

Correction

OPINION

Correction for “Opinion: Gender diversity leads to better science,” by Mathias Wullum Nielsen, Sharla Alegria, Love Börjeson, Henry Etkowitz, Holly J. Falk-Krzesinski, Aparna Joshi, Erin Leahey, Laurel Smith-Doerr, Anita Williams Woolley, and Londa Schiebinger, which appeared in issue 8, February 21, 2017, of *Proc Natl Acad Sci USA* (114:1740–1742; 10.1073/pnas.1700616114).

The editors note that, due to a printer’s error, references 7 and 8 were each inadvertently repeated in the text, in the second and third full paragraphs on page 1741, respectively. The extraneous callouts to references 7 and 8 have now been removed.

www.pnas.org/cgi/doi/10.1073/pnas.1703146114

Gender diversity leads to better science

Mathias Wullum Nielsen^{a,1}, Sharla Alegria^b, Love Börjeson^c, Henry Etzkowitz^{d,e}, Holly J. Falk-Krzesinski^{f,g}, Aparna Joshi^h, Erin Leaheyⁱ, Laurel Smith-Doerr^j, Anita Williams Woolley^k, and Londa Schiebinger^a

Pick up any recent policy paper on women's participation in science and you will find assurances that gender diversity enhances knowledge outcomes. Universities and science-policy stakeholders, including the European Commission and the US National Institutes of Health, readily subscribe to this argument (1–3). But is there, in fact, a gender-diversity dividend in science?

The data suggest that there is. Under the right conditions, teams may benefit from various types of diversity, including scientific discipline, work experience, gender, ethnicity, and nationality. In this paper, we highlight gender diversity (Fig. 1). Guided by key research findings, we propose the following

“mechanisms for innovation” specifying why gender diversity matters for scientific discovery and what managers should do to maximize its benefits (Fig. 2). Encouraging greater diversity is not only the right thing to do: it allows scientific organizations to derive an “innovation dividend” that leads to smarter, more creative teams, hence opening the door to new discoveries.

Productive Team Mechanisms

Well-run, well-performing research teams have become increasingly crucial to the success of modern scientific investigations. Already, experimental research points to positive links between gender diversity and collective



Fig. 1. When it comes to science collaborations, there's ample data to suggest that gender diversity pays a substantial research and productivity dividend. Image courtesy of Dave Cutler (artist).

^aHistory of Science, Stanford University, Stanford, CA 94305; ^bSchool of Social Sciences, Humanities, and Arts, University of California, Merced, CA 95340; ^cGraduate School of Education, Stanford University, Stanford, CA 94305; ^dScience, Technology, and Society, Stanford University, Stanford, CA 94305; ^eTriple Helix Association, Torino 10152, Italy; ^fGlobal Academic Relations, Elsevier, New York, NY 10169; ^gSchool of Professional Studies, Northwestern University, Chicago, IL 60208; ^hSmeal College of Business, Pennsylvania State University, University Park, PA 16801; ⁱSchool of Sociology, University of Arizona, Tucson, AZ 85721; ^jInstitute for Social Science Research, University of Massachusetts, Amherst, MA 01003; and ^kTepper School of Business, Carnegie Mellon University, Pittsburgh, PA 15213

The authors declare no conflict of interest.

Any opinions, findings, conclusions, or recommendations expressed in this work are those of the authors and have not been endorsed by the National Academy of Sciences.

¹To whom correspondence should be addressed. Email: mwn@stanford.edu.

design and data analysis, scientists may add important new dimensions to research.

Supportive Institutional Contexts

Taken together, the above-mentioned mechanisms grease the wheels of scientific discovery. The growing emphasis on teams in knowledge production, combined with women's educational gains in science and engineering, propel gender diversity to the forefront of promising new opportunities for scientific discovery. But what conditions need to be in place for organizations to fully realize such opportunities? There are approaches that can help establish more supportive institutional contexts, where both gender diversity and innovation thrive.

