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Women in Science: Biological Factors Should Not Be Ignored

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WOMEN IN SCIENCE: BIOLOGICAL FACTORS SHOULD NOT BE IGNORED

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When Harvard President Lawrence H. Summers suggested that innate sex differences might partially account for women's low levels of representation in certain scientific fields,[1] he provoked a torrent of outrage. One woman walked out claiming that his remarks caused her to feel physically ill, and another announced that she would no longer donate to Harvard.[2] Yet another critic commented that Summers had unleashed an "intellectual tsunami."[3]

Unfortunately, the "intellectual tsunami" turned out to be an emotional one instead, and despite the nuanced and tentative nature of his suggestions, Dr. Summers apparently felt compelled, perhaps for institutional reasons, to retreat from the beach to avoid being engulfed in the maelstrom. He has apologized repeatedly and announced a new initiative to recruit women into the sciences.[4] Not one but two task forces have been created to figure out how to recruit more women,[5] and based upon the recommendations of these task forces he has pledged at least $50 million to increase faculty diversity.[6] A more fitting response might have been to convene a conference to study diversity in the sciences that actually considered all potential causes rather than blindly assuming that discrimination and sexist socialization are to blame for every unwelcome statistic. Such examination would disclose that the suggestion that Summers made so tentatively could legitimately have been stated with much greater force.

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1 Lawrence H. Summers, *Remarks at NBER Conference on Diversifying the Science & Engineering Workforce*, January 14, 2005, *available at* http://www.president.harvard.edu/speeches/2005/nber.html (last visited Apr. 18, 2005).

2 *See* Sam Dillon, *Harvard Chief Defends His Talk on Women*, N.Y. TIMES, Jan. 18, 2005, at A16.

3 Sam Dillon & Sara Rimer, *No Break in the Storm Over Harvard President's Words*, N.Y. TIMES, Jan. 19, 2005, at A14.

4 *See* Sara Rimer, *Harvard President Apologizes Again for Remarks on Gender*, N.Y. TIMES, Jan. 20, 2005, at A14; *see also* Sam Dillon & Sara Rimer, *President of Harvard Tells Women's Panel He's Sorry*, N.Y. TIMES, Jan. 21, 2005, at A19.

5 *See* Sam Dillon & Sara Rimer, *Harvard Seeks to Advance Opportunities for Women*, N.Y. TIMES, February 4, 2005, at A16.

6 *See* Alan Finder, *Harvard Will Spend $50 Million To Make Faculty More Diverse*, N.Y. TIMES, May 17, 2005, at A1.

Dr. Summers' mistake, in the eyes of his critics, was in treating the question as an empirical one—to which facts would be relevant—rather than as a moral one that would be sullied by anything so coarse as scientific data. Apart from Summers' remarks, the two-day-long conference on diversity in the sciences apparently was spared any suggestion that innate sex differences might have anything at all to do with sex differences in career choices. That is not because no one thinks that they do, but because anyone who would say that such differences even *might* play a role would not be welcome to speak at such a conference, as Summers' experience demonstrates.

There are two fundamental questions that must be addressed in evaluating whether sex differences in occupational outcomes are at least in part a consequence of biologically influenced psychological sex differences. First, are there observable differences between men and women in traits that influence occupational choice? Second, do any differences that are found have biological underpinnings? The latter question is by far the more hotly disputed one. The dispute, it should be noted, is not between those who attribute observed sex differences entirely to social factors and those who attribute them entirely to biological ones. Instead, the dispute is between those who attribute the differences wholly to social factors and those who believe that biology and culture both play important roles. Thus, the suggestion offered here is not that social factors, sometimes including outright discrimination, are not part of the story. Instead, it is that the whole story cannot be understood without taking biologically influenced sex differences into account.

At one level, few people would deny the contribution of biology to sex differences in occupational distributions. Not even the most committed social constructionist would (I think) deny that biology presents some major impediments to equal representation of men and women in some jobs, such as linebacker in the National Football League. However, such an extreme example is as far as many are willing to go in conceding the role of biology. Others, myself included, believe that the role of biology is not limited to physical strength differences and that men and women differ (on average[7]) in both cognitive and temperamental traits that affect their talent for and interest in particular occupations.[8]

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[7] It should go without saying, but perhaps it cannot, that this entire discussion deals with group differences. The point is not that *no women* and *all men* are a particular way, but simply that group distributions are different. Thus, to say that men, on average, are taller than women does not mean that no women are taller than some men; indeed, some women are taller than most men. It does mean, however, that in an enterprise requiring substantial height, such as professional basketball, men will be more heavily represented than women even in the absence of sex-biased selection.

[8] *See generally* KINGSLEY R. BROWNE, BIOLOGY AT WORK (Rutgers University Press 2002) [hereinafter BIOLOGY AT WORK]; DOREEN KIMURA, SEX AND COGNITION (MIT Press 1999); Kingsley R. Browne, *Evolved Sex Differences and Occupational Segregation*, J. ORG. BEHAV. (forthcoming 2005); David C. Geary, *Sex Differences in Mathematical Abilities: Commentary on the Math-Fact Retrieval Hypothesis*, 24 CONTEMP. EDUC. PSYCHOL. 267 (1999); Ernest Govier & Janice Feldman, *Occupational Choice and Patterns of Cognitive Abilities*, 90 BRIT. J. PSYCHOL. 99 (1999); Rose Mary Webb et al., *Mathematically Facile Adolescents with Math-Science Aspirations: New Perspectives on their Educational and Vocational Development*, 94 J. EDUC. PSYCHOL. 785 (2002).

Although average differences between the sexes tend to get the most attention, males tend to be more variable than females on most psychological measures, so that even with no average difference, there is often a disproportionate number of males who are extremely good or extremely bad on the measure in question.[9] For example, although no sex difference appears on most intelligence tests, which are normed to an average IQ of 100 and designed to yield equal means for males and females, males outnumber females by approximately 20% in the above-140 group and by an even greater amount among those below 70.[10]

Even when it comes to mentally demanding jobs such as research scientist at leading universities, there is probably general agreement that biology plays a large role in explaining why *some men* obtain such positions and *other men* do not. As Dr. Summers pointed out,[11] when we are talking about the population of people who have the ability to participate at the very highest levels in fields like mathematics and physics, we are not talking about people in the top 2% of ability but more likely those in the top one-tenth or even one-hundredth of 1%. Thus, only a small fraction of 1% of all men have the mental capacity and temperament to obtain such a job, and much of what separates those who can from those who cannot relates to innate endowment. Similarly, only a tiny fraction of women have the mental capacity and temperament for such a job. Thus, the area of disagreement ends up being quite narrow: the question is whether the tiny percentage of men biologically suited for the job is exactly the same as the tiny percentage of women suited for the job, so that we should expect that the same number of men and women (with only random differences) would find positions in each department in a university. Even if there were no average sex differences in the relevant cognitive and temperamental traits—which, as we will see below, there are—such parity would be unlikely given the greater variability of males and their resultant tendency to be more heavily represented at the extreme ends of distributions.

