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# From margins to mainstream: decolonizing science and promoting diversity for the future of STEM

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Decolonizing science is essential for dismantling entrenched biases that privilege Western methodologies and marginalize valuable contributions from non-dominant regions. These historical and ongoing barriers perpetuate systemic inequalities across STEM fields, hindering diverse voices and restricting the scope of global scientific discovery. Examples within STEM illustrate the reciprocal influence of diverse cultures in shaping scientific knowledge, underscoring that progress is a collaborative, multicultural effort. Entrenched attitudes, often rooted in implicit biases, sustain the notion that scientific excellence is synonymous with famous Western names, further marginalizing diverse contributions. To foster a more inclusive and equitable scientific landscape, radical reforms in educational systems are necessary, integrating non-Western perspectives and encouraging a more comprehensive view of science. Addressing these structural barriers and shifting existing attitudes will create a global scientific community that values diverse contributions and promotes holistic, inclusive advancements in human knowledge.

KEYWORDS

**decolonization, inclusivity, bias, equity, innovation, contributions, reform**

## Introduction

The hierarchical structure of academia is a rigid system that disproportionately allocates power and resources, often to the detriment of underrepresented groups. At its core, academia is built on a tiered framework, with senior faculty and administrators holding substantial authority over funding, hiring, mentoring, and publication decisions, while junior academics, students, and researchers from minority backgrounds often lack the power to challenge exploitative practices. This structure fosters a "Matthew Effect," as described by Merton (1968), where established scholars and institutions continue to accumulate recognition and resources, often at the expense of those without systemic advantages. Studies have shown that women and individuals from minority groups are particularly vulnerable within this framework, facing barriers to career progression and disproportionate workloads in teaching and service (O'Meara et al., 2017). Additionally, the inequitable allocation of authorship and recognition in collaborative projects frequently reflects power dynamics rather than actual capacity to contribute to science, reinforcing exclusionary patterns (Baker, 2023). This paper focuses on the entrenched power structures within academia and STEM, exploring how they have historically marginalized certain groups and how their persistence continues to hinder inclusivity and innovation. Unlike existing literature, which often focuses on either historical inequities or individual examples, this work bridges the past and present by connecting historical abuses to modern systemic barriers and proposing actionable pathways for reform.

Hierarchies in academia are sustained by implicit biases and systemic inequities, as examined Hofstra et al. (2020) in a study highlighting the "diversity–innovation paradox" in STEM, where underrepresented groups often produce more innovative work but receive less credit and recognition. This inequity limits not only individual career trajectories but also the broader scope of scientific progress, as diverse perspectives are crucial for addressing complex global challenges since such hierarchical dynamics in STEM perpetuate a culture of gatekeeping, where senior academics and established institutions control access to resources, mentorship, and high-impact publications.

The prevalence of this issue has become a more obvious concern through global data collection and analysis efforts. Data from 82 natural-science journals in the *Nature Index* highlight that between 2015 and 2022, collaborations between the Global North (wealthier, industrialized nations) and the Global South (developing regions) accounted for only 2.7% of all publications, with authorship heavily biased toward the Global North (Baker, 2023). In addition to stifling innovation and career development, this lack of collaboration also hinders life-saving research. Challenges specific to developing regions – such as environmental challenges, disease outbreaks, or infrastructure needs – risk being overlooked due to lack of representation from contributors with relevant lived experiences. The reluctance to share resources had tangible consequences during the COVID-19 pandemic. For instance, Western companies were hesitant to share crucial information for the development of COVID-19 vaccines with the Global South, despite the World Health Organization's efforts to facilitate technology transfer to low- and middle-income countries for local vaccine manufacturing (Kavanagh et al., 2021; Maxmen, 2021). This unequal access to global representation and collaboration opportunities limits the scope and impact of research efforts to the priorities and perspectives of the Global North. It perpetuates the broader exclusion of underrepresented populations, limiting insights in addressing global issues equitably.

Examination of history reminds us of important contributions from marginalized voices, offering opportunities to reflect on the downstream consequences of unethical behaviors. Marginalization refers to the systematic exclusion or undervaluation of certain individuals or groups based on their ethnicity, gender, geographical location, or socio-economic background (Mansfield et al., 2024). In the context of science, this often manifests through unequal access to funding, mentorship, and opportunities to disseminate research, as well as the devaluation of knowledge systems that do not align with Western scientific paradigms (Quijano, 2000). Marginalization is not merely an oversight but a structural issue, deeply embedded within the hierarchical and exclusionary frameworks that dominate academic institutions.

