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# Biological Factors in the STEM Gender Gap

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**Abstract**

The Gender gap in STEM is a long-term problem that has only recently been addressed. Research has just begun to delve into why so few women pursue university degrees in the STEM fields and even less enter the STEM workforce. This research will examine the evolutionary factors which contributed to the gender gap, such as offspring investment, greater investment in male offspring, and female risk aversion. Despite the fact that there are plenty of modern advances which should compensate for these factors, there are societal stigmas against women in the STEM workplace which allow the gender gap to continue. Societal forces such as the concept of women's work, implicit bias, stereotypes against women, assumed motherhood for all women and the toxic STEM culture ensure that the gender gap is not alleviated. It will also explore the push back against the women going into the field. It is clear that there is a general belief that women do not belong in STEM and that those who dare pursue a career in STEM do so knowing full well that they will have to accommodate male peers and superiors. This research will attempt to explain why the STEM fields are not thought to be a place for women; why gender as a social construct has such an influence in academic and workplace politics and how this has led to the discrepancies in gender percentages in the STEM workforce. Research will both delve into why men do not think women are good a STEM and why women have internalized the bias. While both of these issues arise from societal biases, the manifest in different ways, are processed differently and effect the respective genders differently. This research will address the gap in the literature, as all previous literature has addressed one facet of the gender gap and only done so from either an evolutionary or cultural point of view.

MONTCLAIR STATE UNIVERSITY

Biological Factors in the STEM Gender Gap

by

Yamina Nater-Otero

A Master's Thesis Submitted to the Faculty of

Montclair State University

In Partial Fulfillment of the Requirements

For the Degree of

Master of Arts

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College of Science and Mathematics

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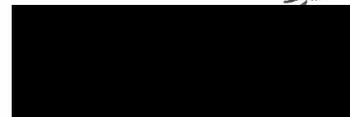
Earth and Environmental Studies



Randall FitzGerald



William Thomas



Greg Pope

Biological Factors in the STEM Gender Gap

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Montclair State University

Montclair, NJ

2017

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## **I. Introduction**

The Gender gap in science, technology, engineering and mathematics fields (STEM) is a long-term problem that has only recently been addressed. Research has just begun to delve into why so few women pursue university degrees in the STEM fields and even less enter the STEM workforce. Studies (Beede et al., 2011) have shown that while women make up 48 percent of the US workforce, they are only 24 percent of the STEM workforce. This research will examine the biological factors that have contributed to the gender gap in STEM and how they manifest in social and cultural phenomenon. The distinction between female and male driven fields, and how they are classified, will also be examined.

This paper will only examine traditional male and female biology, trans or intersex genders will not be examined. Race and LGBTQ identity also factor into the gender gap and STEM but will not be addressed in this paper.

As there are currently few investigations on the biological factors in gender gap in STEM visible manifestations, this paper will pull from a wide variety of sources and fields. The research will include scholarly articles, texts, case studies, anecdotal evidence and statistics from Anthropology, Biology, Education, Neuroscience, Gender Studies and Environmental Studies. Using an interdisciplinary approach allows for an in-depth look at the issues and will lead to new theories on the gender gap. In what follows, I examine the biological evidence that is thought to contribute to the differences in the work force. This research paper is a synthesis of current research in the field to support my hypothesis that there is a biological underpinning to the gap in STEM.

This paper will begin by examining the evolutionary factors that helped create the gender gap in the STEM workforce. It will then examine the cultural factors that arose from humanity's evolutionary history. Societal trends, biases and stereotypes will be examined, along with how they have influenced female choice and STEM work cultures. Despite the technological and social advances that have been made, STEM culture still adheres to outdated gender roles, which is one of a few reasons why the gender gap still persists. This study will survey the existing scientific literature to try and explain why sex differences in STEM related fields are partially the result of sexual selection for different cognitive and behavioral traits.

This research has not been done before, it will pull from a wide range of fields in order to give a more complete picture as to why the gender gap in STEM has a foundation in evolutionary differences in the sexes, how these differences have manifested as cultural and societal norms and how these norms do not allow the gap to disappear. Previous research has examined individual facets from either a biological, neurological or societal stand point.

## **II. Methods**

The purpose of this paper is to examine the biological and evolutionary factors that contributed to the gender gap in STEM, how they have manifested in social norms and how these norms are perpetuated in the form of stereotypes and biases. In order to examine the issue, a literature review has been conducted of scholarly articles, books, periodicals and studies chosen from a wide range of academic fields. Fields from which these studies were selected include evolutionary biology, law, psychology, sociology, neurobiology, education, environmental sciences, economics, gerontology, technology, women's studies and census based research. While articles discussing the biological factors in the STEM gap were not chosen with any limitations on the amount of time since being published, articles on social issues were given priority if published within the last 5 years, though sources used in these articles were sought out if relevant and innovative.

Criteria for selected articles included :

- peer review (for scholarly articles)
- papers which put forward basic concepts in their field
- social studies within the last 5 years
- studies with results that can be replicated
- if contradicting the majority of the research, the methods and procedures must be clear
- older papers were selected if cited repeatedly in modern papers selected
- Studies conducted in Western cultures.

Peer reviewed scholarly articles were elected to ensure that the studies and analyses cited were to the highest standard and had results that could be replicated. Because this paper discusses the very basics of evolutionary biology, experts in the field were chosen, studies which form the very foundation of what we know today. More recent studies were chosen to gain some insight into current statistics and societal

attitudes towards women in the workforce, women as caregivers and women in STEM. Studies that were selected were primarily conducted in developed countries in the western world, though few studies were selected from developing nations in order to examine human behavior under extreme conditions (i.e. a lack of resources). This was done to account for the role of socialization in the gender gap. While there is no uniform societal standard across North America and Western Europe, these cultures are more similar than the societal norms in Asia and North America.

Source	Times Cited	Year Published
A Treatise on the Family	N/A - Book	1993
AERA Open	1	2016
The American Naturalist	2	1986, 1996
American Psychologist	1	1997
Animal Behaviour	1	1990
Annals of human biology	1	2014
Archives of Sexual Behavior	1	2007
Asia-Pacific Forum on Science Learning & Teaching	1	2015
Ateneo Law Journal	1	2009
The Atlantic	1	2016
Behavioral and Brain Sciences	1	1989
Behaviour	1	2014
Behavioural brain research	1	2016
BioScience	1	2013
British Journal of Guidance & Counselling	1	2006
Citizen-Times	1	2017
Contemporary Social Science	1	2011
Continuum	1	2015
Department of Commerce	1	2011
Developmental Psychology	1	2014
Econ Focus	1	2016

Source	Times Cited	Year Published
Entrepreneurship Theory and Practice	1	2016
Ethology and Sociobiology	1	1993
Evolution and Human Behavior	4	2000, 2007, 2008, 2011
Evolutionary Psychology	1	2008
The Gerontologist	1	1999
Hormones and behavior	2	2002, 2015
Journal of Animal Ecology	1	2009
Journal of Applied Gerontology	1	2015
Journal of Comparative and Physiological Psychology	1	1979
Journal of Consumer Research	2	2015, 2016
Journal of Educational Psychology	1	2014
The Journal of Educational Research	1	2014
Journal of Experimental Social Psychology	1	2016
Journal of Personality	1	1990
Journal of Personality and Social Psychology	2	1981, 2002
Journal of Social issues	1	2000
Judgment and Decision making	1	2006
Labour/Le Travail	1	2006
Learning and Individual Differences	1	2016
Medical hypotheses	1	2000
Nation Swell	1	2014
National Science Foundation	1	2015
Nature	1	1981
NPR	1	2016