Large sex differences are observed in a number of scientific disciplines and in academic disciplines more generally. Although it is women's "under-representation" in science that is at the core of the current controversy, women are "over-represented" in other disciplines.[12] We will see that women tend to be under-represented in fields imposing high mathematical and spatial demands and having a low social dimension (for example, physics, engineering, and mathematics). In contrast, they tend to be more heavily represented in disciplines

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9 *See* ARTHUR R. JENSEN, THE G FACTOR: THE SCIENCE OF MENTAL ABILITY 535 (Praeger 1998).

10 *See* ARTHUR R. JENSEN, STRAIGHT TALK ABOUT MENTAL TESTS 249 (Free Press 1981).

11 Summers, *supra* note 1.

12 The terms "over-represented" and "under-represented" refer to the tendency of one of the sexes to be represented in greater or lesser numbers than its proportion of the population. No judgment is being expressed about what the representation of the sexes "should" be.

that have high verbal content and a higher social dimension (for example, the humanities and the social sciences). Existing data concerning psychological sex differences provide a better explanation for this pattern than does some hypothesized differential sexism of the various fields.

Although ability and interest are necessary attributes for successful pursuit of a career as a scientist at top universities, they are not sufficient. Success in these demanding and competitive fields also requires tremendous drive and energy. Long hours are necessary to generate the research and publications that lead to stature in the field. For a variety of reasons, both biological and social, women tend to be less willing than men to subordinate everything else in their lives to careers,[13] which affects women's representation not only in all-consuming science careers but also in similarly demanding positions in corporations and in law firms.[14]

It is perhaps ironic that expansion of opportunities for women has increased the effect of biological sex differences on occupational patterns. When many fields were mostly closed to women, social barriers made biological differences largely irrelevant. As social barriers have been removed and opportunities for women have expanded, the relative influence of biological sex differences on occupational distributions has increased. Parallel patterns are observable in sports, where social influences on sex differences in athletic performance were very large when social norms prevented females from reaching their athletic potential. Now that girls are exposed to, and encouraged in, sports from a young age, a much larger portion of observed sex differences in athletic performance stems from biological causes.[15]

Those who believe that women's relatively slow advancement in scientific occupations is a consequence of male resistance to women are faced with a paradox: women seem to have made the least progress in occupations that provide the most concrete measures of successful job performance. As psychologist Doreen Kimura has commented:

> Why anyone should imagine that [a conspiracy against women] could be maintained in a manifestly egalitarian discipline is never made clear. Science, more than most disciplines, has quite explicit rules of evidence and fairly objective criteria for excellence. We might therefore expect success in science to be, if anything, *more* rather than less related to merit, than in other areas of scholarship.[16]

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[13] *See* Jacquelynne S. Eccles, *Gender Roles and Achievement Patterns: An Expectancy Value Perspective, in* MASCULINITY/FEMININITY: BASIC PERSPECTIVES 245 (June M. Reinisch et al. eds., 1987) (noting that men are more likely to exhibit a "single-minded devotion" to their occupational role and an "excessive concern over [their] work to the exclusion of other concerns," which is consistent with men's general tendency "to exhibit a single-minded devotion to one particular goal").

[14] *See* BIOLOGY AT WORK, *supra* note 8, at 42-44, 73-74.

[15] See Robert O. Deaner, *More Males Run Fast: A Stable Sex Difference in Competitiveness in U.S. Distance Runners*, EVOLUTION & HUM. BEHAV. (forthcoming 2005).

[16] KIMURA, *supra* note 8, at 76.

However, it is in academic disciplines in which assessment of scholarly quality is more subjective and thus especially vulnerable to subtle forms of discrimination (the humanities and social sciences as opposed to the physical sciences and engineering) that women have made the greater strides.

At bottom, the central question is whether one would expect men and women, absent invidious social pressures, to sort themselves into jobs in just the same way, so that statistical disparities necessarily reflect flaws in the system. This seems to be the assumption underlying the complaints we have all grown so accustomed to hearing, such as "Women constitute X percent of the labor force, but only Y percent of engineers/firefighters, etc.," with the explicit or implicit assumption that the extent of deviation of Y from X is a measure of injustice. It must be recognized, however, that the assumption that men and women should be represented equally in all endeavors rests on the foundational assumption that men and women have identical talents, tastes, and preferences. That, it will be seen below, is simply not the case.

I. A FEW OCCUPATIONALLY RELEVANT SEX DIFFERENCES

A variety of differences between the sexes in cognitive and temperamental traits almost certainly affect occupational distributions.[17] Scientific fields like physics, mathematics, and engineering require very high levels of both mathematical and spatial ability, and males predominate at the highest levels of both. For example, among perfect scorers on the mathematics portion of the SAT, the ratio of males to females is about three to one.[18] Even that statistic is misleading, however, as the "ceiling effect" of the SAT is substantial. That is, there are relatively large numbers of test-takers who receive perfect scores (around 5,000 per year), so the SAT fails to discriminate well at the very high end. When the SAT is given to seventh-graders, however, the ceiling effect is less pronounced, so that the sex ratio among those who score over 760 is approximately seven boys for each girl.[19]

Although spatial ability is not typically screened for in admission to science programs, it is an important predictor of success in scientific fields.[20] Males outperform females on most spatial tasks, with three-dimensional mental rotation showing the largest and most reliable sex difference.[21] A review of mental-rotation studies found that the male mean exceeded the female mean by approximately two-

[17] *See generally* BIOLOGY AT WORK, *supra* note 8, 50-67.

[18] College Board, *2000 SAT I Test Performance by Gender, available at* http://www.collegeboard.org/sat/cbsenior/cbs/cbs00/topsrs00.html (last visited Apr. 27, 2005).

[19] E-mail from Julian C. Stanley, Professor of Psychology Emeritus, Center for Talented Youth, Study of Exceptional Talent, Johns Hopkins University (Apr. 25, 2005, 14:37:20 EST) (on file with author).

[20] *See* Daniel L. Shea, David Lubinski, & Camilla P. Benbow, *Importance of Assessing Spatial Ability in Intellectually Talented Young Adolescents: A 20-year Longitudinal Study*, 93 J. EDUC. PSYCHOL. 604 (2001).

[21] KIMURA, *supra* note 8, at 53.

thirds of a standard deviation, and in many studies, it approached or exceeded a full standard deviation.[22] Because males tend to be more variable than females on most traits, even if males and females scored the same on average, there would be more males at the extreme high end (and at the low end, as well). A higher male mean combined with greater male variability means that the sex ratio at the extreme high end of the distribution is especially skewed.