The distinction between Western and non-Western perspectives is central to understanding this marginalization. Western science, shaped largely by Enlightenment-era epistemologies, prioritizes reductionism, empiricism, and objectivity as the cornerstones of knowledge production (Harding, 1998). In contrast, non-Western knowledge systems often emphasize holistic, contextual, and community-based approaches to understanding the natural world (Smith, 1999). For example, Indigenous methodologies frequently integrate scientific observation with cultural and ecological knowledge, offering insights that challenge and enrich dominant paradigms (Wilson, 2008). However, these non-Western perspectives have historically been dismissed or appropriated without acknowledgment within Western academic structures (Harding, 2011). This disparity is a consequence of what Quijano (2000) terms the "coloniality of power," where Western frameworks are privileged, marginalizing others as "alternative" or "less legitimate".

Unethical behaviors from people in positions of power, such as the use of intellectual resources from minority groups without reciprocal allocation of growth opportunities, exacerbate this marginalization. These behaviors not only harm individuals but also perpetuate homogeneity of thought that stifles innovation and limits the global impact of scientific progress. Building an understanding of non-Western scientific contributions requires an awareness of these systemic inequities (Figure 1). This work aims to illuminate these

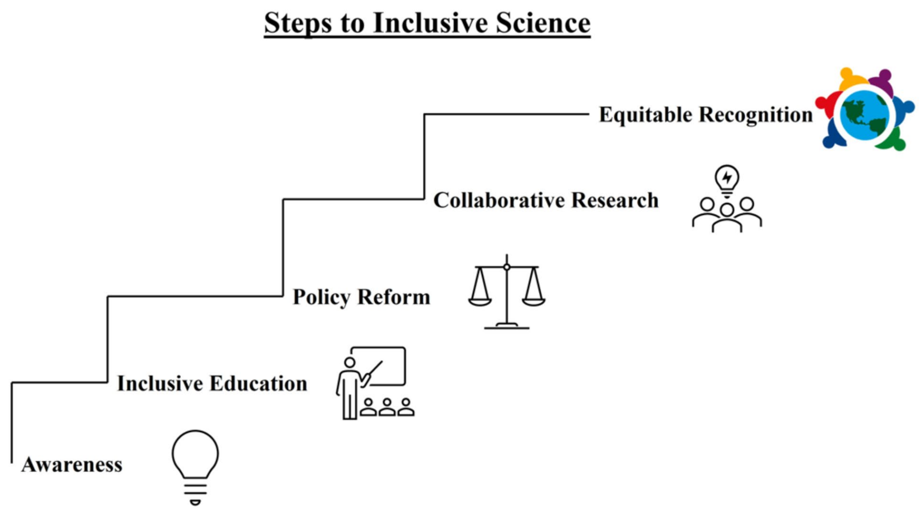


FIGURE 1
A visual representation of key steps toward achieving inclusivity in science. The diagram outlines the pillars of awareness, policy reform, inclusive education, and collaborative research as necessary steps toward equitable recognition.

issues and advocate for a more equitable recognition of diverse knowledge systems.

We do not claim that this exclusion is a deliberate act of racism within the modern scientific landscape, rather it is the consequence of a lack of understanding of the contributions that people from minority communities can make if given the appropriate support. We highlight with our examples from STEM fields when a person from a minority community contributed to the advancement of their relative field but was not met with the accolades due to a successful researcher – rather the response from the institutes that benefitted from the work was to move forward with promoting "one of their own." These cases serve not only as valuable illustrative tools and teaching resources for understanding the nuances of exploitative behaviors, but they also allow examination of the repercussions to affected individuals through a backward-facing lens. By situating historical examples within the context of modern STEM inequities, this paper provides a distinct perspective on the persistent impact of power structures. It diverges from existing studies by moving beyond documentation of historical exclusion to actively propose reforms, such as curriculum redesign, inclusive authorship practices, and the integration of diverse knowledge systems. These recommendations aim to inspire meaningful change within academic institutions, bridging historical understanding with actionable solutions.

## Cases of power dynamics and marginalization in STEM history

A significant barrier to inclusivity in STEM is the influence of geopolitical dynamics and personal biases within academia, which can limit transparency in innovation and restrict the progress of innovative individuals. These dynamics often marginalize contributions from less dominant regions and groups, reinforcing systemic biases that ripple across the global scientific landscape. Such barriers not only hinder the recognition of groundbreaking contributions but also perpetuate a cycle of inequity that limits access to critical resources such as mentorship, funding, and opportunities to collaborate. The effects of these disparities are manifold, including reduced trust in institutions, ineffective allocation of resources, and a narrowed scope of scientific inquiry that fails to fully address global challenges. Furthermore, entrenched systemic biases often operate under the guise of meritocracy, masking the structural disadvantages faced by marginalized groups and reinforcing the perception that their underrepresentation is a result of individual shortcomings rather than institutional barriers.