Source	Times Cited	Year Published
Organisation for Economic Co-operation and Development	1	2011
Personality and Individual Differences	1	2016
PloS one	1	2016
Proceedings of the National Academy of Sciences	2	2009, 2015
Proceedings of the Royal Society of London B: Biological Sciences	1	1997
Psychological Bulletin	1	2016
Psychological science	1	2016
Science	1	2015
Sexual Selection & the Descent of Man	N/A - Book	1972
Social Science Research	1	2011
Society & Natural Resources	1	1992
Structural Change and Economic Dynamics	1	1998
Therapy Today	1	2017
Think Progress	2	2013, 2014
Time	1	2015
Trends in Ecology & Evolution	1	2006
U.S. Census Bureau	1	2007
U.S. Department of Labor	1	2015
Vox	1	2017
Washington Post	1	2016
Wired	2	2016, 2017
Women's Studies International Forum	1	2013

### III. Results

#### A. Biological factors

In polygamous species in which one sex invests more than the other in offspring, the sex with a smaller parental investment will have to compete with like gendered individuals of the species in order to reproduce. In the case of the majority of mammalian species, males invest less in offspring, spend more time looking for potential mates, and compete with other males for access to females, resulting in strong sexual selection on physical, cognitive and behavioral traits (Trivers, 1972). It is beneficial to the sex that makes the smaller investment in parental care to find as many mates as possible to ensure the greatest reproductive success.

Sexual selection consists of two components, competition within one sex and differential choice by members of the other sex (Trivers, 1972). This section will discuss the latter, intersexual selection, while the former, intrasexual selection, will be discussed briefly in the discussion. Sexual selection in polygynous species often results in sexual dimorphism, in that the traits that are selected for in each sex will likely drive the evolution of the sexes (Mitani et al., 1995). Sexual dimorphism can be manifested in size, color, weaponry, cognition, etc., with males typically being selected for traits that bolster competitive abilities, and females selected for mate choice and parenting skills.

Previous research has shown that females select for dominance in mates. In humans, Kendrick et al. (1990) found that females look for male traits such as earning capacity, power, dominance, and ambition. Thus, it is no coincidence that male dominated work fields are either labor intensive or relatively well paying (U.S. Department of Labor, 2015).

These sexually selected traits may possibly be the root of the implicit biases held against women in STEM. While confidence makes males more attractive to females, sexually selected traits typically associated with females are youth and physical attraction (Buss, 1989). Females who do display dominance do so in ways that are more socially acceptable by adhering to gender norms. They display dominant acts that benefit the community, such as initiating social interactions and taking charge of altruistic committees. In fact, Buss (1981) found that in female/male pairings in which the female showed higher dominance, she would decide to make the less dominant male the group leader. However, females who display dominance traits that are selected for in men are seen as being aggressive, bossy, demanding

and talkative (Buss, 1981). Studies have shown that male STEM students view their male peers as more proficient in science classes than female students, possibly because males are more outspoken (Grunspan et al., 2016). Hulme (2006) presents anecdotal evidence of men in a trade course admitting that they were grateful to the lone female student in the course who spoke up and asked a question about the material. He confessed to being reticent to asking questions for fear of appearing less intelligent. This trend would allow male students to appear to understand the material more easily while female students appear to struggle to understand.

### ***1. Parental investment***

Parental investment is typically defined as investment made by the parent in an individual offspring that increases the offspring's chance of survival at the cost of investing in other offspring (Trivers, 1972). It can constitute anything from gamete size to the time allocated to caring for offspring. Among polygynous mammalian species, parental investment varies between the sexes (Clutton-Brock et al., 1981). In these species, the females typically invest more than males as indicated by their larger gamete size, long gestation period and long neo-natal care period. Male investment, what little there is, is likely to be indirect such as defending a territory that includes the female and her young against rival males. Kenrick et al. (1987) found that, in humans, females look for mates who can make larger indirect contributions to offspring than alternative mates. Those indirect contributions, include financial resources (salary) that contribute to the reproductive resources necessary to bring young to adulthood. On the other hand, males look for traits that signal reproductive value, such as physical appearance and youth (Buss, 1989).

Because females invest so much more than males in offspring prior to parturition, it is unwise for them to abandon young after gestation – and indeed in mammals, the young would not be able to survive without lactation from the mother. Since in polygynous males parental investment is so small (gamete size is relatively small, no gestation period, no direct neo-natal care), their best reproductive strategy is to leave immediately after insemination. Their reproductive success (fitness) increases if they immediately seek out other mates as soon as possible. Ironically, the greater the investment either party has put into the offspring the more likely it is that selection will favor either parent leaving. This will put an obligation on the abandoned party to invest more in offspring, rather than risk wasting all previous investment (Trivers,

1972). Around 15% of children in Organization for Economic Co-operation and Development (OECD) countries live in a sole-parent household, 82.6% of sole-parents are mothers (OECD, 2011 and U.S. Census Bureau, 2007).

The distinction between parental investment and reproductive effort is sometimes difficult to differentiate. For example, male territorial defense can be considered parental investment when offspring live in that territory, but it can also result in attracting females, thus increasing the chances for further reproduction. In fact, Trivers (1972) states explicitly that “reproductive effort for the female is essentially synonymous with parental investment” (pg 155), whereas reproductive effort for males is usually synonymous with the number of copulations. Thus, in males the relationship between reproductive effort and parental investment can have a negative correlation, with the more parental investment a male makes, the less reproductive success he is likely to have (Queller, 1997).

Parental investment from female mammals is strongly associated with nurturing and care-giving. Again, it’s not surprising that the top two career fields dominated by women are teaching and nursing. In STEM fields, this trend is also seen with women typically entering the life sciences (NSF, 2015).

Greater parental investment on the part of females is likely the reason why the gender gap is not as prevalent in environmental studies. Caring for the environment is seen as a feminine trait. If a female student pursues a STEM field, she is more likely to pick a course of study that she feels more comfortable with in workplace and in academia. Perhaps she will feel more confident that she will succeed and she will not feel as threatened by her male peers (Brough et al., 2016).

## ***2. Greater Investment in Male Offspring***

Inclusive fitness includes the fitness that an organism gains from the reproductive success of relatives. The more closely related two individuals, the more likely they are to assist each other in their reproductive effort (Foster et al., 2006). In this respect, it is sometimes a better strategy for parents to invest more heavily in male offspring than in female offspring, since their fitness is potentially much greater.

Females are almost always guaranteed the opportunity to reproduce, regardless of the amount of parental investment, whereas males need much more parental investment in order to compete with rival males for access to females. A study examining the rearing habits of red deer have showed that mothers

suckle their male offspring more often and for longer periods of time than they do their female offspring (Clutton-Brock et al., 1981). Becker (1991) posited that parents invest resources in children to maximize child quality, defined by the sum of their offspring's' adult monetary wealth. If one child possesses abilities that will increase their payoff, again in this instance that is financial success, to parents, parents are more likely to invest in those children. With respect to financial success, is it wiser for parents to invest in male offspring as they are more likely to acquire a well paying position, a phenomenon that will be fully discussed later in the paper. However, with respect to evolutionary success, there are contradicting theories. Durante et al. (2015) states that parents are more likely to invest in female offspring who have higher reproductive value. Durante bases this theory on the fact the female offspring are nearly guaranteed to reproduce while the reproductive success of males is dependent on outside conditions and varies greatly. Clutter-Brock et al. (1981) argue that parents are more likely to invest in male offspring as their evolutionary success is no guaranteed and need the help more than female offspring.

In humans, the evolutionary advantage to invest more in male offspring likely manifests itself as parents focusing more on their sons' education than their daughters (Alderman and King, 1998). A study on common Google searches found that "is my son gifted" is 2.5 times more likely to be searched than "is my daughter gifted" (Cimpian et al., 2016). Parents who struggle financially and are not able to send all of their children to school will invest more in their sons than their daughters. The prevalence of the gender wage gap means that investment in female education will lead to smaller financial returns. While in countries in which students typically have a long commute to schools, parents are less likely to allow their daughters to attend due to concern for their safety (Alderman and King, 1998).