There is sometimes a tendency to view the gifted as a relatively homogeneous group, but they are actually highly diverse in ability. For example, in a typical IQ test with a mean of 100 and a standard deviation of 15, the ability range of the top 1%—the extreme right tail of the distribution—is as broad as the range from the bottom 2% to the top 2%. The middle 96% of the range runs from about 66 to 134, while the top 1% ranges from about 135 to over 200.[23] Males especially outnumber females in the top quarter of the top 1% of mathematical ability. Although one might suppose that there is a point of diminishing returns beyond which additional ability has no payoff, that does not appear to be the case in science. For example, Camilla Benbow and David Lubinski have found significant differences between those individuals in the top and bottom quarters of the top 1% on measures such as earning a degree in science, level of college attended, grade-point average, and intensity of involvement in math and science.[24] Indeed, individuals in the top quarter of the top 1% are four times as likely as individuals in the bottom quarter of the top 1% to earn math-science Ph.Ds.[25] Thus, it is simply erroneous to assert, as 79 signatories to a letter to *Science* magazine did, that "there is little evidence that those scoring at the very top of the range in standardized tests are likely to have more successful careers in the sciences."[26] On the contrary, as Wai, Lubinski and Benbow put it, these data "falsify the idea that after a certain point more ability does not matter" and show that "[m]ore ability always seems to matter."[27]

In contrast to the better performance of males on tests of mathematical and spatial ability, females tend to outperform males on a number of measures of verbal ability, including spelling, grammar, and verbal memory. In fact, in broad samples, the female advantage in verbal abilities exceeds the male advantage in mathematical ability. In 1996, for example, male eleventh-graders scored at about the same level as female eighth-graders on the National Assessment of Educational

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22 Daniel Voyer et al., *Magnitude of Sex Differences in Spatial Abilities: A Meta-Analysis and Consideration of Critical Variables*, 117 PSYCHOL. BULL. 250 (1995).

23 Camilla P. Benbow & David Lubinski, *Psychological Profiles of the Mathematically Talented: Some Sex Differences and Evidence Supporting Their Biological Basis*, *in* THE ORIGINS AND DEVELOPMENT OF HIGH ABILITY, at 44 (Ciba Foundation Symposium) (1993).

24 *Id.*

25 Jonathan Wai et al., *Creativity and Occupational Accomplishments Among Intellectually Precocious Youth: An Age 13 to Age 33 Longitudinal Study*, J. EDUC. PSYCHOL. (forthcoming 2005).

26 Carol B. Muller et al., *Gender Differences and Performance in Science*, 307 SCIENCE 1043 (2005).

27 Wai et al., *supra* note 25.

Progress (NAEP).[28] In more select samples, however, the female verbal advantage often declines or disappears, because of greater male variability. Males consistently outscore females on the verbal portion of the SAT, for example, though by only a small margin.[29] On the other hand, on the ACT, which tends to focus on curriculum-based knowledge rather than on the verbal reasoning emphasized by the SAT, girls outperform boys.[30] The lower male mean for verbal ability, coupled with greater male variability, translates into a substantial disproportion of males at the very lowest levels of verbal ability.

Consideration of only a single dimension of an individual's cognitive ability, rather than the entire pattern, can be misleading. One reason that mathematically talented women tend to be found in disciplines other than math and science is not that their opportunities are narrower by comparison to men, but rather that they are broader. Men who are high in mathematical ability tend to have much higher mathematical ability relative to verbal ability, while women high in mathematical ability tend also to be high in verbal ability. Thus, women with high mathematical ability are considerably more likely than men with high mathematical ability to pursue study in fields that require high verbal ability, such as in the humanities, rather than math or science.[31]

Apart from cognitive differences, the sexes also differ in temperament and personality. On most measures of direct competitiveness, for example, males score higher than females.[32] Competition tends to be a more positive experience for males, and adding a competitive element to a task increases the intrinsic motivation of males but does not do so for females.[33] The perception that an academic program is competitive tends to result in improved performance by males but decreased performance by females.[34] Relatedly, males also engage more than females in dominance behaviors—that is, behaviors intended to achieve or maintain

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28 National Center for Education Statistics, *Trends in Educational Equity of Girls & Women*, *at* http://nces.ed.gov/pubs2000/2000030.pdf (last visited Apr. 19, 2005).

29 College Board, *SAT Verbal and Math Scores Up Significantly as a Record-Breaking Number of Students Take the Test (2003)*, *at* http://www.collegeboard.com/prod_downloads/about/news_info/cbsenior/yr2003/pdf/CBS2003Report.pdf (last visited Apr. 27, 2005).

30 ACT, Inc., *ACT High School Profile: HS Graduating Class (2004)*, *at* http://www.act.org/news/data/04/pdf/t6-7-8.pdf.

31 David Lubinski et al., *Top 1 in 10,000: A 10-Year Follow-Up of the Profoundly Gifted*, 86 J. APPLIED PSYCHOL. 718 (2001).

32 BIOLOGY AT WORK, *supra* note 8, at 14-19; Andrew Ahlgren, *Sex Differences in the Correlates of Cooperative and Competitive School Attitudes*, 19 DEV. PSYCHOL. 881 (1983); Richard Lynn, *Sex Differences in Competitiveness and the Valuation of Money in Twenty Countries*, 133 J. SOC. PSYCHOL. 507 (1993).

33 Regina Conti et al., *The Impact of Competition on Intrinsic Motivation and Creativity: Considering Gender, Gender Segregation and Gender Role Orientation*, 31 PERSONALITY AND INDIVIDUAL DIFFERENCES 1273 (2001).

34 KATHARINE & KERMIT HOYENGA, GENDER-RELATED DIFFERENCES: ORIGINS AND OUTCOMES 319 (Allyn & Bacon 1993).

a position of high relative status—in order to obtain power, influence, or resources.[35]

The sexes also vary in risk preference, with males exhibiting a greater preference for both physical and nonphysical risks. Indeed, sex is the variable most predictive of the extent of participation in high-risk recreation.[36] Men are also disproportionately represented in physically risky employment, as reflected in the fact that over 90% of all workplace deaths in the U.S. are males.[37] Commenting on their study of female executives, Margaret Hennig and Anne Jardim observed that "men see risk as loss or gain; winning or losing; danger or opportunity," while "women see risk as entirely negative. It is loss, danger, injury, ruin, hurt."[38]

Females also tend to exhibit more nurturing behavior than males, both inside and outside the family. The greater female interest in infants—present from childhood[39]—increases at puberty.[40] The more social orientation of females is reflected in a consistently found sex difference in "object versus person" orientation, with females tending to be more "person-oriented" and males tending to be more "object-oriented."[41]

These temperamental differences are reflected in occupational interests. Sex differences are consistently found on measures of occupational interest such as the Strong Interest Inventory and the Self-Directed Search, which measure occupationally relevant aspects of personality. Men tend to score higher on the "Realistic" (enjoying building and outdoor work and working with "things") and "Investigative" dimensions (interested in abstract problems and understanding the physical world), and women score higher on the "Artistic" (enjoying creating or experiencing art, music, and writing) and "Social" dimensions (enjoy interacting with people, helping, and instructing).[42]

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35 Allan Mazur & Alan Booth, *Testosterone and Dominance in Men*, 21 BEHAV. & BRAIN SCI. 352 (1998).

36 Michael P. Schrader & Daniel L. Wann, *High-Risk Recreation: The Relationship Between Participant Characteristics and Degree of Involvement*, 22 J. SPORT BEHAV. 426 (1999).

