the complementary roles of men and women. Female skeletons had disproportionately smaller skulls and wider pelvises, which reflected ideas about women's natural fitness for motherhood and their limited intellect. When craniometrists compared male and female skulls some decades later, the argument changed: female skulls, often found to be larger than male skulls, revealed women's biological connection to children.[40]

In the nineteenth-century Darwinian notions of evolution provided a new explanatory framework for sex differences. Darwin's *Origin of Species* (1859) proposed a vision of the natural world defined by vast expanses of time in which species emerged and disappeared as they competed for resources. Published thirteen years later, Darwin's *Descent of Man* (1871) focused on the theory of sexual selection to explain how individuals within a species compete for a mate. Evelleen Richards has detailed how Darwin's own experiences as a

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[38] Fine 2017.

[39] Pieper 2016. See also: Langston 2010.

[40] Schiebinger 1989.

privileged Victorian man of science influenced his approach to thinking about sex in the biological world.[41]

In a now often-quoted excerpt about the "Difference in the Mental Powers of the two Sexes," Darwin elides nature and culture and associates women with the so-called "savage" races:

No one will dispute that the bull differs in disposition from the cow, the wild-boar from the sow, the stallion from the mare, and, as is well known to the keepers of menageries, the males of the larger apes from the females. Woman seems to differ from man in mental disposition, chiefly in her greater tenderness and less selfishness; and this holds good even with savages.... It is generally admitted that with woman the powers of intuition, of rapid perception, and perhaps of imitation, are more strongly marked than in man; but some, at least, of these faculties are characteristic of the lower races, and therefore of a past and lower state of civilization.[42]

In this formulation, women and men are naturally different and biologically complementary. Women's emotionality links them to a more primitive state of human nature. Darwin's evidence for this theory was based on observations of sex difference in non-human animals, racialized theories of social evolution, and biographical data about Victorian men and women in public life.

While some Victorians responded to Darwin's theory positively — man's innate intellect naturalized his role in public life and woman's emotionality naturalized her role at home — others critiqued its gender bias or even co-opted its claims.[43] Nineteenth-century feminists used sexual selection to argue for women's greater role in public life. In the United States, Antoinette Brown Blackwell, Eliza Burt Gamble, Charlotte Perkins Gilman, and Helen Hamilton Gardner borrowed Darwin's theories to argue for women's equality and even their evolutionary superiority. Darwinian evolution offered a flexible scientific framework for either reifying the status quo on the basis of biology or upending it in political debates about American imperialism, women's suffrage, birth control, and women entering into higher education.[44] Untangling how gender bias has influenced theories of sexual selection remains an active area of research in gender studies of science, especially in terms of reevaluating the diversity of genders and sexualities found in the natural world.[45]

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[41] Richards 2017. See also: Milam 2010.

[42] Charles Darwin, *The Descent of Man, and Selection in Relation to Sex* (New York: Appleton, 1871), pp. 310-11.

[43] Russett 1989; Alaya 1977.

[44] Hamlin 2014; Deutscher 2004.

[45] Mortimer-Sandilands and Erickson, 2010; Roughgarden 2004; Gowaty 2003; Hrdy 1999.

Image 2: Caricature of Darwin's treatment of Emotion Source: *Fun*, November 1872

As post-Darwinian scientific and medical practitioners focused on smaller and smaller systems and mechanisms to explain human sex difference, they repeated old patterns of gender stereotyping. Edward H. Clarke's infamous *Sex in Education* (1873), for instance, looked to women's shattered nervous systems as an indicator of their unfitness for higher education.[46] The turn-of-the-century discovery of chromosomes and naming of X and Y chromosomes as human sex chromosomes in the 1920s (despite other nomenclature options available) further reinforced femininity and masculinity as embedded in—and produced by—discrete biological objects.[47] The most classic example can be found in Emily Martin's path-breaking analysis of human reproduction. The "scientific fairytale" of the romance between the egg and sperm uses longstanding gender stereotypes about passive women and active men to describe how the egg, a non-participative damsel-in-distress, waits for the heroic sperm to penetrate her outer vestments. By the 1980s, developmental biologists observed that this narrative did not accurately portray human reproductive biology. In fact, the egg and sperm are mutually active partners in the process of

[46] Russett 1989.