A study conducted in Ethiopia of the Arsi Oromo compared parental investment in offspring in towns with access to tap water versus those without access to tap water (Gibson and Lawson, 2011). The subject pool consisted of 1084 children from villages with access and 1141 children without access to tap water. In this study investment in education was measured by school attendance. Regardless of access to water, females were less likely to get an education than male offspring. In villages with taps, 46.9% of male children were educated compared to 24.7% of female children. In villages without taps the numbers

drop to 41.6% of males and 17.1% of females. Overall in a household census of the area 44.2% of school aged males received an education compared to 20.7% of females.

As evolutionary biology applies to all organisms, its principles can be applied to humans because they are evolved organisms. Feldman (2015) composed a literature review which examines the neurobiological difference and similarities in parenting between humans, other mammals and animals in general. While our complex social structure allows humans to develop flexible attachment patterns, the foundation of these attachments is the same among humans and other mammals. The evolution of the parental brain in humans has retained the ancient components found in most animals and combined it with the higher-order functions that allow for the aforementioned flexibility. The parts of the brain that allow for parent- offspring pairing in rodents served the same function in humans, these being the hypothalamus (which produces oxytocin), amygdala and the limbic dopamine pathway.

McGuire et al. (2013) studied voles in order to examine this trend of greater parental investment in male offspring. This study compared the behaviors of a monogamous species versus a polygamous species with respect to offspring investment; prairie voles which are socially monogamous and meadow voles which are polygynous. In polygynous or promiscuous species, parents who are in good condition will likely invest more towards sons, as there is variation in reproductive success. In monogamous species, reproductive success is similar between males and females and it is likely that investment in offspring will be similar regardless of gender. Previous studies have shown that mother rats (a polygynous species) spend more time licking the anogenital area of male pups (Moore and Morelli, 1979). Gerbil mothers (also polygynous) have also been seen licking male pups more (Clark et al., 1990). However, in bank vole populations, mothers are seen producing more milk when they have an all-female litter (Koskela et al., 2009). Six breeding pairs of prairie voles and meadow voles were observed and kept in optimal conditions (ideal temperature, well fed, and comfortable habitat) in order to measure offspring investment when parents are in good conditions (McGuire et al., 2013). Offspring investment was measured through pup licking, as this behavior can only be directed at one pup at a time. Parents were observed for 30 minutes, randomly from day 7 to day 14 of pup life. Duration and frequency of pup licking were measured. Results showed that the promiscuous meadow vole fathers licked male pups for longer than female pups. Where are the monogamous prairie vole fathers and prairie vole mothers did not

differentiate among offspring. These results are in line with the theory that offspring investment is correlated to mating systems, with polygynous species investing more in male offspring.

Durante et al. (2015) also chose to study resource allotment by parents who are struggling financially. In poor economic conditions the reproductive value of male offspring greatly decreases as they are less likely to reproduce, while female offspring are practically guaranteed at least one child regardless of financial standing. If a family is struggling to feed their offspring, allotting more resources to male offspring will make him healthier but it will not necessarily improve his reproductive success, due to the great variance in reproductive success in males. However, giving more resources to female offspring will likely payoff as women are basically guaranteed mating opportunities. This experiment recruited 629 people, ages ranging from 17 to 81, from the internet panel. Participants were told to behave as if they were parents to two offspring, one male and one female. Two articles were created for the purpose of this study, one depicting economic boom and the other a recession, which were presented to participants. After reading their respective article, participants were told to indicate spending preference with respect to offspring. Two additional conditions were created, a neutral control and a negative effect control meant to match the effect of the economic recession group. Results confirmed the original hypothesis that parents who are struggling will allot more resources to female offspring. Participants in the economic recession group stated that they would give more resources to female offspring. This trend increased as the age of the offspring reached reproductive maturity. One of the goals of this study was to measure how much reproductive methods factor into offspring investment. As seen in McGuire et al (2013) monogamous and polygamous parents display different behaviors. In this instant, the study showed that participants with a higher number of sex partners were more likely to allot more resources to female offspring than those with fewer sex partners. Participants with fewer sexual partners were not affected by economic conditions with respect to offspring investment. This might confirm the hypothesis that monogamous parents will allot resources equally while polygamous parents will give preference to female offspring. As strict monogamy does not allow for reproductive variance between men and women, there is no need to invest more heavily in either male or female offspring to improve their reproductive success. While this seems to contradict the previous theory that parents do not invest in females as much as they do males, it is possible that parents do not invest specifically in female education because it does

not improve their reproductive success, while male offspring are more likely to mate if they are better educated and gainfully employed.

Studies on offspring investment do not agree but all make sense. Because of this it is difficult to determine exactly how offspring investment would function with respect to women in STEM. However, it is possible to infer some theories as to why parents may not invest in the STEM education of their female offspring. First, if evolutionary success is greatly improved by investing in males then it makes sense that female education would suffer for it. Second, if parents are looking to invest in the offspring that will yield the greatest financial return, then it would be wiser to invest in males or invest in the traits in female offspring which contribute to finding a successful mate. Due to the wage gap women in most fields will not make as much money as their male counterparts, so female offspring would yield greater returns by marrying a wealthy male then entering the STEM workforce. Finally, if evolutionary success is measured by the number of offspring produced then it is, again, imprudent to invest in a female's education. As previously mentioned, males do not select for success in female mates but rather youth and physical attractiveness. While further research must be conducted on parental investment in female offspring education, specifically in STEM, these theories offer possible explanations for the phenomena that will be described in the later section on societal factors.

### ***3. Risk Aversion***

In polygynous species it is predicted that males will take more risks in order to improve mating success (Pawlowski et al., 2008). Because, among mammals, females have a larger investment in offspring they are less prone to risky behavior while males are more likely to take risks if it improves their fitness (Harris et al., 2006). Testosterone has been associated with aggression, sensation seeking, hostility, mate seeking, food acquisition, spatial ability and dominance. In mammals, testosterone organizes the brain in early ontogeny during sexual differentiation and again during puberty (Apicella, et al., 2008). In humans, testosterone is linked to an increase in competition and dominance, reduced fear, and is associated with gambling and alcohol abuse. Previous studies have shown that human males are more likely to take risks with respect to conflict, sexual behavior, driving, accident risk, drug taking and financial decisions (Pawlowski et al., 2008). Risky behavior demonstrated by males, and its tie to testosterone, has been associated by previous studies with financial success. One study found that when

the testosterone levels of male traders in London were above their median level for 8 days sampled they made greater profits than on days when their testosterone levels were below median level (Apicella et al., 2008). The higher risk aversion seen in women can be used to explain why women are less likely to choose unstable careers paths (Sapienza et al., 2009). This may explain why women pursue careers in health care despite the high stress and work load involved but do not pursue the hard sciences. Medical students are basically guaranteed a position once they finish their residency, while STEM students will have to compete for the few post-graduate positions that are offered (Adamo 2013).

Pawlowski et al. (2008) attempted to show differences in risk taking between the sexes in everyday, non-life threatening situations. Two studies were conducted, one measuring arrival time for public transportation and the other street crossings. For the first, observations were made at a single bus stop predominantly used by students of the University of Liverpool, for 4 months on 32 mornings. The second study was conducted at a busy road crossing in the middle of the University campus during midday; over the course of 3 months 500 males and 500 females were observed. Results for the first experiment showed that individual males were significantly more likely to arrive later than females, increasing the chances of missing their bus and arriving late to their destination. A group of males was more likely (though not significantly) to arrive earlier than single sex groups of females, it is theorized that this may actually be due to groups of males arriving late for their intended bus and having to wait for the following trip. Males who arrived with females were likely to arrive at the same time as single females, implying that male behavior is affected by females. Results for the second experiment showed that males are more likely to cross the road when it is at higher risk states (more vehicles passing) than females. Males were three times more likely to cross during the highest risk period than females. Males were also seen to be more likely to take a risk in the presence of females, indicating that males are more likely to engage in risky behavior when there are females present to display to.