37 Bureau of Labor Statistics, *Fatal Occupational Injuries by Worker Characteristics and Event of Exposure, All United States, 2002* (2003), *at* http://www.bls.gov/iif/oshwc/cfoi/cftb0161.pdf (last visited Apr. 27, 2005).

38 MARGARET HENNIG & ANNE JARDIM, THE MANAGERIAL WOMAN 23 (Anchor Press/Doubleday 1977).

39 Judith E.O. Blakemore, *Children's Nurturant Interactions with Their Infant Siblings: An Exploration of Gender Differences and Maternal Socialization*, 22 SEX ROLES 43 (1990).

40 Susan Goldberg et al., *Menarche and Interest in Infants: Biological and Social Influences*, 53 CHILD DEV. 1544 (1982).

41 DAVID C. GEARY, MALE, FEMALE: THE EVOLUTION OF HUMAN SEX DIFFERENCES (American Psychological Association 1998).

42 Alan S. Kaufman & James E. McLean, *An Investigation into the Relationship Between Interests and Intelligence*, 54 J. CLINICAL PSYCHOL. 279 (1998).

II. THE BIOLOGICAL ORIGINS OF DIFFERENCES

Many concede that some or all of the above-described sex differences exist, but nonetheless maintain that they are wholly products of socialization. Males, under this view, have been taught to take risks, compete for dominance, and excel at math and science, while females have been taught that math and science are "for boys" and that they should play with dolls, avoid taking risks, and not be "pushy." This argument relies, at least implicitly, on the notion that the human mind, unlike the mind of every other mammal, is sexually "monomorphic"—an implausible assumption for those who believe that humans have evolved from nonhuman animals, none of whom display such a mind[43]—and it implies that if not for differential socialization, males and females would have identical tastes and abilities. This argument runs up against substantial circumstantial evidence against it, as well as substantial evidence directly implicating biology.

The argument that behavioral sex differences are purely products of indoctrination into society's expectations of sex-appropriate behaviors is difficult to square with the finding that many behavioral sex differences, including toy choices and playmate preferences, appear before children can identify their own sex or the sex of others.[44] Even among newborns, females exhibit a greater interest in human faces and males a greater interest in mechanical objects.[45] Although cognitive sex differences are relatively modest before puberty, psychologist Diane Halpern has observed that "the male advantage in transforming information in visual-spatial short-term memory is seen as early as it can be tested—perhaps at age 3—and in mathematical giftedness as early as preschool."[46] The fact that psychological sex differences increase at puberty—an observation sometimes erroneously invoked as support for a socialization argument—parallels the increased physical dimorphism associated with puberty, which is also a result of the tumultuous hormonal changes occurring at that time.

Although boys and girls are sometimes treated differently—though less differently than often thought[47]—there is much evidence that at least part of the differential treatment accorded boys and girls is a result of differences in the

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[43] *See* BIOLOGY AT WORK, *supra* note 8, at 117-129 (discussing the evolutionary origins of temperamental and cognitive differences); *see generally* Kingsley R. Browne, *Sex and Temperament in Modern Society: A Darwinian View of the "Glass Ceiling" and the "Gender Gap" in Compensation*, 37 ARIZ. L. REV. 971 (1995).

[44] *See* Lisa A. Serbin et al., *Gender Stereotyping in Infancy: Visual Preferences for and Knowledge of Gender-Stereotyped Toys in the Second Year*, 25 INT'L J. BEHAV. DEV. 7 (2001).

[45] *See* Jennifer Connellan et al., *Sex Differences in Human Neonatal Social Perception*, 23 INFANT BEHAV. & DEV. 113 (2000).

[46] Diane F. Halpern, *Sex Differences in Intelligence: Implications for Education*, 52 AM. PSYCHOLOGIST 1091, 1093 (1997). *See also* Susan C. Levine et al., *Early Sex Differences in Spatial Skill*, 35 DEV. PSYCHOL. 940 (1999).

[47] *See* Hugh Lytton & David M. Romney, *Parents' Differential Socialization of Boys and Girls: A Meta-Analysis*, 109 PSYCHOL. BULL. 267 (1991).

children themselves.[48] Social constructionists generally assume that the arrow of causation always points from the parent to the child. Christine Williams, for example, attributes women's "greater desire and need for emotional intimacy" to the greater frequency with which parents caress and hold their infant daughters.[49] It may, however, be the other way around. A study of adults' perceptions of infants found that individuals blind to the sex of newborns rated female infants substantially more "cuddly" than male infants.[50] This finding makes it problematic to conclude that later emotional sex differences were caused by differential cuddling of boys and girls. It seems equally plausible, if not more so, that parents are more likely to cuddle particularly "cuddly" infants and that particularly cuddly infants are more likely to be girls than boys.

Many of the sex differences we observe in our society are replicated in societies around the world,[51] and everywhere people tend to hold the same stereotypes of men and women.[52] If males and females did not differ in fundamental ways, it would be surprising to find that they are either socialized to be different in a consistent fashion throughout the world or that people consistently, but mistakenly, believe them to be different.

In the context of sex differences in mathematical ability, some seize on international comparisons to suggest that sex differences cannot be biological because they vary from country to country. The current poster child for this school of thought is Iceland. As three university presidents asked in an editorial in the *Washington Post*, "if innate differences play a role in SAT scores, how do we explain the mathematics scores in countries such as Iceland, where girls outshine boys on standardized international and national exams?"[53] Certainly, it is an interesting fact that Iceland, a country with a population only slightly smaller than that of metropolitan Green Bay, Wisconsin,[54] is alone among the 41 countries participating in the Program for International Student Assessment (PISA) in which girls outperform boys in mathematics.[55] It is a slender reed upon which to build a claim that biological influences have been disproven, however, just as one should

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[48] *See generally* JUDITH R. HARRIS, THE NURTURE ASSUMPTION: WHY CHILDREN TURN OUT THE WAY THEY DO (1998).

[49] CHRISTINE L. WILLIAMS, GENDER DIFFERENCES AT WORK: WOMEN AND MEN IN NONTRADITIONAL OCCUPATIONS 11 (1989).

[50] Joyce F. Benenson et al., *Sex Differences in Neonates' Cuddliness*, 160 J. GENETIC PSYCHOL. 332 (1999).

[51] *See* Geary, *supra* note 8.

[52] *See generally* JOHN E. WILLIAMS & DEBORAH L. BEST, MEASURING SEX STEREOTYPES: A MULTINATION STUDY (1990).

[53] Gerald Goldin et al., *How Summers Offended: Harvard President's Comments Underscored the Gender Bias We've Experienced*, WASH. POST, Feb. 20, 2005, at A27.

[54] Iceland's population was 288,471, as of December 31, 2002. STATISTICS ICELAND, ICELAND IN FIGURES 2003-2004, *available at* http://www.iceland.is/media/Utgafa/Iceland2003.pdf (last visited Apr. 19, 2005). Metropolitan Green Bay's population was 291,000, as of December 31, 2003. U.S. CENSUS BUREAU, *Population*, *in* STATISTICAL ABSTRACT OF THE UNITED STATES: 2004-2005, *available at* http://www.census.gov/prod/2004pubs/04statab/pop.pdf (last visited Apr. 27, 2005).

