The socio-political in human genetics education

Education must go beyond only countering essentialist and deterministic views of genetics

By **R. G. Duncan[1]*, R. Krishnamoorthy[2], U. Harms[3], M. Haskel-Ittah[4], K. Kampourakis[5], N. Gericke[6], M. Hammann[7], M. Jimenez-Aleixandre[8], R. H. Nehm[9], M J. Reiss[10], A. Yarden[4]**

Biological and genetics research have established that racial categories have no biological or genetic basis. Social sciences have established that race is a socially and politically constructed categorization that undergirds racism, which has devastating consequences for the physiological and mental well-being of racially oppressed groups. The continued use of race as a proxy for describing human genetic variation is therefore troubling and has received attention in both the scientific community and the public arena (*1*, *2*). There is also growing recognition of the socio-political nature of human genetics/genomics research itself and the socio-political ramifications of its findings (*2*). To address these problematic aspects of human genetics research and the public's perceptions of its findings, we call on scientists to openly engage socio-political factors in their genetics education efforts. Even for those not involved in equity and justice work, acknowledging the socio-political matters for the generation and communication of robust, nuanced, and productive scientific knowledge.

The methods of conducting genetics research and its outcomes are steeped in, and impacted by, power and privilege dynamics in broader society. The kinds of questions asked, biological differences sought, and how populations are defined and examined are all informed by the respective dominant culture (often Eurocentric, white, economically privileged, masculine, and heteronormative) and its predominant ways of knowing and being (*3*). Findings from human genetics and genomics research subsequently play into existing socio-political dynamics by providing support for claims about putative differences between groups and the prevalence of particular traits in particular groups (*3*). Historically, such research has been used in support of eugenic movements to legitimize forced sterilization and genocides. Yet it would be a mistake to assume that such research is merely a discredited past relic, a stain on the otherwise objective and rational track record of genetic research. Rather, it was mainstream work conducted by prominent researchers and supported by major professional societies. The reality is that some modern human genetics is still informed by the same racist logic (*4*).

A recent report by the National Academies of Science, Engineering, and Medicine (NASEM) (*1*) has urged scientists to scrutinize and justify their use of "race, ethnicity, and genetic ancestry" as population descriptors in genetics and genomics research. That report calls for a shift in scientific practice to engage with the socio-political nature of genetics research in terms of how populations are described and how environments are measured. It also calls for more education related to this shift in practice. Education is an important lever in any approach to this problem, and practicing scientists need to be involved, given their profound impact in educating current and future scientists and teachers. Scientists advise on curriculum development initiatives, engage K-12 students through outreach, and, of particular importance, teach prospective scientists and teachers in their courses.

By arguing that genetics educators should engage with the 'socio-political' we are referring to historical and ongoing power differentials between individuals and groups that result in the distribution, often inequitable, of resources and privilege. Contrary to common views that rigorous science is value-free and impervious to the socio-political context, it is well established that science is and has always been affected by the dominant culture and its values. To explicitly acknowledge this reality in science teaching, including genetics education, is imperative; not doing so is misleading and has the potential to backfire.

To be clear, just because science is inherently socio-political does not mean that it is flawed, or that it cannot generate knowledge that is credible and valuable. Science has always been a socio-political and value-laden endeavor; this is a feature not a bug. Yet this reality in no way legitimizes the arguments of science deniers who misconstrue the socio-political nature of science as partisan and biased and use this misrepresentation to dismiss broad scientific consensus. When we ignore the reality that science is entangled with and inseparable from the socio-political context in which it is done, we end up with naïve and problematic views of science that can lead to its misrepresentation as non-credible.

BEYOND COMPLEX GENETICS

The current instructional overemphasis on Mendelian inheritance and the central dogma contribute to problematic views that are deterministic (genes exclusively dictate phenotypes) and essentialist (groups are homogenous and inherently different from each other). We build on existing efforts in genetics education to shift instruction to more complex and accurate models of gene-environment interactions (multifactorial inheritance) and human trait variation within and across populations (*5*). Such complex knowledge of genetics, and the explicit countering of race as biological, can lessen genetic deterministic and essentialist beliefs (*5*). However, while absolutely necessary, a shift to more complex genetics is not enough, because the socio-political nature of the environment and how genetic populations are defined remains implicit, resulting in incomplete scientific understandings that will not, by themselves, counter scientific racism. Our contention here is that successful genetic education has to be anti-racist, it cannot be race-neutral. Therefore, a core learning objective for human genetics education should be understanding that neither the environment nor our definitions of genetic populations are neutral but rather that they are shaped by the historical, social, and political contexts in which they exist. Below, we unpack the socio-political nature of the environment and genetic populations, and why it is important to emphasize the socio-political.

