

## Questioning Assumptions

Clifton A. Poodry\* and David J. Asai

Science Education Programs, Howard Hughes Medical Institute, Chevy Chase, MD 20815-6789

Your assumptions are your windows on the world. Scrub them off every once in a while, or the light won't come in.

—Isaac Asimov

The persistent underutilization of the diverse U.S. talent pool in science is a complex problem that defies simple explanation. Despite the demonstrated value of diversity (e.g., Page, 2007), articles and reports continue to document the disparities in demographics of scientists (e.g., National Academy of Sciences, National Academy of Engineering, and Institute of Medicine [NAS *et al.*], 2011). A priori, this is surprising: after all, in this country, finding diversity is not difficult. Why, then, have we not been more successful in capturing and cultivating this talent? What are the assumptions and observations that might be holding us back or might provide insights into how we can better understand the challenge? In this essay, we encourage the re-examination of some assumptions.

### OUR PERSPECTIVE

As faculty members, each of us has had the pleasure of doing and guiding research in developmental and cell biology—Clif at the University of California, Santa Cruz; David at Purdue University and then Harvey Mudd College. Within our respective areas of expertise, we continually engaged in a pattern of activities intended to reveal the physical and dynamic workings of cells. It started with observations—sometimes by us and other times by others—followed by efforts to explain the implications of what has been seen. We looked for causal connections using both qualitative and quantitative observations. We explicitly challenged our assumptions and explanations. We sought the input of others to help us recognize blind spots and identify otherwise unrecognized assumptions. This process was rarely linear and unidirectional. And while we enjoyed speculation and flights of fancy, we tried to remember that the explanation must be built on verifiable observations.

Eventually, each of us left academic research and teaching to become an administrator at a national funding agency—Clif as the founding director of training and workforce development at the National Institute of General Medical Sciences (NIGMS), and now as senior fellow at the Howard Hughes Medical Institute (HHMI); David as senior director for science education at HHMI. As administrators, we believe that the same methods and rigor that we value in scientific research should be applied to understand the causes underlying disparities in science, technology, engineering, and mathematics (STEM) participation (e.g., Poodry, 2006).

### WE ARE PERPLEXED

Over the years, we have heard our colleagues—people who are accomplished and respected scientists—recite variations of the well-worn litany of hypotheses to explain the underrepresentation of minorities and women in academic positions. These rationalizations are essentially used to argue “It’s not my fault,” because “most things are beyond my control.” Here are some examples:

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\*Address correspondence to: Clifton A. Poodry (poodryc@hhmi.org).

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- There aren't enough qualified candidates.
- It is a zero-sum game—if we hire a person from an underrepresented group, he or she will soon be recruited away to another institution.
- The applicants from underrepresented groups are weak and uncompetitive because of their poor preparation, poor schools, poor family values, and lack of interest.
- Underrepresented minorities (URMs) have a disproportionate need to be near their roots, and they have obligations to their families/communities that prevent them from leaving home.
- URMs have less interest in science research, because they want to go to medical school.
- Persons from underrepresented groups cannot afford to be idealistic and must consider salary first, making academia an unattractive alternative.
- The deficit begins in middle school or high school, because persons from underrepresented groups do not encounter any role models.

There is no shortage of hypotheses to explain the underrepresentation. While there are a number of studies one can cite (see next section), we have found it is seldom productive to argue with holders of these commonly offered beliefs. Nevertheless, we think it is important to examine some assumptions that persist and, by so doing, open minds to alternative explanations.

### MYTHS

Behavioral scientists are drawing aside the curtains, allowing a better differentiation between the assumptions and realities of STEM preparation and career decisions. For example, an assumption we hear is that URMs are not interested in science. However, the reality is that URMs are OVERrepresented among students entering college intending to study STEM (Hurtado *et al.*, 2008; National Science Foundation, National Center for Science and Engineering Statistics, 2017; see also NAS *et al.*, 2011; Gibbs *et al.*, 2016).

A second assumption is that, even if they are interested in STEM, URMs leave science because they are not well prepared. However, the research shows that, when the outcomes of students with similar precollege backgrounds are compared, URMs switch out of STEM disciplines at significantly higher rates than whites and Asians (Huang *et al.*, 2000; Higher Education Research Institute at UCLA, 2010).

A third myth is that participation by undergraduates in research increases interest and intentions of pursuing a career in science. However, the evidence is that participation in undergraduate research prevents loss rather than increasing interest (Schultz *et al.*, 2011).

A different approach to examining assumptions is to begin with data and then ask scientists what the data might mean. In the following section, we share one example of this approach.