[55] MARIANN LEMKE ET AL., U.S. DEP'T OF EDUC., *International Outcomes of Learning in Mathematics Literacy and Problem Solving: PISA 2003 Results From the U.S. Perspective* (2004).

not conclude that sexual dimorphism in height has no biological roots because the sex difference in stature varies from culture to culture.[56] In the first place, the PISA test was given to broad, representative samples, unlike the SAT, which is given to a more elite sample of college-bound students, where the male advantage at the high end is more evident. Moreover, the extent of sex differences is dependent upon the nature of the test. For example, girls generally do better on tests emphasizing computation, tests closely tied to material in the curriculum, and tests high in verbal content, while boys generally do better on tests of mathematical concepts and tests not directly tied to the curriculum.[57] Thus, it is important to know exactly what a particular test is measuring. Finally, Iceland does not deviate from the usual pattern as much as it may appear, since despite a substantial mean difference between male and female performance on the PISA—and a gross disproportion of boys at the bottom level—the sex difference is negligible at the very highest level of performance.[58] Moreover, on the Third International Mathematics and Science Study (TIMSS), Icelandic boys scored higher than girls on mathematical literacy in the final year of secondary school.[59] An additional similarity between Iceland and the rest of the world is the fact that although 61% of university students in Iceland are women, women account for only one-third of Iceland's science students.[60]

Not only are many of the sex differences seen in Western society replicated in non-Western societies, many of them are observed in other species, as well. For example, the greater dominance-seeking, risk-taking, and aggressiveness seen in male humans is the usual pattern among mammals, as males who compete successfully with other males often reap a reproductive payoff.[61] Greater spatial ability among males is found in a number of mammalian species, including rats,[62] voles,[63] and rhesus monkeys,[64] a pattern thought to be an evolutionary consequence of the greater ranges typically traveled by males.[65] Greater

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[56] *See* Clare Holden & Ruth Mace, *Sexual Dimorphism in Stature and Women's Work: A Phylogenetic Cross-Cultural Analysis*, 110 AM. J. PHYSICAL ANTHROPOLOGY 27 (1999).

[57] *See* Diane F. Halpern, *A Cognitive-Process Taxonomy for Sex Differences in Cognitive Abilities*, 13 CURRENT DIRECTIONS IN PSYCHOL. SCI. 135 (2004).

[58] LEMKE ET AL., *supra* note 55, at 95-99. 3.3% of girls and 3.2% of boys scored at the highest level. *Id.*

[59] INA V.S. MULLIS ET AL., GENDER DIFFERENCES IN ACHIEVEMENT: IEA'S THIRD INTERNATIONAL MATHEMATICS AND SCIENCE STUDY (TIMSS) 16 (2000), *available at* http://timss.bc.edu/timss1995i/TIMSSPDF/t95_gender_all.pdf (last visited Apr. 27, 2005).

[60] Vivienne Walt, *The Iceland Exception: A Land Where Girls Rule in Math*, TIME, March 7, 2005, at 56 (also noting that "[b]oys think of school as purgatory on the way to a future of finding riches at sea; for girls, it's their ticket out of town").

[61] *See* BIOLOGY AT WORK, *supra* note 8, at 118-123.

[62] *See* Christina L. Williams & Warren H. Meck, *The Organizational Effects of Gonadal Steroids on Sexually Dimorphic Spatial Ability*, 16 PSYCHONEUROENDOCRINOLOGY 155 (1991).

[63] *See* Steven J.C. Gaulin et al., *Sex Differences in Spatial Ability and Activity in Two Vole Species*, 104 J. COMP. PSYCHOL. 88 (1990).

[64] *See* Agnès Lacreuse et al., *Spatial Cognition in Rhesus Monkeys: Male Superiority Declines with Age*, 36 HORMONES & BEHAVIOR 70 (1999).

[65] *See* BIOLOGY AT WORK, *supra* note 8, at 126-127.

nurturance among females is the rule in mammals, of course. Sex-differentiated toy preferences, which are so commonly attributed to differential socialization, are exhibited even by young monkeys.[66] These patterns are difficult to explain based upon social expectations.

More direct evidence that biology influences these sex differences comes from the study of sex hormones. It appears that these hormones, especially testosterone, influence the brain, through both their effects on fetal brain development and their effects as they circulate throughout the body later in life, especially at and after puberty.

Evidence for testosterone's effect on the fetal brain comes from a variety of sources, including what might be termed "experiments of nature." For example, in a condition known as congenital adrenal hyperplasia (CAH), the adrenal gland produces excessive levels of testosterone that appear to affect fetuses at a critical stage of brain development. Girls with CAH have a much more "masculine" behavioral pattern than unaffected girls, tending to be "tomboys" who are more likely to play with boys and with "boy toys" and less interested in infants and marriage.[67] They perform better than unaffected girls on targeting tasks,[68] and they have been found in some studies to have higher levels of spatial ability.[69] Significantly for our purposes, they also have more male-like occupational preferences.[70]

Developing fetuses are also affected by their mothers' levels of circulating hormones during pregnancy. For example, the higher the mother's testosterone levels during pregnancy, the greater the level of male-typical behavior in their daughters at age 3-1/2[71] and the less the daughter engages in female-typical behavior as an adult.[72] Also, the spatial ability of seven-year-old girls has been found to correlate positively with prenatal testosterone levels in second-trimester amniotic fluid.[73]

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66 *See* Gerianne M. Alexander & Melissa Hines, *Sex Differences in Response to Children's Toys in Nonhuman Primates* (Cercopithecus aethiops sabaeus), 23 EVOLUTION & HUM. BEHAV. 467 (2002).

67 *See* Catherine L. Leveroni & Sheri A. Berenbaum, *Early Androgen Effects on Interest in Infants: Evidence from Children with Congenital Adrenal Hyperplasia*, 14 DEV. NEUROPSYCHOLOGY 321 (1998); Sheri A. Berenbaum & Elizabeth Snyder, *Early Hormonal Influences on Childhood Sex-Typed Activity and Playmate Preferences: Implications for the Development of Sexual Orientation*, 31 DEV. PSYCHOL. 31 (1995).

68 *See* M. Hines et al., *Spatial Abilities Following Prenatal Androgen Abnormality: Targeting and Mental Rotations Performance in Individuals with Congenital Adrenal Hyperplasia*, 28 PSYCHONEUROENDOCRINOLOGY 1010 (2003).

69 *See* Elizabeth Hampson et al., *Spatial Reasoning in Children with Congenital Adrenal Hyperplasia Due to 21-Hydroxylase Deficiency*, 14 DEV. NEUROPSYCHOLOGY 299 (1998).

70 *See* Sheri A. Berenbaum, *Effects of Early Androgens on Sex-Typed Activities and Interests in Adolescents with Congenital Adrenal Hyperplasia*, 35 HORMONES & BEHAV. 102 (1999).

71 *See* Melissa Hines et al., *Testosterone During Pregnancy and Gender Role Behavior of Preschool Children: A Longitudinal, Population Study*, 73 CHILD DEV. 1678 (2002).