[47] Richardson 2013.

fertilization.[48] Despite the outsized impact of Martin's analysis on academic gender studies of science, gendered language in scientific textbooks (and online educational platforms) continue to promote the misperception of fertilization. In this case, cultural scripts about masculinity and femininity overwhelm scientific evidence.

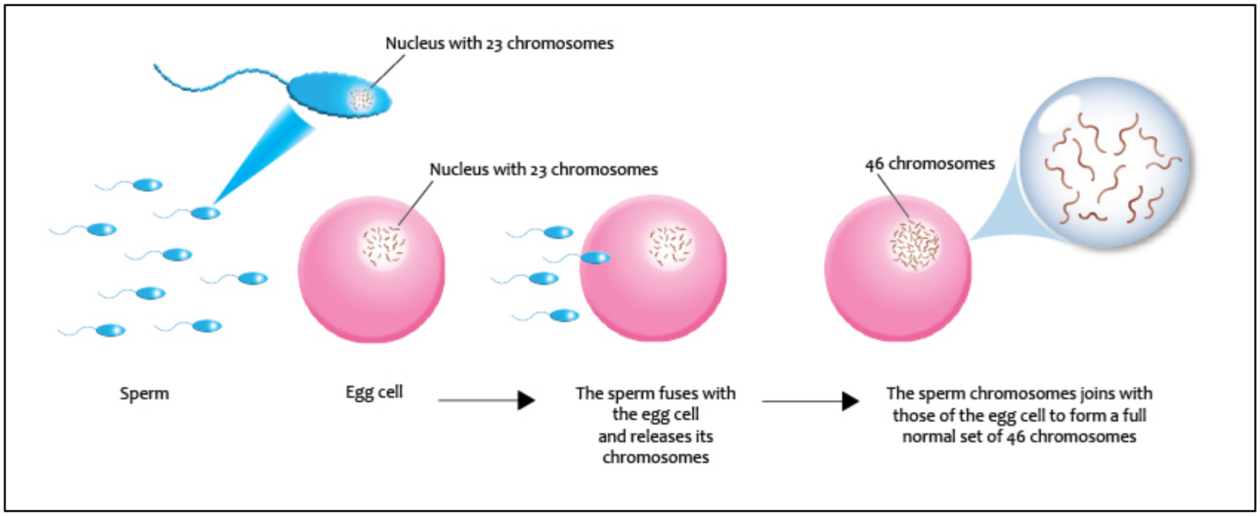

Image 3: Pedagogical depiction of fertilization as a gendered process (note the coloring in particular). Source: NHS National Genetics and Genomics Education Centre

These patterns of thought can be found most markedly in the world of brain science. In the decades around 1900, practitioners started applying quantitative methods to figure out whether men or women are more intelligent. Educational psychologists like James McKeen Cattell and Edward L. Thorndike turned to a biological variability hypothesis for answers. Based on sets of biographical data, they argued that men are more likely to have both higher and lower intelligence, while women are more likely to be of average intelligence. This data fit with evolutionary ideas that variability conferred fitness to males (while less-variable females lagged behind). They also confirmed social apprehensions about expending limited resources to train women for positions outside of their natural aptitude. As feminist scholars including Anne Fausto-Sterling have pointed out, the data used for this research (e.g. Cattell's *American Men of Science*) offered a ready set of observations to reify existing assumptions about male genius.[49]

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[48] Martin 1991.

[49] Fausto-Sterling 1992.

Rebecca Jordan-Young's examination of brain organization research untangles another scientific fairy tale from the field of cognitive neuroscience that suggests male and female brains differ due to prenatal exposure to sex hormones. Since it is ethically impossible to run experiments on how hormones influence human development, this field relies on quasi experiments with humans and experiments with animals to approximate how hormone exposure might confer traits related to gender or sexuality later in life. But, as Jordan-Young demonstrates, human development is vastly complicated. It is almost impossible to draw a straight line from prenatal hormonal exposure to adolescent or adulthood sexualities, career preferences, and/or gender identities.[50] Biologically deterministic modes of inquiry circulate in other areas of research about human sexualities – from the search for the gay gene (or gay brain) to attempts to identify the genetic foundations for social behaviors like altruism, aggression, and competitiveness.[51]