An experiment conducted by Bönnte, Procher and Urbig (2015) was designed to measure the causal link between Prenatal Testosterone Exposure (PTE) and entrepreneurship and indirectly, risky behavior. PTE affects brain organization relating to traits such as altruism, cognitive reflection and sexually differentiated behavioral characteristics. This investigation tested the theory put forward by previous studies, which showed that entrepreneurs are less risk averse, as entrepreneurship requires

making very risky choices in potentially unstable and uncertain conditions. This study surveyed first and second year undergraduate students at a German University. Entrepreneurial intent was measured via the Individual Entrepreneurial Intent Scale, which requires subjects to answer multiple questions. PTE is measured through the 2D:4D biological marker, which has previously been shown to be inversely related to PTE. The 2D:4D ratio is defined as the proportion of the length of the index finger to that of the ring finger. This is thought to be determined in early foetal development. A low 2D:4D, characterized by a longer ring finger than index finger, may indicate the introduction of a high level of PT (Klimek et al., 2014 and Manning and Bundred, 2000). An extreme version of this relationship is seen in males with congenital adrenal hyperplasia (CAH), a disease characterized by high levels of prenatal androgens. Males with CAH have low 2D:4D values, which is consistent with the theory that the testosterone levels and 2D:4D are inversely proportional (Brown et al. 2002).

Results showed that there is a positive correlation between PTE and entrepreneurial intent. It would appear that biological selection has led to a relationship between testosterone and risky behavior, even when it comes to business and financial decisions. This might be a result of sexual selection, in that human women have been shown to favor a mate who can provide for offspring. An inherent aspect of risky behavior is that the riskier the choice, the bigger the payoff. So while there is not guarantee that a risk will pay off, if it does the payoff will be larger than that of a safer choice.

Apicella et al. (2008) examined the fluctuating levels of testosterone in men and the biological markers for testosterone exposure in utero and puberty. 2D:4D and facial masculinity were used to measure testosterone exposure, with the former being negatively correlated to prenatal exposure and the latter a result of exposure during puberty. Current testosterone levels were measured via saliva samples. The subjects in the study were 98 males between the ages of 18 and 23, most of whom were Harvard University students. Risk preference was measured by an investment game with real monetary payoffs. While sexual orientation was found to be a significant predictor of risk, with homosexual men being more risk averse, this was used as a control in the analyses. Results found that men with higher testosterone level took more risks while playing the investment game. Masculinized facial features were a stronger predictor of risky behavior than 2D:4D. Implying that testosterone exposure during puberty is the leading cause of risky behavior in men. Previous studies have found that women who are menstruating, during

which testosterone levels are at their highest in women, engage in riskier behavior while bidding in a first price auction than at any other time in their cycle, linking testosterone to risky financial behavior in women as well.

While a career in STEM may not sound like a large risk, it can become one if you are not likely to be hired because of your gender, despite your education and experience. Covert (2014) reports that women are less likely to be represented in STEM careers despite receiving more degrees in these fields.

A study conducted at Columbia University found that people are more likely to hire male mathematicians regardless of the skill levels of male and female applicants (Reuben, Sapienza and Zingales, 2013). The experiment began by having male and female participants complete a series of basic arithmetic problems, summing as many sets of four two-digit numbers as possible in 4 minutes, something in which men and women have been shown to have comparable ability. It is also a skill set for which women face great bias. Participants were also asked to complete the Implicit Association Test (IAT) which measure bias and will be discussed in greater detail later in this paper in the section on implicit bias. Two subjects were randomly chosen to be candidates while the other participants were designated “employers” who had to hire one of the employees. While there were multiple combinations of employees (male-male, female-female and female-male) only data on male-female pairs was analyzed. Employers were asked to choose one employee and to estimate the number of sums each candidate would answer correctly. Employers were recompensed and were paid more if they chose the candidate out of the pair who performed better on the task. Results from this experiment showed that both male and female employers were more likely to hire the male candidate. This bias was reflected in the IAT testing in which participants associated males with math (results which will be replicated in an experiment discussed in the implicit bias section). Different groups of employers were given different information, the ‘No Information’ condition required the employers to make a choice with no previous information on the candidates, the ‘Cheap Talk’ condition allowed candidates to discuss their abilities and the ‘Past Performance’ condition allowed employers to learn about the candidates current and previous abilities in arithmetic. Results from Cheap Talk condition showed that males tend to oversell and overestimate their skills while women underestimate their abilities. Without the presence of bias the expected employment

rates would be 50/50 but in both the No Information and Cheap Talk conditions employers were significantly more likely to hire the male candidate.

A study to measure the biases of university faculty and how they influence hiring choices found similar results (Moss-Racusin et al., 2012). This study was conducted using participants from research-intensive universities, 127 professors of biology, chemistry and physics were asked to evaluate the application materials of undergraduate students applying for a science laboratory manager position. The materials were the same, with randomly assigned male or female names. Making the gender of the applicant the only variable. The results showed that faculty participants viewed the female students as less competent and offered female students less mentoring. The starting salary offered to the female students averaged at \$26,207.94 while that offered to the male students was \$30,238.10. The study also found that this trend was seen in all faculty, regardless of gender, implying that the biases were held by everyone. The more strongly a participant held a bias the less competence and hire ability they attributed to the female applicant. Participants were also asked how much they liked the female student, while they reported liking the female applicant more than the male student this did not translate into them finding the applicant more hireable or competent. This could mean that these biases are subconsciously held beliefs of which that participants were not aware. This may also be the result of existing stereotypes of women being warm and likable but not competent in STEM.

The results of these studies could mean that even if a female studies STEM and does well, she is not likely to be hired for a position for which she is fully qualified. If women are risk averse, like the previously cited studies state, they are not likely to invest in an education that will not guarantee a payoff. In this case, STEM is too high a risk for women to hinge their entire future on given that their employment is unlikely. For those women who take the risk, the payoff is even smaller than for men given the wage gap. Women in the STEM field can expect to make \$75,100 while men average \$91,000 (Covert, 2013).

#### ***4. Spatial Ability***

Sexual selection leads to gender differences. The discrepancy in spatial ability between the sexes is likely the result of sexual selection (Gaulin and FitzGerald, 1986). Multiple studies have shown that among polygynous mammals, females do not possess the spatial ability that males do. Mental rotation

of objects accurately and maze running ability has consistently been shown to be skills in humans in which the sexes differ the most, with males consistently outperforming females (Jeng and Liu 2016). One of the more common explanations for this sex difference in spatial ability is sexual selection. Various studies have found that males in polygamous species have a larger home range and better spatial abilities, resulting in accessing a larger number of females for copulations (Gaulin and Fitzgerald, 1986). In the course of their investigations, Gaulin and FitzGerald found that monogamous species displayed no sex differences in the ranging patterns or spatial ability, while the polygynous species they studied showed significant sex differences, with males ranging further in the field and exhibiting superior spatial ability in the lab. Under this theory it is assumed that selection has favored males with good spatial ability, allowing them to find and mate with more females. Given that humans display some polygynous tendencies, this line of reasoning would explain the difference in spatial ability between the sexes.