72 *See* J. Richard Udry et al., *Androgen Effects on Women's Gendered Behaviour*, 27 J. BIOSOCIAL SCI. 359 (1995).

73 *See* Gina M. Grimshaw et al., *Mental Rotation at 7 Years: Relations with Prenatal Testosterone Levels and Spatial Play Experiences*, 29 BRAIN & COGNITION 85 (1995).

Behavior and cognitive performance also seem to be influenced by circulating hormones. A number of researchers have reported an association between testosterone and dominance behaviors, although the direction of causation is not always clear.[74] A much larger body of data supports a relationship between hormones and cognitive performance. For example, the optimal level of testosterone for high spatial ability appears to be in the low-normal male range, so that among men, those in the low-normal range have the highest ability, while among women, those with the highest testosterone levels tend to have the highest performance because their levels are closest to the low-normal male range.[75] It is not just testosterone that affects spatial ability, however. Estrogen seems to have a depressing effect,[76] which may at least partially explain both the increased sex difference in spatial ability observed after puberty and the tendency of extremely feminine women to have relatively low spatial ability.[77]

Female performance on cognitive tasks varies depending upon the phase of the menstrual cycle. Spatial performance tends to be highest in those phases of the cycle when estrogen levels are low (and therefore the testosterone/estrogen ratio is at its highest), and performance on verbal tasks that show a female advantage tends to be highest in the high-estrogen portions of the cycle.[78] Female rhesus monkeys also show cognitive changes across the menstrual cycle.[79]

Treatment with hormones produces predictable effects. For example, spatial performance in female-to-male transsexuals increases after androgen therapy, and male-to-female transsexuals experience enhanced verbal-memory performance after estrogen treatments.[80] Even a single administration of testosterone to women in a laboratory setting has been found to result in enhanced mental-rotation performance,[81] while administration of testosterone to normal men results in a reduction in spatial performance,[82] consistent with the finding that men in the low-normal range perform best.

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[74] *See* Richard E. Tremblay et al., *Testosterone, Physical Aggression, Dominance, and Physical Development in Early Adolescence*, 22 INT'L J. BEH. DEV. 753 (1998).

[75] *See* Catherine Gouchie & Doreen Kimura, *The Relationship Between Testosterone Levels and Cognitive Ability Patterns*, 16 PSYCHONEUROENDOCRINOLOGY 323 (1991).

[76] *See* Markus Hausmann et al., *Sex Hormones Affect Spatial Abilities During the Menstrual Cycle*, 114 BEHAV. NEUROSCIENCE 1245 (2000).

[77] *See* HELMUT NYBORG, HORMONES, SEX, AND SOCIETY: THE SCIENCE OF PHYSICOLOGY 110 (1994).

[78] *See* Elizabeth Hampson, *Variations in Sex-related Cognitive Abilities Across the Menstrual Cycle*, 14 BRAIN & COGNITION 26 (1990).

[79] *See* Agnès Lacreuse et al., *Fluctuations in Spatial Recognition Memory Across the Menstrual Cycle in Female Rhesus Monkey*, 26 PSYCHONEUROENDOCRINOLOGY 623 (2001).

[80] *See* Clare Miles et al., *Estrogen and Memory in a Transsexual Population*, 34 HORMONES & BEHAV. 199 (1998); Ditte Slabbekoorn et al., *Activating Effects of Cross-Sex Hormones on Cognitive Functioning: A Study of Short-Term and Long-Term Hormone Effects in Transsexuals*, 24 PSYCHONEUROENDOCRINOLOGY 423 (1999).

[81] *See* André Aleman et al., *A Single Administration of Testosterone Improves Visuospatial Ability in Young Women*, 29 PSYCHONEUROENDOCRINOLOGY 612 (2004).

[82] *See* Daryl B. O'Connor et al., *Activational Effects of Testosterone on Cognitive Function in Men*, 39 NEUROPSYCHOLOGIA 1385 (2001).

Opponents of biological explanations often argue that we cannot say anything meaningful about the existence of biological differences because children do not grow up in a world in which the sexes are treated exactly the same and where there are no differential expectations about what the sexes are actually like. By the same reasoning, however, we cannot really say anything meaningful about the effect of social factors because they are acting on sexually differentiated individuals. Social constructionists often assume that demonstration of a social expectation that males and females will behave differently proves that social forces are responsible for any differences in behavior that actually occur. However, it is equally plausible *a priori* that the expectation exists because of the difference, rather than vice versa. Surely, one cannot argue plausibly that people would be *less* likely to hold stereotyped views of the sexes if sex differences were biologically caused.

III. WOMEN IN SCIENCE

An analysis of occupational distributions that takes into account the patterns of biological sex differences just reviewed can provide a richer and more plausible account than one that assumes that no such differences exist. A coherent theory of the workplace requires an explanation not only of areas where women's participation lags but also of those areas where it does not. Critics of the low representation of women in science often cite discrimination and other sexist social forces for the paucity of women in occupations in which they are under-represented, but often fail to take account of those areas in which there is either proportional representation or even over-representation. An approach that looks at the percentage of women in occupations and then simply denounces as "sexist" those in which the percentage is low does not explain much.

It is true that women have not made proportionate inroads in some occupations, and many occupations remain highly segregated. For example, over 90% of bank tellers, receptionists, registered nurses, and pre-school and kindergarten teachers are women, and over 90% of firefighters, mechanics, and pest exterminators are men.[83] In other fields, however, such as book editing, public relations, and insurance adjusting and examining, women have quickly gone from being a minority to a majority.[84] Although there are relatively few female physicists and engineers, there is now near parity in medical schools and law schools.[85] Is the difference really just due to different levels of sexism in the different fields?

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[83] BIOLOGY AT WORK, *supra* note 8, at 6.

[84] *See generally* BARBARA F. RESKIN & PATRICIA A. ROOS, JOB QUEUES, GENDER QUEUES: EXPLAINING WOMEN'S INROADS INTO MALE OCCUPATIONS (1990).

[85] *See* American Bar Association, *2004 Enrollment Statistics* (2005), *at* http://www.abanet.org/legaled/statistics/fall2004enrollment.pdf (last visited on Apr. 19, 2005) (In 2004, women constituted 47.5% of entering law students.); Association of American Medical Colleges, *Facts: Applicants, Matriculants and Graduates* (2004), *at* http://www.aamc.org/data/facts/2004/2004school-2.htm (last visited Apr. 19, 2005) (In 2004, women constituted 49.5% of entering medical students.) [hereinafter AAMC].

