Books & arts

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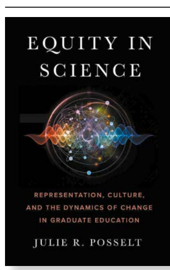
Sequencing DNA at the Cancer Genomics Research Laboratory in Gaithersburg, Maryland.

Deep changes needed for graduate-school diversity

Case studies show that efforts to address equity need to learn from past mistakes. **By Sibrina N. Collins**

In 1916, Saint Elmo Brady became the first African American to be awarded a doctorate in chemistry in the United States. Eighty-four years later, I was one of only 44 Black chemists in the country to earn a PhD that year. As a chemistry professor in academia, I have seen many efforts to address diversity in science, technology, engineering and mathematics (STEM). Yet the needle has barely budged. In 2016, in a nation where 33% of people identify as Black, Latin American (Latinx) or Native American, only 9% of all science and engineering doctorates in the United States went to students from these groups.

Some of the reasons behind this are explored in the book *Equity in Science*. Social scientist and education researcher Julie Posselt warns that we must learn from previous efforts or we are doomed to repeat past mistakes. She focuses on case studies from geoscience, psychology, chemistry and applied physics that serve as potential models for universities and colleges looking to recruit and retain women and people of colour in STEM graduate education. Posselt defines equity work as "reconfiguring structures, cultures, and systems to empower marginalized groups and close disparities". Institutional change is required to make substantial shifts. She admits it can be very messy.



Equity in Science: Representation, Culture, and the Dynamics of Change in Graduate Education
Julie R. Posselt
Stanford Univ. Press (2020)

Equity work begins with facilitating conversations with key stakeholders; data and storytelling have major roles in that process. Posselt provides heart-wrenching vignettes describing unacceptable behaviour towards women and students of colour. "I just wish dirty old men would keep their hands to themselves," one student told her. "It was like 'diversity-diversity-diversity' on the website, and when I came here there was nothing," said another.

Deep dive

One chemistry department (at an institution anonymized as "High Tower University") attained gender parity in graduate-student enrolment only after the department took a deep dive to understand why so many women had been denied tenure – in short, because of marginalization and lack of mentoring. This department used a more targeted approach to hire female faculty members who were strategically aligned with its intellectual interests. A star recruit led to more women coming aboard, which led to an increase in the enrolment of female chemistry graduate students.

At the University of Michigan in Ann Arbor, faculty leaders designed an inclusive applied-physics programme; it has recruited African American, Latinx and Native American students who have earned PhDs. Tactics included lecturers making visits to institutions that serve undergraduates from minority communities, and creating a 'family' environment for these students to succeed. Staff were hired to act as advocates and cultural translators for students. These institutions are US-based, but the lessons can be applied internationally.

Other key stakeholders are academic societies. Pivotal in graduate education, they need to do more. Posselt examines the American Physical Society and the American Astronomical Society. Among other things, these organizations recommended that standardized tests called the graduate record examinations be eliminated as a requirement for admission – they have been shown to reflect privilege more than ability.

Posselt draws from quantum theory's tools for thinking about the dynamics of change in complex systems fraught with uncertainty. She highlights the work of Niels Bohr and Albert Einstein, but misses an opportunity by failing to mention Elmer Imes. In 1918, he became the second African American to be awarded a physics PhD in the United States. His doctoral work, published in the *Astrophysical Journal*, provided tangible evidence of quantum behaviour in complex systems. Teaching students about scientists such as Imes broadens their image of who can be a physicist. This is one strategy to transform STEM curricula and to demonstrate how faculty members can respect the contributions of women and people of colour. In short, students should see scientists who look like them reflected in classroom content. Researchers such as Christopher Emdin, a scholar of science education at Columbia University in New York City, have used this approach to attract students from historically under-represented groups into STEM fields. Called culturally relevant pedagogy, it merits more detailed discussion than it gets in this book.

Early in her narrative, Posselt asks a crucial question: how much should graduate programmes reform "to accommodate the diverse career pathways in their fields"? There are simply not enough tenure-track positions, and most PhD holders don't work in academia. STEM fields have been slow to empower graduate students who choose to use their training to improve or uplift their communities.

Departments and faculty members need to provide safe spaces for students interested in careers outside academia. Students in Michigan's applied-physics programme said they wanted to secure employment and make a difference in society. The programme involves collaborations with many different departments, showing how physics can improve people's daily lives. This approach can resonate with and empower graduate students from historically under-represented groups.

