

Why Females Remain Underrepresented in Mathematics at the Highest Level

The scarcity of women among the tenured faculty of elite research universities, especially in mathematics and related fields, received much attention after January 2005. That's when then-president of Harvard Lawrence Summers speculated about reasons for its continuing existence. Speaking at the National Bureau of Economic Research "Conference on Diversifying the Science & Engineering Workforce," Summers posited "that in the special case of science and engineering, there are issues of intrinsic aptitude, and particularly of the variability of aptitude, and that those considerations are reinforced by what are in fact lesser factors involving socialization and continuing discrimination... [Thus,] even small differences in the standard deviation will translate into very large differences in the available pool substantially out... [leading to] different availability of aptitude at the high end."¹

I initially learned about Summers' remarks and the resulting controversy through the lay news media. Although I am a biochemist and molecular virologist by vocation, I also happen to be the parent of a young adult who excels in mathematics at the one-in-a-million level. Through my son's phenomenal success in extremely difficult mathematics competitions, I had met folks who could help me gain access to data about children from throughout the world who possess profound talent in mathematical problem solving. Over the subsequent three years, I gradually gathered data that could be used to test the validity of Summers' speculation. These data were published in fall 2008 in *Notices of the American Mathematical Society*.²

Nature vs. Nurture

Summers was referring, perhaps unconsciously, to the "greater male variability hypothesis," originally proposed by Ellis in 1894. Greater



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male variability in mathematics performance has been observed in many countries throughout the world.³ Many people assume it is a consequence of innate biological differences between the sexes in aptitude for mathematics. However, in a recent review of contemporary literature on gender, culture, and mathematics performance that I coauthored with Janet S. Hyde, professor of psychology at the University of Wisconsin–Madison, we conclude that this assumption is false.⁴ Rather, the scarcity of outstanding women in mathematics and, by inference, other science, technology, and engineering fields is largely due to changeable sociocultural, educational, and other environmental factors.

Inadequate Nurture

Numerous findings indicate that inadequate nurture, not nature, is the primary reason many fewer females than males are identified as excelling in mathematics at the high and highest levels. These include:

- The variability in the distribution of scores on standardized mathematics examinations such as the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) is similar between girls and boys in some countries, including Denmark and The Netherlands. Girls even exhibit significantly greater variability than boys in Indonesia. These facts directly contradict the assumption that greater male variability in mathematics performance is primarily due to innate biological differences between the sexes.
- While significantly more high school-age white boys than girls in the U.S. are identified as scoring above the 99th percentile in math performance on standardized tests such as the 2003 PISA, this ratio is essentially unity in the UK and Thailand, and for



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Asian-Americans in Minnesota. In Iceland, even more girls than boys are identified as excelling in mathematics at this high level.

- Benbow and Stanley originally reported a 13:1 boy:girl ratio among pre-teenagers scoring 700 or above on the SAT I in their Study of Mathematically Precocious Youth in the 1970s.⁵ However, this ratio dropped to 2.8:1 by 2005.
- Although women accounted for only 5% of mathematics Ph.D.s awarded in the 1950s and 1960s in the U.S., their numbers have steadily increased since Title IX was enacted in 1972, reaching over 30% by 2006.
- Throughout its first 23 years of participation in the International Mathematical Olympiad (IMO), an extremely difficult precollegiate examination in mathematical problem solving, the U.S. failed to have even one girl qualify for its six-member teams. The U.S. finally identified three medal-winning girls, who participated a total of five times during the past 11 years. Likewise, the UK had only one girl on its first 21 IMO teams, yet 10 girls participated a total of 13 times during the past 20 years. On the other hand, Bulgaria has had 22 girls participate a total of 31 times throughout the decades, beginning with the very first IMO held in 1959. And Russia and Serbia have had over 20% girls on their teams during some decades.
- Although U.S.-born white and historically underrepresented minority girls are 30-fold or more underrepresented in proportion to their percentage of the U.S. population among the students qualifying for the U.S. Mathematical Olympiad Summer Program, the training camp for IMO team hopefuls, Asian-American girls are twofold overrepresented.
- The Gender Gap Index (GGI) is the World Economic Forum's composite measure of a country's gender equality with respect to economic, educational, health, and political opportunities.⁶ Both the ratio of girls to boys scoring above the 95th percentile on the 2003 PISA and the percentage of girls on a country's IMO teams during the past two decades strongly correlate with the country's GGI. Noteworthy is the fact that the U.S. ranked only 31st, between Estonia and Kazakhstan, out of the 128 countries included in the 2007 GGI report.
- National differences in an indicator of implicit gender-science stereotyping strongly correlate with nations' mean gender

differences in science and math performance among eighth graders taking the 2003 TIMSS.⁷