For example, during World War II, a team of Polish cryptographers, led by Marian Rejewski (1905–1980), provided the British with replicas of the Nazi cipher device, Enigma. This crucial contribution enabled the British to decode critical communications between Hitler and his generals, significantly altering the course of the war (Kasparek, 2002; Wesolkowski, 2001). Despite their pivotal role, the contributions of Rejewski and his team were largely excluded from Western recognition. The lack of acknowledgment extended beyond the war, as Rejewski himself was not invited to participate in subsequent cryptographic projects, effectively sidelining his expertise and minimizing the contributions of Eastern intellectuals in this field (Kasparek, 2002). This exclusion underscores a broader trend in which contributions from less dominant geopolitical regions are overshadowed by those from Western nations, perpetuating an inequitable distribution of credit and opportunity.

Similarly, in the field of biology, the development and application of the Golgi method, created by T. Camillo Golgi (1843–1926), contributed to major advancements in neuroscience. Golgi's work was foundational, yet his academic lineage reveals the appropriation of intellectual contributions by more dominant figures. Golgi was trained by a student of Rudolf Virchow (1821–1902), a renowned German physician and academic (Mazzarello et al., 2009) widely attributed with the theory of cell division. However, what is less known is that Virchow appropriated the work of Robert Remak (1815–1865), a Jewish-Polish academic and member of a minority group at the time. Remak's groundbreaking discovery of cell division challenged prevailing theories and was initially dismissed until Virchow later cited Remak's work without proper acknowledgment, ultimately minimizing his contributions while advancing his own career (Kisch, 1954).

Although it is speculative to draw conclusions on the full impact of the scientific discoveries that could have been made if Remak had been fairly supported and advanced in his career, this example highlights how systemic barriers have long stifled innovation by limiting access to resources, recognition, and opportunities for marginalized groups. These dynamics echo in modern STEM fields, where implicit biases and structural inequities continue to exclude diverse voices from shaping scientific progress. The propagation of perpetrators of unethical behaviors into favorable positions in STEM also provides them with opportunities to do more harm. As these individuals gain prominence, their behaviors are less likely to be questioned, creating a feedback loop that further entrenches systemic inequities, as was again illustrated by Virchow who went to produce a large-scale anthropological project that systematically characterized Jewish and non-Jewish children in German schools, documenting details of their appearance to classify "the blond type" as belonging to the German race and everyone else as non-German. This study, which involved over six million children, was applauded by intellectuals in European circles and perpetuated the notion of "whiteness" as an experience, not simply a consequence of geography (Zimmerman, 1999). Collectively, these examples underscore the interplay between academic authority and social prejudice that can go unchecked in the absence of diverse perspectives. By fostering a more inclusive environment, science stands to benefit from the diverse insights and approaches that arise when all voices are valued.

Diversity fosters innovation if we take the time to learn from it (Ely and Thomas, 2001). However, the careers of underrepresented groups often end prematurely, even when they are making novel contributions (Hofstra et al., 2020). A fundamental shift is required in how scientific contributions are valued, moving beyond traditional metrics of success such as publication counts and citation indices to include mentorship, collaboration, and societal impact. Expanding our knowledge of the diverse individuals who have shaped scientific progress globally is essential, particularly those whose contributions have been systematically excluded from the Western narrative of science.

Recognizing contributions challenges the systemic suppression of minority voices, which, when replaced by favoritism toward established figures, undermines not only fairness but the very quality of science itself, limiting its potential to benefit all of humanity. Achieving this recognition requires sustained effort to dismantle the hierarchical structures that perpetuate inequality, alongside initiatives that elevate the voices of marginalized scholars. Only by embracing this broader perspective can science fulfill its potential as a truly inclusive and global enterprise.

## The importance of understanding the multinational legacy in scientific progress

The global scientific community has long benefited from multicultural influences that have shaped the development of modern sciences, both in practical applications and theoretical insights. However, scientific disciplines like biosciences are deeply intertwined with histories of colonial exploitation and exclusion. These disciplines have been dominated by white European perspectives, with pseudoscientific arguments historically used to justify racial discrimination, ableism, and the erasure of non-Western contributions (Mansfield et al., 2024). The resulting biases not only distort the history of science but also create ongoing barriers to inclusivity, as the contributions of underrepresented groups are frequently overlooked. A typical STEM curriculum still disproportionately highlights Western names as the primary drivers of scientific progress, perpetuating this historical inequity.