There are many more successful doctoral programmes than Posselt can cover. For example, Louisiana State University in Baton Rouge is the leading producer of African Americans with PhDs in chemistry. The university has succeeded through targeted recruitment, mentoring and support.

Equity in Science does a good job of highlighting some of the barriers and challenges to equity in graduate programmes, and provides examples of what some do right and wrong. The book supplies specific guidance on inclusive practices. What we need now is a companion volume on getting and keeping scientists of colour in the next section of the pipeline: faculty. As I found after securing that PhD, rising through the ranks of academia as a Black woman chemist is tremendously hard work. What kept me going? Inspired by Saint Elmo Brady's legacy, I knew I too deserved a seat at the table.

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The code-breakers who led the rise of computing

World wars, cold wars, cyberwars — marking a century of state surveillance at GCHQ. By Andrew Robinson

"Most professional scientists aim to be the first to publish their findings, because it is through dissemination that the work realises its value." So wrote mathematician James Ellis in 1987. By contrast, he went on, "the fullest value of cryptography is realised by minimising the information available to potential adversaries."

Ellis, like Alan Turing, and so many of the driving forces in the development of computers and the Internet, worked in government signals intelligence, or SIGINT. Today, this covers COMINT (harvested from communications such as phone calls) and ELINT (from electronic emissions, such as radar and other electromagnetic radiation). Ellis and Turing are just two of the many code-breakers and code-builders in *Behind the Enigma*, the first authorized history of one of the world's pre-eminent secret intelligence agencies, GCHQ, the United Kingdom's Government Communications Headquarters. Famous for its Second World War decryption of the German Enigma cipher at Bletchley Park, there is so much more to this secrecy-shrouded outfit, reveals Canadian historian John Ferris.

Fielding formidable research, Ferris tells a global tale of mathematics, engineering, data sciences and linguistics in the service of politics, diplomacy, war and security. Spanning a century, it ranges from telegraphic intercepts to malware that can bring down infrastructure. After a brief introduction to pre-1914 intelligence based on letters, cables and wireless messages, his story begins with First World War cryptography and the foundation of GCHQ in 1919 as the Government Code & Cypher School. It ends with the agency's current, not-so-secret incarnation as a protector of the cyber commons. In September 2001, the director of GCHQ crossed the Atlantic on the only aircraft allowed into the United States immediately after the al-Qaeda attacks, to work with his US opposite number.

Behind the Enigma: The Authorised History of GCHQ, Britain's Secret Cyber-Intelligence Agency
John Ferris
Bloomsbury (2020)

What emerges is that SIGINT has ranged from highly effective to almost useless. In July 1962, a few months before the Cuban missile crisis, GCHQ picked up enciphered Soviet messages suggesting that two Soviet passenger and cargo ships were "possibly en route Cuba" and that their voyages might be "other than routine". But there was no hint of the ships' purpose and content. Then, in mid-October, a US U-2 spy plane detected the first proof of Soviet missiles in Cuba, triggering the crisis. Two weeks later, soon after US president John F. Kennedy's announcement of a naval blockade of Cuba, GCHQ detected a flurry of urgent enciphered messages sent from Moscow to Soviet ships. Thus, SIGINT helped to alert and inform governments, but the US political decision depended on ground observations by the military.

By contrast, at the end of the Falklands War against Argentina in 1982, the commander of the British task force declared that, without GCHQ's advance penetration of the Argentine plan of attack, mainly through COMINT in Spanish, the invasion would have failed at sea. But once the soldiers landed on the Falkland Islands, SIGINT failed them in battle, because of the improvised nature of the chain of command.

Central to these events was UKUSA, or 'Five Eyes' — which receives frequent mention in the book. This is the still-operative multilateral agreement for cooperation in SIGINT between Australia, Canada, New Zealand, the United Kingdom and the United States. It was inaugurated between GCHQ and the US National Security Agency in 1946, at the beginning of the cold war, but its existence was concealed from the public until 2005.

Intriguing are the backgrounds and mindsets of past and present GCHQ staff — today 6,000 in number, compared with 10,000 at its wartime peak — and their working conditions, breakthroughs and varied relationships with peers in other countries. Of their US counterparts, retired GCHQ director David Omand joked to the BBC in 2013: "We have the brains. They have the money. It's a collaboration that's worked very well."

Certainly, GCHQ mathematicians were often secretly ahead of the academic game. For example, in 1970 Ellis came up with the possibility