- Comparisons between countries with very similar gene pools show large differences in girl participation rate in the IMO. The identically high-ranked East and West German IMO teams had five and no girl participants, respectively, during the 13 years immediately prior to reunification in 1991. Slovakia has sent 12 girls to the IMO versus the Czech Republic's four since the countries were partitioned in 1993. South Korea has topped Japan for IMO participation by girls by nine to two during the past two decades. As Sharon Begley of *Newsweek* states, "It's hard to see that as anything but the result of the starkly different social and other environmental forces in each country, not intrinsic biology."⁸

Other Factors

Thus, the identification of females who excel in mathematics performance at both the high and one-in-a-million levels significantly correlates with measures of gender equity, varies considerably among nations and even among ethnic groups within nations, and can significantly change over time. Such findings are not consistent with innate gender differences being a primary reason for greater male variability and the scarcity of outstanding female mathematicians. Rather, they provide strong support for sociocultural, educational, and other environmental factors being the main cause for female underrepresentation in mathematics and related fields.

Gender inequity is complex and multifaceted. It can encompass:

- Classroom dynamics that lead teachers to provide more attention to boys
- Bias by guidance counselors who buy into stereotypes and advise girls against taking advanced math courses
- "Stereotype threat" that leads females to underscore on mathematics examinations, based upon the unfounded belief that females are inferior in math ability
- Failure to identify and adequately nurture mathematically gifted girls
- Unwillingness on the part of girls to study extracurricular mathematics for fear of being socially ostracized as nerds
- A scarcity of women role models in math-intensive careers that leads girls to believe they do not belong in those careers
- Unconscious bias against women in hiring decisions

- Chilly work environments that lead qualified women to drop out in favor of friendlier climes

Thus, much effort is needed at multiple levels of our society to ensure that all people are free to develop their talents and to pursue the careers best suited to their own personal interests and desires. ■

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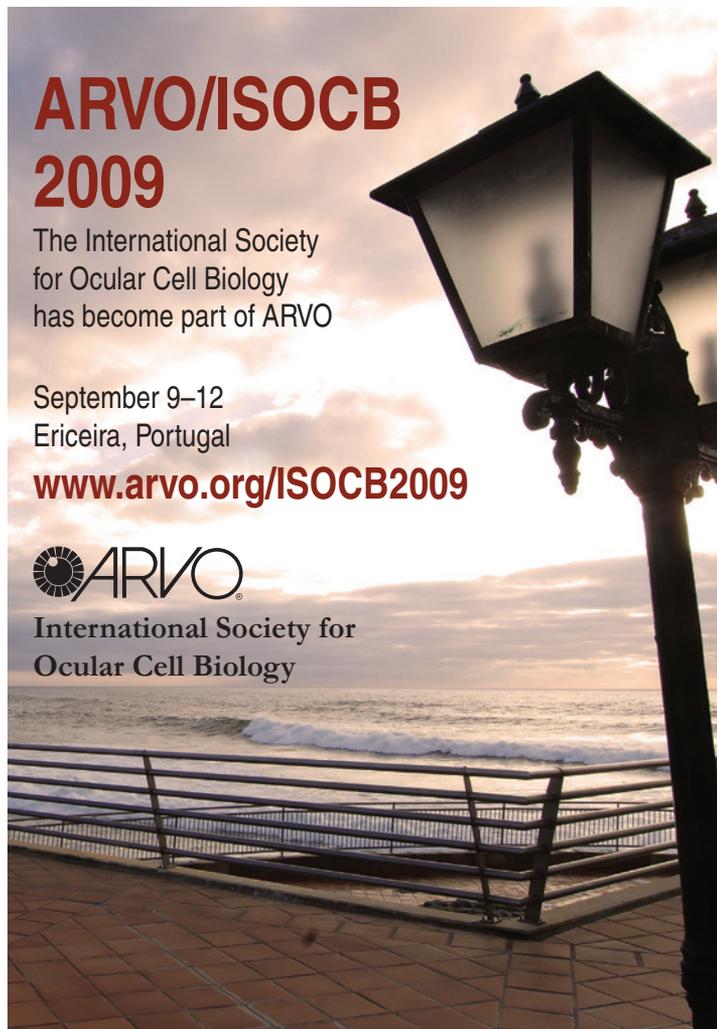
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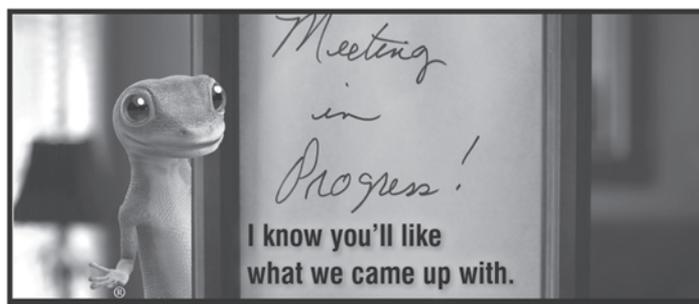
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