Decolonization involves actively confronting the legacies of colonialism in shaping scientific knowledge and recognizing the ongoing impact of coloniality in modern academia (Mansfield et al., 2024). By integrating non-Western contributions into educational curricula, we not only honor the intellectual achievements of marginalized groups but also challenge harmful stereotypes. For instance, the reductive portrayal of Muslims in Western narratives as violent or subservient often neglects their profound contributions to science, such as Avicenna's (*Ibn Sina*) influence on European medical education through *The Canon of Medicine* (Russell, 2010). Understanding these interconnected legacies is essential for fostering a more inclusive and equitable STEM landscape that values global collaboration and diverse knowledge systems.

Teaching STEM as a dynamic, bidirectional exchange highlights the transformative power of cross-cultural collaboration and the imperative to decolonize bioscience education. Decolonization involves challenging the dominance of white European perspectives that have historically shaped the discipline, as well as confronting the lasting impact of colonial exploitation, scientific racism, and exclusionary practices, which need to be addressed through improved teaching practices of STEM history (Menon, 2021). For instance, Western medicine introduced more precise anatomical knowledge to Chinese doctors and scholars during the 19th century, notably through the pioneering efforts of Dr. Benjamin Hobson (1816–1873), whose work profoundly influenced Chinese medical practices (Chu, 2009). At the same time, the West benefited significantly from the millennia-old Chinese understanding of *Ephedra sinica's* medicinal properties, which have shaped Western pharmacology, including the development of treatments for respiratory conditions (Chu, 2009). However, these exchanges were often characterized by exploitation rather than collaboration, as seen in contemporary "parachute science," where researchers from the Global North conduct fieldwork in developing regions while excluding local expertise and failing to share benefits (Joshi et al., 2024).

Similarly, the translation of Dutch medical texts during Japan's Edo period enriched Japanese medical scholarship, highlighting how the flow of knowledge transcends geopolitical boundaries. Japanese advancements, such as the meticulous study of Hirano bodies, provided significant insights into age-related changes in the microfilament system, contributing to Western medical understanding of neurodegenerative diseases (Hirano, 1994; Takahashi, 2010). Yet, the recognition of such contributions often lags due to entrenched biases in STEM curricula, which disproportionately highlight Western achievements while marginalizing others. Mansfield et al. (2024) point out that this systemic bias not only erases non-Western contributions but also reinforces exclusionary structures within academic institutions. Addressing these inequities requires intentional curriculum reform, such as incorporating frameworks like Thomas and Quinlan's Culturally Sensitive Curriculum Scale, which emphasizes the representation of diversity, positive portrayals of marginalized groups, and active discussions of historical and contemporary exploitation (Mansfield et al., 2024; Thomas and Quinlan, 2021).

These examples underscore that scientific progress is inherently multinational, built on the collective efforts of diverse cultures working across time and space. Expanding STEM curricula to reflect these contributions is not just about correcting historical omissions but also about creating inclusive environments that inspire students from underrepresented backgrounds. Recognizing the value of diverse knowledge systems can foster innovation by broadening the scope of inquiry and dismantling the exclusionary structures that persist in STEM and addressing these inequities is not just a moral imperative but a pragmatic one, as it will enable a more equitable and dynamic scientific community that reflects the collaborative spirit at the heart of global scientific progress. By actively dismantling exclusionary structures, fostering cross-cultural exchanges, and embedding diverse contributions into educational and research frameworks, STEM disciplines can unlock innovative solutions to pressing global challenges.

## Conclusion

Despite the significant increase in the number of published papers since 1945, the pace of truly groundbreaking scientific discoveries has slowed (Kozlov, 2023; Park et al., 2023). While some contest these findings (Leahey, 2023), this moment presents a critical opportunity to confront the entrenched power structures within STEM and reshape the frameworks that guide knowledge production and collaboration. This paper emphasizes the persistent impact of these power structures on inclusivity and innovation, illustrating their historical roots and contemporary manifestations. By focusing on the intersection of power, equity, and reform, this work contributes a unique perspective to the growing discourse on decolonizing and diversifying STEM.

Policymakers, educators, and academic institutions must seize this moment to improve the administration of multinational collaborations and prioritize initiatives that decolonize STEM fields. Producing major scientific breakthroughs requires more than volume; it demands extensive, equitable collaboration and a deliberate engagement with diverse worldviews. Funding, sponsorship, and institutional support must be reoriented to amplify voices from marginalized communities and foster a genuinely inclusive scientific environment. These reforms are not merely additive but transformative, capable of reshaping how science is conducted and who gets to participate meaningfully in the process.