Environment

The environment is not neutral; rather, it is experienced differently by different people. For example, in the U.S., People of Color show higher allostatic load (cumulative burden of

[1]Department of Learning and Teaching, Rutgers University; New Brunswick, NJ, USA. [2]College of Education, Pennsylvania State University; State College, PA, USA. [3]Department of Biology Education, IPN – Leibniz Institute for Science and Mathematics Education; Kiel, Germany. [4]Department of Science Teaching, Weizmann Institute of Science; Rehovot, Israel. [5]Department of Biology, Section of Biology and IUFE, University of Geneva; Geneva, Switzerland. [6]Centre of Science, Mathematics, Engineering Education Research, arlstad University; Karlstad, Sweden. [7]Centre for Biology Education, Münster University; Münster, Germany. [8]Department of Applied Learning, Universidade de Santiago de Compostela; Santiago de Compostela, Spain. [9]Department of Ecology and Evolution, Stony Brook University; Stony Brook, NY, USA. [10]Department of Curriculum, Pedagogy and Assessment, University College London, London, UK. Email: ravit.duncan@gse.rutgers.edu

Duncan, R. G., Krishnamoorthy, R., Harms, U., Haskel-Ittah, M., Kampourakis, K., Gericke, N., Hammann, M., Jimenez-Aleixandre, M., Nehm, R. H., Reiss, M. J. & A. Yarden, A. (2024) The socio-political in human genetics education: Education must go beyond only countering essentialist and deterministic views of genetics. *Science*, **383(6685)**, 826-828. https://doi.org/10.1126/science.adi8227.

chronic stress) compared to white people even when adjusted for age and poverty rates; these differences amount to aging almost a decade faster due to discrimination and ongoing oppression (*6*). The COVID-19 pandemic brought into sharp focus persistent racial and ethnic inequities in disease risk and outcome.

Moreover, what might be considered the "same" environment, such as seeing a police car in your rearview mirror, can trigger different physiological responses for different people, with particularly stressful ones for racially minoritized individuals who often experience discrimination (*6*). Differences in environments are not benign. Rather, the racial health disparities in the U.S. largely stem from living in hostile environmental conditions both physically and socially. That these environments are oppressive is not happenstance, it is largely by design – through the historical and ongoing efforts of white supremacy (7). Thus, systemic racism is at play in shaping both the environment and the physiological responses to it within individuals and across generations.

Genetic populations

Similarly, how geneticists construe human genetic populations and how these are operationalized in terms of sampling and stratification is also socio-political. Genetic distinctions between human populations are not natural, they are the consequences of categorizations developed by geneticists for the purposes of their research and the questions they pursue (*3*, *8*). The search for genetic differences among populations, even when not done using explicit racial categories, can still yield findings that are problematic in that they can make social hierarchies appear "natural", for example caste differences in India (*9*). Yet, genetic studies can also promote notions of genetic unity and similarity across culturally distinct social groups. This was the case with a study by the Indian Genome Variation Consortium, which showed greater genetic similarities between the rival and culturally distinct Hindu and Muslim groups living in Kashmir compared to their counterparts elsewhere in India (*8*).

Regardless of whether research highlights genetic differences or similarities across social groupings, these endeavors are socio-political in that they are situated in, and therefore informed by, historical and ongoing dynamics of social hierarchies. Ruha Benjamin (*8*) describes other prominent cases that exemplify the non-neutrality of genomics research and argues that these efforts ultimately serve to unify or differentiate the population often as part of a larger national "branding" process.

RECOMMENDATIONS FOR EDUCATION

Why is it important for students to know about the socio-political nature of genetic populations and the environment in multifactorial models of trait variation? Is it not enough to counter genetic essentialism? We offer several reasons.

First, if we wish to dismantle racism (and other systems of oppression) in science and society, then we need to understand the ways in which such oppression is woven into the fabric of genetics research and disrupt and counteract these practices early and often through education. To achieve this aim, it is not enough to counter genetic essentialism. The understanding that race is not genetic (or biological) does not automatically translate into an understanding that race is a social construct, or that it can, and does, shape our biology. Moreover, knowing that race is a social construct does not automatically explain racial disparities in health or any other arena because it ignores the systemic nature of racism and the resulting inequities. Solely countering beliefs in race-based genetic differences and focusing on the similarities between racial groups obscures the real and devastating differences in the wellbeing of minoritized racial groups. This can lead to racial "color-blindness" of a genetic flavor that sees everyone as the same and turns a blind eye to the impact of racism on people's biology.