Another explanation for the difference in spatial ability between the sexes is that it is left over from humanity's hunter gatherer days. In this theory, 3D mental rotation is equated with navigating through a forest following prey (Silverman et al., 2000). The ability to mentally retain a 3D image and picture it mentally from different angles translates being able to find a starting point without keeping track of markers. While gatherers, females, would be able to walk at their own pace and keep track of landmarks, hunters would have to move quickly after their prey.

The difference in spatial ability between the sexes has long been cited as a cause for the gender gap in STEM. Multiple studies have shown that females do not possess the spatial ability that males do, specifically mental rotation. It has been shown that spatial memory is affected by both gender, age, and hormones, with spatial memory decreasing in both genders as they enter old age. (León et al, 2016) There does appear to be a shift around the onset of puberty when the gap in spatial ability becomes prominent (Jeng and Liu 2016), coinciding with sexual activity.

Hormonal and neurological causes for the gap in spatial awareness between the sexes have been found as well. Fluctuating estrogen levels throughout the menstrual cycle influence spatial ability in women. Silverman and Philips (1983) reported on the Effects of Estrogen Changes During the Menstrual Cycle on Spatial Performance. They tested this hypothesis by administering the 3 dimensional mental rotation test to female college students, some of whom were on the contraceptive pill. The test was

administered during menstruation and a few weeks later during the Luteal Phase when estrogen and progesterone levels are their highest. Women who were menstruating scored higher than those that were not, consistently across the four studies conducted. Results found that increased spatial ability is caused by higher levels of testosterone in women, though not in men. It is possible that this fluctuation is present in reproductive women, which is why the skill decreases during ovulation, when feminine traits are increased in order to attract a mate.

Neurological structure is also cited as a cause for cognitive differences. Yeo, et al. (2016) conducted the Paper Folding Test from the Johnson O'Conner Research foundation and the Mental Rotations Tests in order to measure the correlation between cortical surface area and cognitive abilities, spatial and verbal. Larger surface area on the cortex across the anterior and posterior brain is seen in men, correlates with superior spatial ability. However, the study did not find a correlation between cortical thickness, volume, or surface area and verbal ability. This correlation between cortical surface and spatial ability was only found in men, there was no correlation found in the women who participated in the study. In fact, there was no method for predicting female cognitive ability found in women with the final hypothesis being that these cognitive skills develop independent of each other in women. In males, testing found that either verbal ability or spatial ability was a strength implying a negative correlation between the two. The study also found a direct correlation between participants who listed their college major as a hard science STEM field and higher spatial ability but not necessarily lower verbal ability.

There are concerns that studies on the differences in spatial ability between the sexes contain biases that exist against women with respect to abilities in general. It is likely that this bias influences both the test and the subjects. Women involved in these studies are adults already and have heard repeatedly that men are good at physical activities and STEM while women are better at things that involve emotion and intuition. This bias is taken into account in a study conducted by Tarampi et al., (2016). This study sought to find if there is a change in the spatial ability of women if the activity was framed from a social perspective. Subjects were divided into groups. The first group was given a test with a neutral introduction that made no mention of gender. The second group was given instructions that pointed out that men are better at spatial ability and that the test measures spatial ability. The third group was given a set of instructions stating that women are better at empathy and that the test measured the

ability to picture things from another person's point of view. There were two versions of the road map test that was administered, one group was given a regular test with no adjustments and another group was given tests with images of a person walking the path they were meant to follow. The original test was preceded with information stating that perspective taking is a measure of spatial ability and that males score higher on measures of spatial ability. The test administered under social conditions, with the human figure, were given information stating that perspective taking ability is a measure of empathy and that females often score higher in this respect. Results showed that tests that measure spatial ability typically favor males but when the tests are adjusted and use human figures females test better and show higher levels of spatial ability. The results suggest that teaching spatial concepts to females would benefit from being adjusted so that perspective taking and empathy are emphasized.

Though a lack of spatial ability would appear to be innate in females, solutions have been found. In *Strategy Training Eliminates Sex Differences in Spatial Problem Solving in a STEM Domain*, Stieff et al. (2013) found that adjustments can be made to teaching methods to compensate for discrepancies in sex differences in spatial ability. Subjects in this study were comprised of 372 students enrolled in an organic chemistry course. These students were divided into three mixed-gender groups: One group was taught analytic intervention strategies in which students were taught using solely diagrams without the use of concrete models. Students in this group were encouraged to use only diagrams and heuristic strategies. The second group was taught using imagistic intervention which allowed for the use of concrete models and spatial gestures when analyzing spatial relationships. Students in this second group were encouraged to mentally visualize spatial relationships. A third group of students was taught combined intervention in which both disciplinary heuristics and imagistic strategies were taught and the use of models was allowed. Students were given the Mental Rotation Test, the Paper Folding Test and Guay's Visualization of Views Test and were given the quizzes and exams typically administered in the Organic Chemistry course. Results showed that the gender gap in spatial ability was closed when students were exposed to both imagistic and analytical training. Traditional imagistic methods are only successful when used by people who already have good spatial reasoning, typically males. Though this study focused solely on organic chemistry, the pedagogy used is likely applicable to any STEM field that requires spatial reasoning skills. Jeng and Liu (2016) found that the gender gap in spatial ability could be narrowed through the use of

interactive 3D mental rotation activities. These skills can be generalized via video game play, which is shown to greatly improve spatial ability in girls.

## **B. Societal Studies**

The invention of the birth control pill in 1956 and its legalization in 1971 were turning points in feminism (Gibson, 2015). This led to women being able to choose when and if they wanted to have children and, not saddled with child-rearing, were given the option to pursue a career. According to the OECD women went from having an average of 2.7 children in 1970 to 1.7 in 2009 (OECD, 2011). Women are also having children at a later age with the average age at which women have children in 2009 being 28 up from 24 in 1970. More women are also choosing to have no children at all, a choice which would appear to be directly correlated with education. The more educated a woman the less likely she is to have children (OECD, 2011). About 30% of women in OECD European countries live in a childless household, this percentage increases up to about 40% when only taking into account women who have achieved a tertiary education (OECD, 2011). Modern day women are also more educated than men with 40% of women aged 25 - 34 receiving a tertiary education compared to 32% of their male peers. Despite their education, women are less likely to be employed and more likely to have part time or seasonal jobs. 70% of women ages 25-54 are employed compared to 85% of men, 21.7% of those women work part-time compared to 4.4% of employed men (OECD, 2011). Employment percentages decrease for women who have more children: 60% of women with one child, 55% with two children and as much as 30% in certain countries for women with three children. Women who work are also tasked with carrying the brunt of home care, with women typically spending at least twice as much time on home care work as men (OECD, 2011).

Despite all of the progress, there is still a prevalent gender gap in STEM fields such as engineering and computer science. A gap in knowledge has previously been cited as a cause but recent studies have found that the math and science gap in testing is virtually non-existent, with girls outperforming boys in elementary school math tests (Bieri Buschor et al, 2014 and Cheryan et al., 2017). While motherhood and a lack of access to education were problems in the past, enough progress has been made that women should have caught up to men in the workforce, including STEM fields. However, the

current gap is likely to be explained by female choice, and cultural and societal forces. Sassier et al. (2016) cited gendered expectations on the part of the employer, in the form of maternal profiling, to be part of the problem. Women's abilities are downgraded and they are seen as less capable and hireable, because they are all seen as potential mothers. These stereotypes mean that putting off marriage and children does not necessarily improve chances for women looking to enter the STEM fields. Ironically, these outdated gender stereotypes work in favor of men entering STEM. While women with liberal, modern gender ideologies are more likely to enter the STEM fields, the opposite is true for men. Most men who enter STEM fields expect spousal support and few family responsibilities (Sassier et al., 2016). The advantages given to men that enter the STEM workforce are the same gender stereotypes that keep women from entering that same workforce.