Although women's representation in many scientific fields is lower than that of men, it is not uniformly low. Instead, it varies widely from field to field. There is a discernible pattern, however. It is a reasonably accurate generalization to say that the more spatial, mathematical, and abstract the scientific field, the lower the frequency of women. In 2002, for example, women earned 16% of the physics doctorates, 18% in engineering, 29% in mathematics, 34% in chemistry, 45% in biology, and 67% in psychology.[86] In the social sciences, women were relatively scarce in economics (27.5%) but abundant in anthropology (59%) and sociology (61%). Even within fields, there is marked differentiation by subfield. Women earned relatively few doctorates in mining/mineral engineering (0%), biophysics (23%), and psychometrics (22%), but considerably more in bioengineering (28%), nutritional sciences (76%), and developmental and child psychology (83%).[87] Often neglected in discussions of women in science are women in applied-science professions, such as medicine, pharmacy, and veterinary science. Women now make up almost half of all medical students,[88] 65% of pharmacy students,[89] and 70% of veterinary students.[90]

If low levels of female participation in an occupation are a function of hostility toward women, then there is something quite complex about this hostility. Engineering, in this view, is hostile to women, although bioengineering is less hostile than mining/mineral engineering. Biology is friendly to women, except for biophysics, which is not. Psychometrics is hostile to women but developmental and child psychology are not. Schools that provide entry into high status professions like medicine and law are welcoming, but math and science departments (well, at least some sciences) are unrelenting in their opposition to women. It would take an intricate argument to connect this pattern to broad patterns of sexism.

These observed patterns are just what would be predicted in light of the temperamental and cognitive differences previously described. The fields in which women are scarce tend to have the lowest social dimension, while those attracting larger numbers of women tend to have higher social content. Lubinski, Benbow, and Morelock have characterized this distinction as being between the "organic" and the "inorganic."[91] The fields avoided by women tend also to be the most

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86 National Science Foundation, *Science and Engineering Doctorate Awards: 2002*, NSF 04-303 (2003), *available at* http://www.nsf.gov/sbe/srs/nsf04303/pdf/nsf04303.pdf (last visited Apr. 27, 2005).

87 *Id.*

88 AAMC, *supra* note 85.

89 American Association of Colleges of Pharmacy, *Fall 2003 Profile of Pharmacy Students, Table 5*, *available at* http://www.aacp.org/Docs/MainNavigation/InstitutionalData/5872_Table5.pdf (last visited Apr. 19, 2005).

90 Jennifer Fiala, *Are Male Veterinarians No Longer the Majority*?, DVM: THE NEWSMAGAZINE OF VETERINARY MEDICINE, March 1, 2004, *available at* http://dvm.adv100.com/dvm/article/articleDetail.jsp?id=86961 (last visited Apr. 19, 2005).

91 David Lubinski et al., *Gender Differences in Engineering and the Physical Sciences among the Gifted: An Inorganic-Organic Distinction*, *in* INT'L HANDBOOK OF GIFTEDNESS AND TALENT 627-641 (Kurt A. Heller et al. eds, 2d ed. 2000).

mathematically and spatially demanding. Given the relative positions of the sexes on the "people versus things" dimension and the abundance of men at the highest levels of mathematical and spatial ability, it would be truly startling not to find differing sex ratios in these widely differing fields, at least if people sort into occupations based upon their interests and abilities.

Risk preferences may also play a role in occupational distributions, as they can affect career choices in complex ways. The most obvious way that they do so is in selection of physically dangerous occupations, which are overwhelmingly dominated by males.[92] The fact that females are more averse not only to physical risk but also to social risk may have an equally powerful impact on occupational choice. Female risk aversion has been cited as a contributor to sex differences in achievement-orientation[93] and may contribute to women's relative scarcity in positions involving "career risk"—that is, positions presenting a serious risk of clear failure.[94]

It is plausible (and certainly worthy of study) that attitudes toward risk affect selection of careers in mathematics and hard sciences. One reason for thinking they might is the fact that in these fields more than in the humanities and social sciences, there are "right answers." A mathematical proof is either correct or it is not, and, if it is not, someone will point it out. Moreover, scientific creativity can be judged more objectively than creativity in, say, literary criticism. Apparently because of the greater objectivity in such fields, the sciences have been spared to some extent the grade inflation that has plagued the humanities and social sciences.[95] In sum, studying science is a "risk"—presenting a real possibility of failure—in a way that study in other fields is not.[96]

The demands of top research positions may also affect women's participation. There are a number of reasons that "all-consuming" jobs are aversive to women. One reason, of course, is children. Seventy or eighty-hour (or even fifty or sixty-hour) work weeks are not compatible with the level of family involvement that many people, but especially many women, desire. Because women, on average, desire greater day-to-day involvement with their children than men do, intense career investment is more costly to them.[97] Despite the fact that surveys find that women are as satisfied with their jobs as men are, they are less

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92 *See* BIOLOGY AT WORK, *supra* note 8, at 64.

93 *See* Elizabeth C. Arch, *Risk-Taking: A Motivational Basis for Sex Differences*, 73 PSYCHOL. REP. 3 (1993).

94 *See* BIOLOGY AT WORK, *supra* note 8, at 40-42.

95 *See* Henry Rosovsky & Matthew Hartley, *Evaluation and the Academy: Are We Doing the Right Thing? Grade Inflation and Letters of Recommendation*, American Academy of Arts & Sciences, 5-6 (2002), *at* http://www.amacad.org/publications/monographs/Evaluation_and_the_Academy.pdf (last visited Apr. 27, 2005).

96 *See* Jonathan Osborne et al., *Attitudes Towards Science: A Review of the Literature and its Implications*, 25 INT'L J. SCI. EDUC. 1049, 1071 (2003).

97 *See* Eccles, *supra* note 13, at 265-266.

satisfied with the number of hours they work, despite the fact that they work shorter hours.[98]

Not only are the psychic costs to women higher for participation in grueling careers, the psychic rewards may be smaller. Because women, on average, attach less value to being at the very top of their profession than men do, the psychic payoff to women from single-minded dedication to (or obsession with) achievement of professional status is often less than for men. That is, women are more likely than men to say, "If that's what this career requires, it's not worth it to me." In academia, a primary measure of status is scholarly productivity. Scores of studies of academic productivity have found that men publish more articles than women do, typically about 50% more (independent of whether they have children).[99] This disparity is obviously not due to women's inability to publish more but rather to the fact that they choose not to.[100]

Although one might argue that jobs should not be structured to require so many hours, the fact that some people (predominantly men) are willing, even eager, to work such hours, means that competitive pressures to be productive result in many other people working longer hours than they might like even in the absence of a formal requirement. The two most obvious solutions to this problem, if it is a problem, is to break the link between productivity and reward or to prohibit people, even those who are eager to do so, from working long hours. Neither of these courses of action is practical, of course. Even if universities stopped providing tangible rewards for scholarly productivity, the major status reward of scholarship is not in its tangible recognition by one's employer but by its reception in the scholarly community. As for limiting work hours, that is easy enough to do for factory workers, but not so easy for academics who may do much of their work at home or in otherwise unsupervised settings. Apart from practical concerns, there is, of course, the further question whether either of these responses would be desirable.

It is often asserted that the science pipeline is "leaking" women all along its length—from high school to college to graduate school to postdoctoral fellowships to faculty positions.[101] It is not so clear that this is accurate, at least in all sciences. A recent study by the American Institute of Physics found a substantial difference between the number of girls taking physics in high school and the number of women obtaining bachelor's degrees in physics.[102] After that initial "leak,"

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98 *See* BIOLOGY AT WORK, *supra* note 8, at 136.