CONCLUSION

So why does it matter? What can we say about the relationship between who gets to do science and the kind of knowledge produced in the modern sciences? One instructive case study for thinking about how the underrepresentation of women in STEM fields shapes knowledge production can be found in the field of computer science. Recent reporting highlights the startling gender gap currently found in Silicon Valley. According to the Center for Employment Equity at University of Massachusetts Amherst, thirty percent of employees in the 177 largest tech companies identify as women. When it comes to racial diversity, less than eight percent of tech employees are Latinx and less than five percent are Black.[52] Firms are even less diverse at the executive level.[53] Gulfs in representation are compounded by reports of gender-based discrimination, sexual harassment, homophobia, and racism in the tech industry.[54]

The gender gap in computer science is a relatively recent invention, however. During the late nineteenth and early twentieth centuries, women worked as computers at the Harvard College Observatory, calculating the distance between stars and measuring their brightness

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[50] Jordan-Young 2010.

[51] Lloyd 2005; Travis 2003; Dreger 1998; Rosario 1996; Terry and Urla 1995.

[52] Center for Employment Equity, University of Massachusetts, Amherst, "Is Silicon Valley Tech Diversity Possible Now?" 2018 (Report PDF).

[53] Sissi Cao, "A Data-Backed Look Into Silicon Valley's Gender Equality Problem," *Observer*, November 16, 2017 (https://observer.com/2017/11/a-data-backed-look-into-silicon-valleys-gender-equality-problem/).

[54] Sheelah Kolhatkar, "The Tech Industry's Gender-Discrimination Problem," *The New Yorker*, November 20, 2017 (https://www.newyorker.com/magazine/2017/11/20/the-tech-industrys-gender-discrimination-problem).

for male astronomers.[55] During World War II, women worked as programmers for the ENIAC in the United States and the Colossus in Britain, pioneering the field of electronic digital computing.[56] During the Cold War, women computers supported NASA's space program.[57] By the 1960s, women were so associated with computer programming that companies like IBM ran advertisements explaining: "Now have come the big, dazzling computers— and a whole new kind of work for women: programming. Telling the miracle machines what to do and how to do it. Anything from predicting the weather to sending out billing notices from the local department story. And if it doesn't sound like woman's work—well, it just is."[58]

Janet Abbate and others have documented that with the professionalization of computer science as an academic discipline, women started leaving the field. Women earned thirty-seven percent of undergraduate degrees in computer science in 1984 but by 2008 earned only eighteen-percent.[59] Gatekeeping methods in undergraduate curricula and low numbers of women in graduate computer science programs have been connected to changing cultural narratives about the computer. In the 1980s, spaces like the video game arcade and cultural stereotypes of the male hacker, the geeky computer nerd, the basement gamer, and the volatile computer genius replaced older images of the woman computer.[60] According to Nathan Ensmenger, "the association of masculine personality characteristics with innate and intuitive programming ability helped create an occupational culture in which female programmers were seen as exceptional or marginal."[61] Twenty-first century geek hypermasculinity, on display in TV shows like the *Big Bang Theory* and in Gamergate's boundary policing through trolling and doxxing women gamers and game developers, has amplified this gender divide in the wider media.[62]

A gendered analysis of computer science reveals not just the personal costs to practitioners but also the consequences for the way everyday consumers and citizens interact with technical systems and devices.[63] In particular, proprietary algorithms are developed in secret, making it difficult to know how assumptions about gender or race filter into Google page

[55] Sobel 2016.

[56] Abbate 2012. See also: Hicks 2017.

[57] Shetterly 2016.

[58] Lois Mandel, "The Computer Girls," *Cosmopolitan*, April 1967.

[59] Abbate 2012, p. 145.

[60] Kocurek 2015.

[61] Ensmenger 2015, p. 51.

[62] Salter and Blodgett, 2017.

[63] Creager, Lunbeck and Schiebinger 2001.

rank results or tools for predicting parolees' recidivism rates. Scholars such as Safiya Noble have maintained that these algorithms work as powerful "technological redlining" tools that serve to strengthen gender and racial stereotypes and reinforce existing social inequalities.[64] Unpacking this contemporary moment in modern science requires understanding the history not only of who is allowed to practice science but also the gendering of science itself.

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[64] Noble, S. 2018.

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