### ***1. Motherhood***

Women who are interested in both pursuing a career in STEM and having a family are met with many roadblocks. The United States is the only OECD country where women aren't guaranteed paid maternity leave, possibly giving rise to declining female employment rates in the US (OECD, 2011 and Fessenden, 2016). The United States also does not guarantee subsidized day care for children ages newborn to three. Again, this is likely the cause of more women in the US choosing to stay at home, a percentage which increased from 23% to 29% in 2012 (Fessenden, 2016). These lack of resources related to child-bearing force women who want to work and raise a family to choose part time work, which is less conducive to career advancement and provides less pay (Fessenden, 2016). In addition, women with children are more likely to leave STEM careers than single women or men (Adamo, 2013). As stated above marriage and children do not appear to negatively affect the careers of men in STEM. Female students and professionals have reported facing discrimination for being pregnant, with professionals being fired and students being told that their only viable course of action is to drop out of their academic programs (Williams and Massinger, 2016). Once again, health care professions serve as an example of a high stress STEM job that does not display the same attrition rates as other hard sciences with respect to women looking to start a family. In this instance, timing becomes a large factor in female decision making. Pursuing high level health care fields is most competitive when entering medical school, before women are trying to start their family. The most stressful time in a biologist's career is after they finish

school when they are trying to start their career, which coincides with the period in which women typically start their families. When women are forced to choose between a career and a family they are more likely to choose a family (Adamo, 2013). Adamo (2013) states that “it is not motherhood that drives women from science; is it the interaction of motherhood with the corrosive competitiveness that follows from too few positions for too many biologists” (Pg 47).

## ***2. Women's Work***

As previously mentioned, women who enter the work force tend to gravitate towards care giving fields including those who choose to pursue STEM. NSF data on female employment from 2015 shows that while 12.9% of engineers are women, they comprise 73% of Physicians' assistants, 70.5% of Psychologists, 89.4% of registered nurses and 76.3% of primary school teachers (NSF, 2015). This may be due to the societal norms which dictate that caregiving is women's work. Women are the predominant caregivers in the household and caregiving careers are simply seen as an extension of women's domain.

Lee and Tang (2015) conducted a study using data from the Health and Retirement Study (HRS). The aim of the research was to measure the effect of caregiving on labor force participation. The participant sample was comprised of 2,062 men and 3,057 women ages 50-61. Results of their study showed that women were more likely to care for their parents, with 7% of women and 3.6% of men providing care. Caregiving was found to negatively correlate with work force participation for women, this trend was not seen for men. Of the women who stated that they were responsible for spousal caregiving 60.7% reported being employed, compared to 75.3% of women who did not provide caregiving. For men, 87.4% of those providing spousal caregiving were employed compared to 89.9% of men who do not provide caregiving. The results of this study may point to two important factors that contribute to the gender gap. First, it would appear that women are expected to care for their older parents, how much of this is due to some evolutionary trend is not known. Second, that women in these unpaid caregiving positions are less likely to be in the workforce. With respect to the second point, it is of note that men who are caregivers are still able to stay in the workforce, though more research must be done as to why this is. However, it stands to reason that a woman who is interested in a job which requires long hours in the office will be deterred from entering this field if the expectation is that she will care for her elderly parents.

Allen et al. (1999) used data from a previous study, “Cancer Patients Home Care Needs and Costs”, which gathered data on cancer patients with a 6-month survival prognosis and were 21 years or older. This study reached out to the participants to gather information on spousal caregiving. Out of the 1,004 people originally in the study, 353 met the requirements, married with advanced stage cancer and in need of care. The goal of the study was to identify a primary caregiver and how gender affected a large a role the spouse played. Results showed that men were more likely to name their spouse as their primary caregiver, 86.2% of men compared to 61.8% of women listed their spouse. Women constitute the majority of people who are caregivers to the elderly and differently abled. Women are typically the primary caregivers with men providing support and secondary caregivers. In married couples, when the wife needs a caregiver the role is filled by family members as well as her husband. When the husband is in need the wife is typically the sole care giver. This is attributed to the gender norms which dictate that women are better at taking care of the household, raising children and caregiving. They are also more available to fulfill these tasks but as seen above it is at the cost of entering the workforce. For women, caregiving is simply a part of their domain while for men it may be seen as a foreign task. Men have described feeling inadequate when performing caregiving tasks. (Allen et al., 1999) This creates a self fulfilling prophecy in which it is assumed that women are better at caregiving, therefore they are taught these skills and so they become better at this role than men.

Brown (2017) used statistics from the UK Council for Psychotherapy (UKCP), the British Association for Counseling and Psychotherapy (BACP), as well as anecdotal evidence to examine the high percentage of female counsellors but few women in higher level positions such as clinical leads and service directors. Female counselors outnumber men five to one. In the UK 84% of counselors are women. Counseling underpays with most counselors earning less than £10,000 a year and only working 12-13 hours a week. While the first predominant voices in talking therapy were male (i.e. Freud, Jung, Adler), a lot of modern counseling has origins in the women’s movement, with work around rape, sexual violence and domestic abuse being conducted by female volunteers. BACP Chair Andrew Reeves states, “I think there is something about gender socialization that continues to place caring, nurturing, empathetic attributes more along the feminine spectrum and that men continue to be gender socialized along the more controlling, managing, sonic?, thinking spectrum. Men are more programmed to assert themselves, to

articulate themselves and to be taken more seriously” (pg. 2). Men will apply for a job even if they only meet 60% of qualifications while women will only apply if they meet 100%. One of the causes attributed to the lack of women in managerial roles in counseling is attributed to women’s love of counseling and working with patients. However, there are plenty of male counselors who love the work but still progress in their field, it is likely that women are not given the opportunities that men are. This trend is also reflected in the NSF data cited above on the female STEM workforce, while women comprise 73% of physician’s assistants, they are only 37.9% of physicians. In academia, women are 76.3% of primary school teachers, a job which deals with younger pupils and is seen as more nurturing than teachers in college and university, where women are only 46.5% of teachers (NSF, 2015).

Gutsell and Remedies (2015) conducted a study in which they collected data from 291 participants, 103 of which were woman and all of which consisted of undergraduate college students from Brandeis University and Tufts University. The cut off age for participants was 25. A questionnaire was given to participants which measured career preference based on flexibility and how it is influenced by a desire to have children. The study found that women who intend to have children prefer jobs that have flexible hours despite the fact that these jobs tend to pay less and do not allow for professional growth. It also found that women are expected by both genders to be the primary care giver in their household. As such, male dominated fields have longer work weeks and are less flexible but are more lucrative, since it is expected that the largest contribution males make to families is financial.

### ***3. Implicit Bias***

There are also implicit biases held by educators, peers and even female students themselves about female math and science skills. While it does not accurately reflect the academic standing of female students, internalized bias can affect how a female student succeeds. In a study on implicit bias and concept associations, it was found that there is a correlation between low SAT test scores and female students who hold a strong association between math and males (Nosek, 2002). This association has the opposite affect for male students and is hypothesized to correlate with higher SAT scores. It is likely that female students who believe that math is a male trait, create a self-fulfilling prophesy in which they do poorly in math courses and testing, not because of any lack of ability but because they do not believe they can do well, due to their gender. Implicit bias can also effect female students if they are held by educators.

University faculty members, both male and female, are more likely to mentor male students, more likely to respond to emails from male students and more likely to call on male students in class (Grunspan et al., 2016). Discrimination is no longer as obvious as it has been in the past, it now consists of smaller, subtle instances that accumulate over time. This lack of support can cause female students in STEM programs to feel unwelcome and have lower self-confidence. Robinson-Cimpian et al., (2013) found that teachers hold higher expectations for male students and believe that male students have an innate gift for math while girls who do not succeed in math are seen as lacking this innate ability and are more likely to receive praise for nonintellectual aspects than male students. All of this despite the fact that females typically earn higher grades than male students in most subjects including math and science (Cheryan et al., 2017).