### PUBLICATIONS BY GRADUATE STUDENTS

The most important goal for a graduate student is to discover something important to elevate the thinking in their field and to create opportunities for themselves and others.

—Tom Pollard, in a personal communication

Publications are important. As former department heads, we saw that faculty hiring committees relied heavily on lists of publications and pedigrees of applicants when drawing up the short list of candidates (see also Clauset *et al.*, 2015).

Perhaps even more important than its influence on hiring, published scholarship documents our advancing knowledge and development. Publications express the scientific judgment, proclivities, and biases of the authors. They are culturally nuanced stories. The ways students prepare for and tell their stories are influenced by beliefs on both sides of the mentoring equation. How much risk should the student take? How much faith does the adviser have that the student can pull off a “high risk–high reward” project? Because advisers endeavor to provide guidance tailored to each student, there are ample opportunities for our biases to influence decisions and mentoring.

About a dozen years ago, Nettles and Millett (2006) reported that African-American graduate students publish significantly less than their peers. Similarly, a recent study found that URM students submitted fewer papers than whites and Asians (Mendoza-Denton *et al.*, 2017). And it has been reported that the different publication rates of men and women are related to whether their advisers are male or female (Pezzoni *et al.*, 2016). Although the publication record is just one criterion used in hiring, promotion, and tenure decisions, it is an important criterion. Small disparities early in a career can have a profound and amplifying effect (e.g., Martell *et al.*, 1996; von Bartheld *et al.*, 2015). If a graduate student publishes less than his or her peers, he or she might be less competitive for a postdoctoral position in a top lab, which, in turn, can influence the interest of departments recruiting new faculty.

Thus, the possibility of disparities in publication rates caught our attention. To see whether the observation of Nettles and Millett (2006) held for biomedical graduate students and postdocs, Cliff, when he was at NIGMS, queried friends and colleagues who were principal investigators of biomedical training programs. On the promise that the information would in no way be held against them when applying for the renewal of their training grants, many responded, and four provided extensive data. Institutions responding were from the eastern, southern, or western United States. They all reported that URMs published less than their peers, some by as much as 30% less.

Recently, we have extended that informal study. In 2017, we invited the thesis advisers of the HHMI Gilliam graduate fellows and the panelists reviewing Gilliam applications to collect data from their graduate programs. We asked them to find the answers to four questions:

1. How many students are currently enrolled in your PhD program?
2. In the last 5 years, how many students completed a PhD in your program?
3. For the completed PhDs, how many first- and coauthored papers did they publish from their dissertation?
4. For the completed PhDs, how many persons published their dissertation work as first or coauthors?

For each question, we asked the respondents to bin the numbers by gender and URM status (African American, Hispanic/Latino, and Native American). The identities of individual students were not reported.

**TABLE 1. Publication rates by recent biomedical PhDs<sup>a</sup>**

	All	Men	Women	Non-URM	URM
Enrolled	1934	900 (46.5%)	1034 (53.5%)	1633 (84.4%)	301 (15.6%)
5-year PhDs	1466	654 (44.6%)	812 (55.4%)	1289 (87.9%)	177 (12.1%)
First-authored papers per PhD	1.73	1.79	1.69	1.77	1.48
Coauthored papers per PhD	2.70	2.97	2.48	2.74	2.37
PhDs who were first authors	80.2%	80.7%	79.7%	80.7%	76.3%
PhDs who were coauthors	86.8%	87.9%	85.8%	86.6%	88.1%

<sup>a</sup>In the Winter/Spring of 2017, scientists serving as competition reviewers and the thesis advisers of the HHMI Gilliam graduate fellowship program were asked to collect information from their respective graduate programs. Complete data were obtained from 14 different universities, all classified as “highest research activity doctoral universities” by the Carnegie Classification of Institutions of Higher Education (2016).

These are not the kinds of questions most of us are prepared to answer, and many of the programs were not able to find the numbers. We collected complete data from PhD programs at 14 different research universities, all of which are classified as “highest research activity doctoral universities” in the Carnegie Classification of Institutions of Higher Education (2016). At those universities, a total of 1934 students were enrolled in academic year 2016–2017, of whom 1034 were women and 301 were URMs. The completed PhDs numbered 1466, of whom 812 were women and 177 were URMs (Table 1).

Our survey revealed disparities in publication rates. For example, URMs published, on average, 16.4% fewer papers as first authors from their thesis work than their peers (1.77 papers per PhD for non-URM students vs. 1.48 papers per PhD for URMs). When we asked how many PhDs published their thesis work, we found that the disparity between non-URM and URM PhDs is -4.4% (i.e., 80.7% of non-URM PhDs published as first authors vs. 76.3% of URMs).