Second, knowing that the environment interacts with our genes positions the environment as an important consideration but does not problematize it as resulting from socially constructed power hierarchies with real and tangible (physical, social, economic) manifestations that are decidedly not neutral or benign. Sociopolitical awareness allows students to understand that there is no genetic basis for race on the one hand, but that racism has profound biological impacts on the other. Ignoring the political nature of how we define both genetic groups and the environment leads to un-nuanced and impoverished understandings of the very phenomena that scientists aim to study.

Third, students should come to value their social responsibility towards the moral and ethical ramifications (intended or not) of genetics research that they sponsor and consume. As a society we underwrite and are responsible for the knowledge we develop and how we use it.

Towards these ends, we provide three recommendations for secondary and post-secondary genetics education, grounded in genetics education research (*5*, *10*).

Emphasize the socio-political context of the environment.

In the context of human gene-environment interactions, instruction should address how physical, economic, and social environments can be damaging to people, particularly from minoritized and disadvantaged backgrounds, and are a cause of health disparities. Moreover, instruction should emphasize that these environments and their detrimental outcomes did not come about by chance but are manifestations of past and ongoing systemic racism and its underlying power and profit motives. Current treatments of the environments in genetics education often ignore the socio-political context and position the environment as largely neutral background conditions.

Entangle environment and biology

To grasp the biological effects of oppressive environments, students need to understand how the environment is entangled with the mind and body – how is it, exactly, that the environment "gets under our skin"? Instruction therefore needs to open up the black box of the mechanisms involved in gene regulation and epigenetic changes in response to environmental conditions. Students should come to understand that, in a sense, and to a certain extent, we can inherit effects of environments, especially traumatic ones, experienced by prior generations (*11*).

Scrutinize the socio-political categorization of human populations.

Instruction should encourage students to critically scrutinize how human populations are defined and bounded in genetic studies; they can identify the ways in which such categorization may serve political ends (i.e., who benefits and who loses from these boundaries). Similarly, instruction should foster awareness of the potential ramifications of findings from comparisons of social groups in terms of naturalizing these social categories (e.g., comparisons based on race contribute to making race seem a "natural" biological construct). Research continues to use categorization schemes that unnecessarily racialize traits biologically or genetically; for example, race is still viewed as a risk factor for type 2 diabetes in ways that can amplify a biological/genetic basis and downplay an environmental one (*12*). While this may be done with good intention (to help minoritized communities) it can, and often does, naturalize group differences as biological and promote deficit views of racialized communities and their cultures (*12*).

There are clearly challenges in implementing these recommendations. Both long- and short-term strategies involving multiple leverage points will be needed. In the long term, we see instructional materials as a powerful lever bolstered by a commitment to fund and implement them across education systems. Designing such materials will require the work of

Duncan, R. G., Krishnamoorthy, R., Harms, U., Haskel-Ittah, M., Kampourakis, K., Gericke, N., Hammann, M., Jimenez-Aleixandre, M., Nehm, R. H., Reiss, M. J. & A. Yarden, A. (2024) The socio-political in human genetics education: Education must go beyond only countering essentialist and deterministic views of genetics. *Science*, **383(6685)**, 826-828. https://doi.org/10.1126/science.adi8227.

interdisciplinary teams of geneticists, science educators, and sociologists who share an equity focus. There are powerful exemplars of curricula at the high school level that engage students with ambitious science, its socio-political dimensions, and a focus on social justice (e.g., *13*, *14*). There is a growing number of excellent books (*15*) and online resources for anti-racist genetics and biology education, for example, the LabXchange's "Racism as a public health crisis" curriculum, and the Fred Hutchinson Cancer Center's materials on "Race, racism, and genetics". These resources include supports for teachers in creating brave and safe spaces for discussions about race and genetics. Funding and committed support of national and professional science and science education organizations will also be instrumental for these efforts.

In the short term, we see scientists' role in the education of future scientists and teachers as one powerful lever for change. Undergraduate coursework in biology and genetics, often taught by faculty in those departments, are spaces where we can begin "sowing the seeds" of socio-political awareness in genetics. We offer two practical suggestions that science faculty can take to support such learning.