A nationwide survey of faculty, postdoctoral fellows and graduate students from 30 academic disciplines, 12 of which were STEM, from public and private universities across the United States was conducted to examine the association between innate intelligence and women (Leslie et al., 2015). The questions measured personal preference in work and academic fields as well as biases about different disciplines. In fields which are believed to require innate talent the gender gap is much more prevalent. Men are linked with brilliance, women are not. The 2011 NSF survey of earned doctorates found that women have earned about half of Ph.D.'s in molecular biology and neuroscience in the United States but less than 20% of those earned in the fields of physics and computer science. The more selective a field is the fewer women employed in that field. There is also a negative correlation between the number of women and the more systematic (as opposed to empathetic) a field is perceived to be. This study did not find a significant correlation between the number of hours worked a week and female preference. Women were perceived as being less suited for fields that are associated with raw talent than their male peers. These same fields are also perceived as being less welcoming to women.

#### ***4. Stereotypes***

Stereotypes can place pressure on an individual and affect their performance. In this case, the stereotype that women are bad at math can affect a female student's performance causing them to do poorly and falling in line with the stereotype. One of the studies cited by Steele (1997), this paper directly measured stereotype threats by administering a math test to college sophomores, pulling questions from the General Records Examination (GRE). One group of students were administered the test and told that

it produced gender differences while another group was told that the exam was insensitive to gender differences. While both groups received the same exam, the women in the first group did significantly worse than their male peers than the women of the second group.

Another stereotype that exists is the idea that the hard sciences are not feminine careers (Cheryan et al., 2017). Women are less likely to enter a STEM field if behavioral expectations in the field (i.e. confidence) clashes with societal gender norms (i.e. modesty) (Cheryan et al., 2017). The masculine culture of STEM fields such as computer science, engineering and physics lead women to feel like they do not belong. Top scoring females in mathematics still choose to pursue social, behavioral, clinical and health fields (Cheryan et al., 2017).

While it has been demonstrated that females have a greater investment in offspring, there is a societal stereotype which states that women are the more caring sex with respect to the environment as well. The roots of this stereotype may be closely tied to those of the previously discussed trend of caregiving being a female dominated work field. The idea that females are the more caring of the two sexes is nothing new, but as women have entered the work force it has forced upon them a limited number of socially acceptable careers (Queller, 1997).

Environmentalism is something that is highly associated with femininity. Brough et al. (2016) found that men are less willing to engage in green behavior if it is labelled as environmentally friendly “green” and “eco-friendly”. The idea that environmentalism is feminine is so prevalent in our society that it keeps men from purchasing green products out of a fear of seeming feminine. While this stereotype likely stems from the idea that women are more likely to care for the environment due to their natural caregiving role, it was further cemented by the ecofeminism movement that gained traction in the 1980s (Resurrección, 2013). The entire basis of ecofeminism is the idea that men and women’s attitudes and ideas of nature are different, with women demonstrating greater knowledge and more care. (Ewen et al., 2015) One of the inherent beliefs in ecofeminism is that women and the environment experience a similar oppression. Women are also more closely associated with nature because they give birth and are more involved in child rearing. Later with the exploitation of nature and the rapid use of nonrenewable resources the connection between women and nature became one in which both were objects to be tamed and ruled. In developing countries women are regarded as having a more in-depth knowledge of nature.

In *A Take on Ecofeminism: Putting an Emphasis on the Relationship between Women and the Environment*, Messina (2009) examines environmental law and policy that addresses the tenants of ecofeminism. Ecofeminism is defined as “an effort to link feminism, the study of women and women’s values with the exploration of environmental issues” (pg. 1121). This movement attempts to illuminate the injustices women (and other minorities) face with ecological damage. Global initiatives such as the United Nations Environment Program (UNEP) acknowledge that ecological disasters affect women, especially those in developing countries, differently than they do men, Women in developing nations are typically in charge of gathering resources and growing food locally, and are exposed to more hazardous materials than men whose work is elsewhere. These women also struggle to gain aid in natural disasters as preferential treatment is given to men. The interconnectedness proposed by the ecofeminism movement cites the relationship between women and “mother earth”. This has led to a belief that women are more connected to the planet than men and understand nature better. It is not likely a coincidence then that most environmental grassroots movements in developing countries are female driven and that the women exhibit the community driven dominance cited by Buss (1981).

Mohair (1991) conducted a study on gender differences in environmental concern and activism via the Survey of the Public’s Attitudes toward Soil, Water and Renewable Resources Conservation Policy. This sample survey was sponsored by the U.S. Department of Agriculture and consisted of 7010 in person interviews, participants included 3255 men and 3755 women. Participant were asked questions which were meant to gauge their environmental concerns. Results demonstrated that women did rate items dealing with the seriousness of environmental problems higher than male participants. Female participants were also more likely to perceive possible future shortages of natural resources. Despite women being seen as caring more about the environment they are not as involved politically as their male counterparts (Mohai, 1991). Socialization has taught women to be “motherly” to be nurturing and caring (Mohai, 1991). Political socialization explains that women are not socialized to be political, while men are socialized to be politically active. However, it is possible that women are so burdened with care giving work that they do not have the free time that their male counterparts do, It is also possible that women are so busy struggling in other social domains the the environment is low on their list of priorities (Mohai, 1991). It is also possible that women struggle with more work at home, less free time and fewer resources

than men and therefore are not able to engage in social activism as much as men. Also of note is that politics, like STEM, is a male dominated field. Women in the United States comprise only 24.5% of State legislators, 19.4% of Congress members and 12% of governors (Kurtzleben, 2016).

Research conducted by Zelezny, Chua and Aldrich (2000) focuses on the idea of ecocentrism, a belief in the inherent value of nature and all living things, which is closely tied to the idea of otherness. Feminine socialization is founded on the idea of otherness, therefore it does not come as a surprise that women are socialized to be the more environmentally friendly sex. This research consisted of 3 studies, one on environmental concerns in children, the second on international environmental concerns and the third was an attempt to explain why differences exist between the genders with respect to environmental concern. The first study distributed a 35 item questionnaire to a sample of primary and secondary school students, 1,293 in total, from various socioeconomic groups in California. This questionnaire was created to gauge environmental concerns. The results demonstrated that girls reported stronger concern about the environment than boys and felt more personal responsibility to improve the environment. The results of this study imply that girls are socialized from a young age to care for the environment. Participants in the second study consisted of 2,160 English and Spanish speaking students, with an average age of 24.72, from Europe, Latin America and the United States. These participants were also given a questionnaire in their native language. Across the 14 countries in which the study was conducted, females reported stronger environmental attitudes, stronger ecocentric values and greater participation in pro-environmental behaviors. The third study consisted of 119 university students (79 females and 40 males) who volunteered to answer a questionnaire to measure environmental attitudes, gender orientation, the ability to take the role of the other and ethic of care to take responsibility for ameliorating social problems. Results showed that females reported more concern for the environment, were more able to take on the role of the other and reported stronger levels of social responsibility. The results of this study support the theory that gender differences in environmentalism are caused by socialization.

However, despite the prevalence of the idea that the environment is a female domain, the gender gap is still apparent in the environmental sciences workforce. According to the Bureau of Labor Statistics women comprise 30% of environmental scientists and geoscientists, 43.4% of conservation scientists and foresters. The U.S. Forest Service reports that 37% of their labor force is female. (Chavez,

2017). These numbers are comparable to those of higher level medical professionals. Women comprise 46.9% of medical scientists, 75.6% of healthcare practitioners and technical occupations, a large category which is broken into subheadings like chiropractors (27.4%), registered nurses (90%), and physicians and surgeons (38.2%). It is also common to see women study environmental studies at University but not enter the workforce. Chavez (2017) states that 61% of the students in the environmental studies program at UNC Asheville are women. However, only 28.5% of U.S. Forest Service in North Carolina is female. At Great Smokey Mountain National Park 24% of permanent employees are females.