99 *See* BIOLOGY AT WORK, *supra* note 8, at 80-82.

100 *See* Stephen Cole & Robert Fiorentine, *Discrimination Against Women in Science: The Confusion of Outcome with Process*, *in* THE OUTER CIRCLE: WOMEN IN THE SCIENTIFIC COMMUNITY 205-226 (Harriet Zuckerman et al. eds., 1991).

101 *See* Joe Alper & Ann Gibbons, *The Pipeline Is Leaking Women All the Way Along*, 260 SCIENCE 409 (1993).

102 Rachel Ivie & Kim N. Ray, *Women in Physics and Astronomy, 2005*, AIP Report, AIP Publication Number R-430.02 (February, 2005) *available at* http://www.aip.org/statistics/trends/reports/women05.pdf (last visited June 13, 2005).

however, women are represented along the rest of the pipeline in numbers roughly commensurate with their levels at earlier stages. So, for example, the fact that only 5% of full professors in physics are women reflects the relatively small number of women who earned physics Ph.D.s at a time when people who are now full professors earned their doctorates.

None of this is to deny the possibility of impediments to female participation in the sciences. However, many of the factors identified as "barriers" can be labeled as such only using an odd definition of the term. For example, a study of attrition of women in engineering and science programs found that frequently cited barriers were isolation, lack of self-confidence, and lack of interest in the subject matter.[103] It is not obvious that these factors should be considered "barriers" at all, as they seem to represent women's reactions to the fields rather than obstacles placed in their way. Negative reactions to science are not surprising in a group that tends to be less quantitative and less competitive than the group to which its members compare themselves. Moreover, women's more social nature may tend to result in a feeling of isolation in math-intensive fields, in which individuals tend to have a "low need for people contact."[104] Significantly, the attrition study found that the rate at which women in scientific majors reported negative perceptions increased over time, so that the percentage of those reporting that their lack of self-confidence was a barrier almost doubled from freshman to senior year (23% versus 44.5%), and the percentage of women who reported a lack of interest tripled (12.6% versus 38%). The primary reason given by women who actually switched out of science and engineering was lack of interest. These figures should give pause to those who view it as their mission in life to persuade women who would not otherwise do so to pursue a career in the hard sciences, as well as to those committed to numerical parity in every scientific specialty.[105]

IV. CONCLUSION

Much of the reaction to Dr. Summers' comments has been fundamentally illogical. For example, MIT biologist Nancy Hopkins—who claimed that her departure in the middle of Summers' remarks was necessary because she would have "either blacked out or vomited"[106] if she had remained—took issue with his statement that women are disproportionately unwilling to work 80-hour weeks, stating that she "didn't like the way he presented that point because I like to work

[103] *See* Suzanne G. Brainard, & Linda Carlin, *A Six-Year Longitudinal Study of Undergraduate Women in Engineering and Science*, 87 J. ENGINEERING EDUC. 369 (1998).

[104] David Lubinski et al., *Reconceptualizing Gender Differences in Achievement among the Gifted*, *in* INTERNATIONAL HANDBOOK OF RESEARCH AND DEVELOPMENT OF GIFTEDNESS AND TALENT 693 (Kurt A. Heller et al. eds., 1993).

[105] *See* Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*, 58 (2000) (defining success in diversity programs as "parity among all subgroups," which it describes as a "strategic need").

[106] *See* Brian McGrory, *Chill Sets in at Harvard*, BOSTON GLOBE, Jan. 21, 2005, at A1.

80 hours a week, and I know a lot of women who work that hard." Such a response is as much a non sequitur as a statement by Houston Rockets star Yao Ming that his seven-foot-six-inch stature would rebut an assertion that there are not many Asians in the NBA because there are few Asians over seven-feet tall.[107]

The particular offense taken by female scientists to Summers' remarks seems misplaced, as his comments were focused primarily not on women who pursue scientific careers but rather on those who do not. There is good reason for thinking that these two groups are quite different. Among mathematically talented individuals generally, for example, substantial sex differences exist on such measures as mathematical ability, interests and values, and career orientation. However, a study of a subset of this group—graduate students in math and science at top universities—found that sex differences were either much reduced or nonexistent.[108] Thus, an observation about the talents and interests of women who do not pursue scientific careers says little about those women who do.

Another similarly misdirected response is to collect anecdotes from women in science about how people had discouraged them from their pursuit of scientific careers.[109] It seems that if these tales have a moral, it is the opposite of that for which they are told. That is, these stories show that women do, in fact, enter science even if they hear discouraging words. The relevant group would be women who did not enter science because of such discouragement, not those who went in despite it. No doubt there are some diverted women, but one wonders whether women who would alter their career aspirations because of such words ever would have had the self-confidence and ego strength necessary to become top-notch research scientists. Indeed, it seems likely that the women who persisted in science despite discouragement did so because their response pattern was more male-like than those who did not. How likely would it be, after all, for a man who actually had the interest and ability to become a top physicist to reverse his career plans because someone told him he was not good enough to succeed? As military trainers have long known, the best way to motivate a man is to tell him that the task is hard and that he probably cannot do it, but as military trainers are now finding out, that is not a way to motivate most women.[110]

As long as all fields are open to qualified women (and men) who choose to enter them, it is not clear why Harvard or any other institution should try to manipulate sex distributions. It is also not clear why sexual parity is the appropriate goal in fields in which men predominate but not in fields in which women predominate. Women earn approximately the same proportion of

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[107] *See* Selena Roberts, *Yao Proving a Bigger Man Than O'Neal*, N.Y. TIMES, Jan. 18, 2003, at D1.

[108] *See* David Lubinski et al., *Men and Women at Promise for Scientific Excellence: Similarity Not Dissimilarity*, 12 PSYCHOL. SCI. 309 (2001).

[109] *See generally* Pat Galloway, *Bad Idea. You'll Flunk Out*, TIME, Mar. 7, 2005, at 58; Sue Goetinck Ambrose, *Success and Gender Debate: What New Millennium? Want to Rile 5 Scientists? Tell Them They Can't Because They're Women*, DALLAS MORNING NEWS, Jan. 30, 2005, at 1H.

[110] *See* Kingsley R. Browne, *Women at War: An Evolutionary Perspective*, 49 BUFF. L. REV. 51, 186-190 (2001).

doctorates in chemistry as men do in psychology, the same proportion of doctorates in engineering as men do in developmental and child psychology, and the same proportion of doctorates in biology as men do in anthropology. Why is women's under-representation a problem while men's is only a fact? Should we conclude that some of the "excess" female psychologists should have become chemists instead?

Given the very real biologically influenced psychological differences between the sexes, it is unrealistic to assume that their aggregate occupational choices will be, or should be, the same. Although we should be alert to arbitrary social barriers that might stand in the way of women's participation in the occupations of their choice, it is not sensible to assume that when they do not enter all occupations in the same numbers as men, there is necessarily some invidious barrier standing in their way. Freedom of choice should be the goal, and freedom to choose entails the freedom to choose differently.