The first suggestion is to bring in the historical context of key discoveries in genetics in ways that highlight how the socio-political milieu at the time afforded and constrained the theories and methods used and their social consequence. For example, the monumental accomplishment of the Human Genome Project is often taught in genetics courses. What tends to be missing from this account is the broader socio-political context that shaped this project and its legacy. The prevailing, and rather essentialist and reductionist (it all boils down to genes), view at the time, of DNA as a blueprint for human capacities, powered this Herculean project. While this project, and those that followed, showed the overwhelming genetic similarity between people, it nonetheless contributed to a theoretical and methodological "science of difference" and ushered in an ongoing flurry of research efforts to locate socially relevant genetic differences within and between groups. The search for genetic differences has risks and benefits; instruction should address both and draw on emerging best practices in the field (*1*).

In this sense, the Human Genome Project was developed in, and sustained by, a socio-political context that upheld (and still upholds) value-laden group differences. This understanding can help students see the inter-relatedness of the historical, social, and political context of genetics science and society. Arguably, some of these ideas are taught in science and technology studies (STS) courses and we would welcome requiring such courses for any science or education major. However, we know that knowledge and learning are situated (context and discipline dependent) and therefore to be relevant and useful it is important for ideas to be learned in the discipline of their use rather than in a separate STS course.

The second suggestion is to engage students in reflection on the undergirding assumptions and aims of common research approaches in genetics (e.g., genome-wide association studies) – questioning who decides how to define populations, which populations are included or excluded in studies, who benefits from the knowledge generated by these approaches, and who might be harmed by them (intentionally or not)? Such questions can help students become more attuned to the intended and unintended, oppressive, or liberating, consequences of research.

We acknowledge that engaging with the educational recommendations we propose, especially given social polarization, is challenging and potentially risky (but change invariably involves risk and struggle). Yet we believe that engaging with these recommendations is worth the risk. Moreover, this risk can be lessened if those with power, such as professional societies in science, join the struggle with their voices, resources, and backing. The NASEM report (*1*) has re-centered these issues and we call on other organizations to follow suit. Through a commitment to critical and caring education we can change minds and structures towards more just futures.

REFERENCES AND NOTES

1. National Academies of Sciences, Engineering, and Medicine, "Using population descriptors in genetics and genomics research: A new framework for an evolving field" (The National Academies Press, 2023); https://doi.org/10.17226/26902.
2. D. O. Martschenko, M. Smith, *Nat. Genet.* **53**, 255–256 (2021).
3. J. A. Hamilton, B. Subramaniam, A. Willey, *Feminist Studies* **43**, 612–623 (2017).
4. A. C. Lewis, et al *Science* **376**, 250–252 (2022).
5. M. Haskel-Ittah, A. Yarden, Eds., *Genetics Education: Current Challenges and Possible Solutions* (Springer, 2021).
6. D. R. Williams, J. A. Lawrence, B. A. Davis, *Annual Review of Public Health* **40**, 105–125 (2019).
7. C. Anderson, *White Rage: The Unspoken Truth of Our Racial Divide* (Bloomsbury, 2017).
8. R. Benjamin, *Policy Society* **28**, 341–355 (2009).
9. Y. Egorova, *Genomics, Society and Policy* **6**, 1–18 (2010).
10. B. Donovan, R. H. Nehm, Eds., *Science Eduaction* **29** (2020).
11. R. Yehuda, *Scientific American*. **327,** 50-55 (2022).
12. J. Doucet-Battle, *Sweetness in the Blood* (University of Minnesota Press, 2021)
13. D. Morales-Doyle, *Science Education* **101**, 1034–1060 (2017).
14. E. Tan, A. Calabrese Barton, A. Benavides, *Science Education* **103**, 1011–1046 (2019).
15. J. L. Graves, A. H. Goodman, *Racism, Not Race: Answers to Frequently Asked Questions* (Columbia University Press, 2022).

Duncan, R. G., Krishnamoorthy, R., Harms, U., Haskel-Ittah, M., Kampourakis, K., Gericke, N., Hammann, M., Jimenez-Aleixandre, M., Nehm, R. H., Reiss, M. J. & A. Yarden, A. (2024) The socio-political in human genetics education: Education must go beyond only countering essentialist and deterministic views of genetics. *Science*, **383(6685)**, 826-828. https://doi.org/10.1126/science.adi8227.