### UNCOVERING ASSUMPTIONS

A long time ago, when we were research advisers, we tried to guide the development of our students. Generally, students were first assigned to projects that were relatively certain to discover something noteworthy. When the students had mastered some of the thinking and technical skills, we then encouraged them to imagine experiments or projects that were exciting, although with uncertain outcomes. Throughout this process, we encouraged students—for example, through journal clubs and group meetings—to develop the skills of a good scientist: how to reflect on data by dissecting and deconstructing others’ data and then their own data, discerning between sensible and less sensible data, and discussing their work in the context of the larger field of research.

Today, we engage with colleagues in a similar exercise. We have shared the observations anonymously provided by NIGMS grantees and now from anonymized data on publication rates gathered from the HHMI Gilliam program faculty, summarized above, and asked folks to reflect on the disparities and to suggest possible reasons for the disparities. A common first response is to question whether there really is a disparity, to question the veracity of the data, whether there were proper comparison groups or the data are reproducible, or to respond that the disparities are not statistically significant. This skepticism could be healthy scientific thinking. However, skepticism that is closed minded is not. In our experience, showing the data and even referencing earlier studies don’t move the conversation. This

response shouldn’t be surprising, as research has shown that people, especially the best educated, favor studies that agree with their current beliefs and dismiss studies that challenge their beliefs (e.g., Lord *et al.*, 1979; Kahan, 2013; Kahan *et al.*, 2017; see also Ropeik, 2010; Shermer, 2017).

Even when the data were accepted, at least tentatively, the thinking and explanations were often reminiscent of many previous discussions that emphasize a deficit model for the students. For example, URM students and postdocs are poorer scientists, the outcome of social promotion and affirmative action. Or the writing skills of URMs are weaker in general because they come from disadvantaged backgrounds and less prestigious undergraduate institutions.

However, when we presented the data as part of organized Gilliam program mentor development workshops, a different tone emerged. Participants wondered whether subtle, unintentional differences in guidance or in assignment of projects might follow from assumptions, conscious or not, on the capabilities of trainees. To paraphrase comments: “I want to put my best people on the most important projects, and I wonder if I tend to have the greatest confidence in the student(s) with whom I am more comfortable.” Importantly, rather than focusing on “not my fault, not my responsibility,” the discussion moved to a more constructive “What are ways that I, as adviser, can help improve communication between all of the members of the lab?” The conversations in the workshops shifted from the mind-set of *selecting* talent to *developing* talent (e.g., NIGMS, 2011; McGee *et al.*, 2012). The context, even the environment in which the questions are asked (such as in a workshop on mentoring), may promote different reactions and lead to different understandings.

The persistent underrepresentation of minority groups in the biomedical research workforce surely has multitudes of causes, but the acknowledgment of the role and agency of the faculty in the professional development of their students is a promising step forward.

### SUMMARY

Whether the problem is making sense of observations in our primary scientific disciplines or making sense of challenges and observations in the training of scientists, we will continue to ask questions, especially when common-sense answers don’t quite fit the data. Importantly, we have seen in our discussions on how to enhance representation that the context in which assumptions are questioned and in which the questions are asked has potential to affect the openness of the scientific mind.

Because it is unlikely that any single approach or answer will solve the problem, we see the value of diversity in bringing multiple points of view to examine the issues. We will continue to question our own assumptions and observations and remember that correlation is not causality. We will always ask “How much?” and “So what?” We invite others in the science community to join us in questioning assumptions.