Understanding the historical contexts and power dynamics that shape knowledge production and dissemination is essential for driving meaningful change. Recognizing the diverse origins of contributors not only restores historical accuracy but also fosters transparency and trust in institutional legitimacy. These efforts pave the way for holistic, sustainable policies grounded in a profound understanding of human behavior and the interconnected nature of global challenges. Such policies will not only address historical injustices but also create a foundation for future generations to innovate without the constraints of systemic inequities.

Additionally, incorporating the perspectives of junior academics, such as doctoral students, into decision-making processes is vital for dismantling power imbalances. Current promotion criteria often overemphasize research output through publication metrics and impact factors (Mills, 2024), overlooking critical aspects such as mentorship, ethical conduct, and contributions to community-building. A shift toward a more comprehensive evaluation system—one that values the full spectrum of academic contributions—could create a more equitable and supportive academic environment. By acknowledging and rewarding these often-overlooked dimensions of academic work, institutions can cultivate a culture of fairness and collaboration.

Ultimately, the path forward requires a collective commitment to reforming academic and research structures to centre equity, inclusivity, and shared growth. By addressing the systemic barriers that hinder progress, we can unlock the full potential of global scientific collaboration. This is not merely about correcting past injustices but about building a future where diverse perspectives fuel innovation, and where scientific discovery is truly a shared endeavor. The transformative potential of these reforms lies in their ability to create a thriving, inclusive scientific community that reflects the collaborative spirit at the heart of human progress. With intentional action, we can leave a legacy of not only groundbreaking discoveries but also of a just and equitable global scientific enterprise for generations to come.

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RK: Conceptualization, Writing – original draft, Writing – review & editing. IT: Conceptualization, Project administration, Writing – original draft, Writing – review & editing.

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## Glossary

**Decolonization** - The process of challenging and dismantling dominant structures and ideologies that privilege certain cultural, economic, or scientific viewpoints, often rooted in colonial history. In science, it involves integrating diverse methodologies and knowledge systems from underrepresented regions

**Marginalized** - Refers to groups or individuals who are systematically excluded or underrepresented in mainstream scientific discourse and practice due to factors such as ethnicity, geography, or socioeconomic status

**Western** - Pertaining to the scientific methodologies, perspectives, and traditions developed in Western Europe and North America. These are often regarded as the default standards for scientific excellence, which can marginalize non-Western knowledge systems

**STEM** - An acronym for Science, Technology, Engineering, and Mathematics. It represents a broad set of academic disciplines that are crucial for technological and societal advancement

**Implicit Bias** - Unconscious attitudes or stereotypes that affect understanding, actions, and decisions. In the context of science, implicit biases can result in favoring Western perspectives over non-Western contributions

**Systemic Bias** - Prejudices that are entrenched within the structures of institutions, which favor certain groups over others. In scientific communities, systemic biases may manifest in the form of unequal access to resources, publication opportunities, or recognition

**Citation Metrics** - Quantitative measures used to evaluate the impact of scientific articles, journals, or researchers. Metrics like the journal impact factor can perpetuate Western-centric standards by prioritizing certain types of publications over others

**Epistemology** - The study of knowledge, including its origins, nature, methods, and limitations. In the context of decolonization, epistemology refers to questioning whose knowledge is valued in the scientific community

**Intellectual Property (IP)** - Legal rights that result from intellectual activity, such as inventions, literary works, or research findings. Issues of IP in the paper relate to the acknowledgment and ownership of scientific contributions

**Positionality** - The recognition of how the authors' backgrounds, experiences, and identities influence their perspectives and research. Positionality helps contextualize motivations and potential biases within the work

**Global North/Global South** - Terms used to describe socio-economic and political divisions between wealthier, industrialized nations (Global North) and developing regions (Global South). These terms are used to discuss disparities in scientific contributions and access

**Collaborative Science** - An approach that emphasizes cross-cultural and interdisciplinary collaboration in scientific research, valuing diverse contributions and perspectives to foster innovation

**Impact Factor** - A metric used to evaluate the importance of academic journals based on citation frequency. It is often criticized for reinforcing Western-centric standards in academia

**Equity** - Fairness and justice in the distribution of resources, opportunities, and recognition within the scientific community, aiming to create an environment where all participants can succeed

**Innovative Methodologies** - New and creative research methods that challenge traditional scientific norms, often incorporating insights from non-Western knowledge systems to foster a more inclusive approach to problem-solving