As mentioned above, stereotype threat can deter a person from engaging in an activity that is not associated with their identity. It is more difficult to see then, why there are not more women working in a STEM field that is closely associated with their gender. It is possible that this is due to fact that the ideas put forth by ecofeminism do not fit the characterizations society attributes to scientists. Ecofeminism emphasizes the idea that men and women are different, that women are mothers and kin to mother nature and the women are like nature in that they are both oppressed by mainstream culture. The STEM workforce on the other hand, emphasizes maleness and a lack of distractions (such as offspring). The women one thinks of when discussing ecofeminism are mother in developing countries fighting to protect their environment and livelihood, not female scientists in lab coats or women working for the US Forestry Service.

### ***6. Toxic STEM Culture***

Finally, I feel it would be remiss to ignore the toxic levels of sexual harassment in STEM academia and the workforce. Hyper masculinity, is defined as “the exaggeration of masculine stereotypes”, involves the use of competitiveness, dominance, gender role stress, and anti-gay behavior to reinforce masculinity (Morley, 2011). This hyper masculinity manifests as misogynist backlash when a perceived invasion or threat of feminization occurs. A study conducted in 2014 found that 71% of female scientists had been sexual harassed in the field while 26% had been sexually assaulted (Scoles, 2016). Investigations into the numerous accounts of sexual harassment in the Parks Service have begun despite denial from the community (Washington Post, 2016).

The idea of femininity having no place in STEM is addressed in the first-hand account of Eve Forster (Forster, 2017). Forster first observed a correlation between femininity and a lack of perceived

authority when she faced backlash from her students after she transitioned from a less feminine hairstyle to wearing her hair down. Forster, a neuroscientist, conducted an informal experiment on twitter by changing her avatar from her original genderless cupcake to an image of a female scientist and then a male scientist. As expected, Forster received less backlash when tweeting with the male scientist avatar than when she tweeted with the female scientist avatar. Forster also noted that she felt more confident when tweeting from the “male” account because she knew that in the case she tweeted a mistake, she would be given the benefit of the doubt (her own words) as opposed to the female account which was constantly criticized for things as small as including a typing error in a tweet.

The gaming industry provides the most glaring examples of the backlash against women who enter male designated spaces. The #gamergate incident is one of the most famous examples of a woman threatening the masculine status quo in a predominantly male STEM field. The hashtag was created in 2014 by actor Adam Baldwin to bring attention to the growing theory that the gaming industry was being undermined by feminists. This theory was first put forward after the creator of a game called Depression Quest, Zoe Quinn, was accused via social media of trading sex for positive game reviews. Once the hashtag spread Quinn was flooded with death threats (Chess and Shaw, 2015). Another instance is that of well-known celebrity and gamer Felicia Day who was insulted and harassed via a series of tweets by video game journalist Ryan Perez. Despite her being well known in the gaming world, creating a channel on YouTube dedicated to gaming, starring in multiple tv series which are loved in the nerd community, and having been the basis and voice of for a chapters in the Dragon Age series, Day was dismissed as a “glorified booth babe” (Tomkinson and Harper, 2015). Finally, Anita Sarkeesian, a vlogger, received graphic images of herself being raped by video game characters after starting a kickstarter campaign to gain funding for a video series on the portrayal of women in video games (Tomkinson and Harper, 2015). The fact that all of these rumors were proven to be false did not affect the number of death and rape threats the women received. The opposition to women in gaming is likely the cause of the discrepancy between number of female video game consumers and the female video games workforce. While women consist of nearly half of the people who purchase video games and consoles, they are practically nonexistent in the higher level positions at game developers. In the U.S. in 2014 only 13% of people working in the video game industry were women (Skarda, 2014). This backlash against women in the

gaming industry is targeted at the few female developers, bloggers and critics who attempt to break into the male dominated field. It is obvious that some men feel the need to protect the fields that they have always dominated and any threat to that dominance is met with extreme anger. While the gaming community is an obvious example of a male dominated space and the pushback that females get when trying to “invade” such a space, this trend manifests in most STEM fields in more quiet ways. Women who enter male-dominated work fields must assume that they will face sex harassment. These issues are not addressed since women are punished for speaking out or dismissed completely.

#### **IV. Discussion**

While there is no one clear solution to ameliorate the gap problem, there are measures that society, academia and the STEM community can take to ensure that more women have the opportunity to pursue careers in STEM fields if they choose. While certain policies (e.g. paid maternal leave and child care services) would help to make pursuing a career easier for a woman who also wants to have children, ideally a woman would not have to choose between the two. Guaranteed family leave for men would ensure that the woman would not have to be the only care giver in the household. While our evolutionary history has predisposed females to being the primary care giver, technology such as breast pumps allow for men to take more of an active role in child rearing. The idea of men having the option to stay home and raise children needs to become the new normal, rather than being seen as something that attacks their masculinity. There are also measures that educational institutions can take to make STEM more inviting and inclusive to their female coeds. Carnegie Mellon University removed the computing experience prerequisite for admission into their computer science program, included discussions about diversity into their curriculum, created a peer support network and supported more female teaching assistants. As a result of their initiative, in less than a decade, the percentage of female computer science students at the university increased from 10% to 40%. The University of Washington doubled their percentage from 15% to 30% via a similar initiative (Cheryan et al., 2017). A simulation found that the number of women majoring in STEM in college would increase if high school science students were required to take only one more year of a science course. (Cheryan et al., 2017). In fact, countries that have higher STEM requirements have a smaller gender gap in college (Cheryan et al., 2017). While in the US females are more likely to take high school level biology and chemistry, they opt out of courses like physics and

computer sciences (Cheryan et al., 2017). Marketing a career in STEM as a field in which one can help others might also get more females to pursue STEM as women are more likely to choose people oriented jobs (Cheryan et al., 2017).

Finally, it is important to continue studying the societal biases and norms that contribute to the gender gap and inform the general public and the STEM community of the issues. Handley et al. (2015) conducted a study in which they measured how receptive people are to research demonstrating that the gender gap in STEM exists. The results not only show that men view this research less favorably than women do, but that men in the STEM field are even less receptive than those in other fields. Because the current STEM workforce is predominantly male, and men comprise most of the higher positions, their denial of the problem is even more worrisome, as this issue can not be resolved if it is not even addressed. Handley, et al. posit that men in the STEM workforce are not receptive to this research because solving the problem might lead to their losing standing in their respective fields. As mentioned earlier in this paper in the section on toxic STEM culture, there is a perceived threat to masculinity when women try to enter an masculine dominated field.

## **V. Conclusion**

Among mammals, the difference in reproductive effort between the sexes has led to differences in reproductive strategies, with females saddled with the bulk of parental investment. When considering humans specifically, these differences in reproductive strategies have favored females who contribute much more to raising young to adulthood, limiting them from entering the workforce and, when they do, predisposing them to “care-giver” careers. Biological factors such as the greater investment in male offspring or possibly a lack of investment in the education of female offspring, greater demands on females with respect of offspring investment, female risk aversion and weaker spatial ability in females lead to the gap in the STEM workforce. These biological factors may have manifested as societal factors such as an expectation placed on women to become mothers and to provide more unpaid caregiving work to family members, as well as implicit biases and stereotypes and a toxic STEM culture which is not receptive to women. Today, despite advancements in birth control and child care, a stigma remains in the STEM community which appears to limit modern women from entering the workforce. Changes to work policy, academia and cultural biases could possibly help finally close the gender gap in STEM.

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