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## REFERENCES

- Carnegie Classification of Institutions of Higher Education. (2016). Retrieved July 11, 2018, from <http://carnegieclassifications.iu.edu/>
- Clauset, A., Arbesman, S., & Larremore, D. B. (2015). Systematic inequality and hierarchy in faculty hiring networks. *Science Advances*, *1*(1), e1400005. doi: 10.1126/sciadv.1400005
- Gibbs, K. D., Jr., Basson, J., Xierali, I. M., & Broniatowski, D. A. (2016). Research: Decoupling of the minority PhD talent pool and assistant professor hiring in medical school basic science departments in the US. *eLife*, *5*, e21393. doi: 10.7554/eLife.21393
- Higher Education Research Institute at UCLA. (2010, January). *Degrees of Success: Bachelor's Degree Completion Rates among Initial STEM Majors (HERI report brief)*. Retrieved from [www.heri.ucla.edu/nih/HERI\\_ResearchBrief\\_OL\\_2010\\_STEM.pdf](http://www.heri.ucla.edu/nih/HERI_ResearchBrief_OL_2010_STEM.pdf)
- Huang, G., Taddese, N., & Walter, E. (2000). *Entry and Persistence of Women and Minorities in College Science and Engineering Education*. Arlington, VA: National Center for Science and Engineering Statistics. Retrieved November 27, 2017, from <https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2000601>
- Hurtado, S., Eagan, M. K., Cabrera, N. L., Lin, M. H., Park, J., & Lopez, M. (2008). Training future scientists: Predicting first-year minority student participation in health science research. *Research in Higher Education*, *49*(2), 126–152. <https://doi.org/10.1007/s11162-007-9068-1>
- Kahan, D. M. (2013). Ideology, motivated reasoning, and cognitive reflection. *Judgment and Decision Making*, *8*, 407–424.
- Kahan, D. M., Landrum, A., Carpenter, K., Helft, L., & Hall Jamieson, K. (2017). Science curiosity and political information processing. *Political Psychology*, *38*, 179–199. <https://doi.org/10.1111/pops.12396>
- Lord, C. G., Ross, L., & Lepper, M. R. (1979). Biased assimilation and attitude polarization: Effects of prior theories on subsequently considered evidence. *Journal of Personality and Social Psychology*, *37*, 2098–2109.
- Martell, R. F., Lane, D. M., & Emrich, C. (1996). Male–female differences: A computer simulation. *American Psychologist*, *51*(2), 157–158.
- McGee, R., Jr., Saran, S., & Krulwich, T. A. (2012). Diversity in the biomedical research workforce: Developing talent. *Mount Sinai Journal of Medicine, New York*, *79*, 397–411. doi: 10.1002/msj.21310
- Mendoza-Denton, R., Patt, C., Fisher, A., Eppig, A., Young, I., Smith, A., Richards, M. A. (2017). Differences in STEM doctoral publication by ethnicity, gender and academic field at a large public research university. *PLoS ONE*, *12*(4), e0174296. doi: 10.1371/journal.pone.0174296
- National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. (2011). *Expanding underrepresented minority participation: America's science and technology talent at the crossroads*. Washington, DC: National Academies Press. <https://doi.org/10.17226/12984>
- National Institute of General Medical Sciences. (2011). *Investing in the future: National Institute of General Medical Sciences strategic plan for biomedical and behavioral research training 2011*. Retrieved July 11, 2018, from <https://publications.nigms.nih.gov/trainingstrategicplan/>
- National Science Foundation, National Center for Science and Engineering Statistics. (2017). *Women, minorities, and persons with disabilities in science and engineering: 2017 (Special report NSF 17-310)*. Arlington, VA. Retrieved July 11, 2018, from [www.nsf.gov/statistics/wmpd/](http://www.nsf.gov/statistics/wmpd/)
- Nettles, M. T., & Millet, C. M. (2006). *Three magic letters: Getting to the Ph.D.* Baltimore, MD: Johns Hopkins University Press.
- Page, S. E. (2007). *The difference: How the power of diversity creates better groups, firms, schools, and societies*. Princeton, NJ: Princeton University Press.
- Pezzoni, M., Mairesse, J., Stephan, P., & Lane, J. (2016). Gender and the publication output of graduate students: A case study. *PLoS ONE*, *11*(1), e0145146. doi: 10.1371/journal.pone.0145146
- Poodry, C. A. (2006, November). The scientific approach. *Diversity 2007*, pp. 8–10, supplement to *The Scientist*.
- Ropeik, D. (2010, July). *Why changing somebody's mind, or yours, is hard to do*. *Psychology Today*. Retrieved July 11, 2018, from [www.psychologytoday.com/us/blog/how-risky-is-it-really/201007/why-changing-somebody-s-mind-or-yours-is-hard-to-do](http://www.psychologytoday.com/us/blog/how-risky-is-it-really/201007/why-changing-somebody-s-mind-or-yours-is-hard-to-do)
- Schultz, P. W., Hernandez, P. R., Woodcock, A., Estrada, M., Chance, R. C., Aguilar, M., & Serpe, R. T. (2011). Patching the pipeline: Reducing educational disparities in the sciences through minority training programs. *Educational Evaluation and Policy Analysis*, *33*(1), 95–114. <https://doi.org/10.3102/0162373710392371>
- Shermer, M. (2017, January). How to convince someone when facts fail: Why worldview threats undermine evidence. *Scientific American*. Retrieved July 11, 2018, from [www.scientificamerican.com/article/how-to-convince-someone-when-facts-fail/](http://www.scientificamerican.com/article/how-to-convince-someone-when-facts-fail/)
- von Bartheld, C. S., Homanfar, R., & Candido, A. (2015). Prediction of junior faculty success in biomedical research: Comparison of metrics and effects of mentoring programs. *PeerJ*, *3*, e1262. <https://doi.org/10.7717/peerj.1262>