Effectively implemented policies are crucial for gender inclusion. However, some of the most widely

However, even flat structures are not effective unless the newcomers (women or underrepresented minorities) hit a critical mass, defined as representing between 15% and 30% of team members. Cindy Cain's and Erin Leahey's (10) systematic qualitative analysis of hundreds of autobiographical essays written by academic scholars in psychology, psychiatry, the life-sciences, engineering, and physics suggest that in fields where women have achieved a critical mass, they experience less stereotyping, more involvement in decision making and teamwork, and higher levels of support. Informal relationships move from being about "old boys' networks" to emphasizing connections, inclusiveness, and opportunities that likely benefit the scientific team and organization as a whole (10).

Scientific organizations can expedite the effects of critical mass by actively cultivating a positive climate for gender diversity. Lisa Nishii's employee survey of work climates in 100 units of a large United States biomedical company, for example, highlights the importance of fostering an open work culture that encourages all employees to freely express their cultural and gender identity on the job. Furthermore, her findings illustrate the benefits of actively encouraging an inclusive approach to decision making, where diverse insights and viewpoints are valued, even when challenging the status quo (11). Through dedicated leadership, these approaches can help reduce interpersonal bias and conflict while increasing employee satisfaction in teamwork. Women scientists' turnover rates will decrease and team science benefits as a result.

Recruiting women is not enough: Carefully designed policies and dedicated leadership allow scientific organizations to harness the power of gender diversity for collective innovations and discoveries. Put simply, we can't afford to ignore such opportunities.

Carefully designed policies and dedicated leadership allow scientific organizations to harness the power of gender diversity for collective innovations and discoveries.

used diversity policy instruments have proven inefficient and sometimes even harmful in countering inequalities. In longitudinal analyses of more than 800 United States firms between 1971 and 2002, Frank Dobbin et al. (8) find that control instruments, such as performance ratings, job tests, and grievance systems—designed to prevent discriminatory behavior among managers—can have negative outcomes. In contrast, motivating managers to voluntarily engage in the recruitment and training of underrepresented groups better supports the advancement of women and minorities.

Research also demonstrates that women flourish in organizations with high degrees of cross-job communication and nonhierarchical structures. Based on career information of more than 2,000 United States life scientists, Laurel Smith-Doerr (9), for example, finds that women are nearly eight times more likely to lead research projects in biotech firms with flat job-ladders than in more hierarchical academic and pharmaceutical settings.

Acknowledgments

These ideas and views emerged from a National Science Foundation-funded workshop held at Stanford University in February 2016.

- 1 European Commission (2012) *Communication from the Commission to the European Parliament, the Council and The European Economic and Social Committee and the Committee of the Regions: A reinforced European Research Area Partnership for Excellence and Growth* (European Commission, Brussels).
- 2 Valentine HA, Collins FS (2015) National Institutes of Health addresses the science of diversity. *Proc Natl Acad Sci USA* 112(40):12240–12242.
- 3 Maes K, Gvozdanovic J, Buitendijk S, Hallberg IR, Mantilleri B (2012) Women, Research and Universities: Excellence Without Gender Bias (League of European Universities, Leuven, Belgium).
- 4 Woolley AW, Chabris CF, Pentland A, Hashmi N, Malone TW (2010) Evidence for a collective intelligence factor in the performance of human groups. *Science* 330(6004):686–688.
- 5 Woolley AW, Aggarwal I, Malone TW (2015) Collective intelligence and group performance. *Curr Dir Psychol Sci* 24(6):420–424.
- 6 Joshi A (2014) By whom and when is women's expertise recognized? The interactive effects of gender and education in science and engineering teams. *Adm Sci Q* 25(2):202–239.
- 7 U.S. General Accounting Office (GAO) (2001) *Drug Safety: Most Drugs Withdrawn in Recent Years Had Greater Health Risks for Women* (Government Publishing Office, Washington, DC).
- 8 Dobbin F, Schrage D, Kalev A (2015) Rage against the iron cage: The varied effects of bureaucratic personnel reforms on diversity. *Am Sociol Rev* 80(5):1014–1044.
- 9 Smith-Doerr L (2004) *Women's Work: Gender Equality vs. Hierarchy in the Life Sciences* (Lynne Rienner, Boulder, CO).
- 10 Cain CL, Leahey E (2014) Cultural correlates of gender integration in science. *Gen Work Organ* 21(6):516–530.
- 11 Nishii LH (2013) The benefits of climate for inclusion for gender-diverse groups. *Acad Manage J* 56(6):1754–1774.