Justice Oriented Genetics Education: Fostering Complex Genetics Understandings & Sociopolitical Awareness

The Political Genetics Research Group

PI- Ravit Golan Duncan, Rutgers University

Motivation for the Project

The Problem with Current Genetics Education

Over a decade of research has drawn attention to the ways in which genetics education either does not address, or even engenders, problematic deterministic and essentialist views that contribute to racial bias (Donovan, 2014; Gericke & El-Hani, 2018; Jamieson & Radick, 2017; Stern & Kampourakis, 2019). Essentialist and deterministic views largely stem from interactions between cognitive biases and limited knowledge of genetics (Dar-Nimrod & Heine, 2011; Jamieson & Radick, 2017). Therefore, recommendations for instructional antidotes have focused on countering these biases by promoting more complex understandings that emphasize population thinking and multifactorial genetics (Dougherty, 2009; Donovan et al., 2019).

While we agree that such countering is necessary, we posit that it is insufficient and that in addition we need to focus instruction on the socio, political, and historical dimension of genetics and genomics. The enterprise of defining and distinguishing groups is grounded in colonial sciences of difference that perpetuate hierarchical categorizations of humans (Hamilton et al., 2017). How we construe human groups and populations is dependent upon, and often strategically calibrated with, the sociopolitical (Benjamin, 2009). If we espouse social justice aims for genetics education, then we need to explicitly address the entanglement of genetics/genomics and the sociopolitical-historical contexts in which we live. Students need to understand that oppressive policies and structures continue to be shaped by sciences of difference and that these oppressive policies and structures result in environments that shape traits and genomes of populations.

Theoretical Frameworks

Consequential Learning

Consequential learning provides opportunities for multiple ways of knowing and doing science that deepen engagement with disciplined science while expanding what counts as science, who can do science, and what are valued outcomes of this endeavor.

Consequential learning affords youth agency to use their scientific understanding along with other forms of expertise to identify, investigate, and redress injustice in their lives and in their community.

(Birmingham et al., 2017; Jurow & Shea, 2015).

Rightful Presence

Rightful presence means having legitimate agency (right) to change the norms and rules of the community (not just abiding by existing norms/rules of those in power). It entails a shift in powered host-guest relationships such that the cultural knowledge and experiences of newcomers are valued as powerful contributions. The framework has three tenets:

> *Tenet I: The right to re-author rights*. Teachers and students work together to challenge and transform what it means to learn and do science in ways that value students as whole people.
>
> *Tenet II: Making (in) justice visible*. Youths' whole lives become a visible part of classroom interactions and upon which meaningful learning is built.
>
> *Tenet III: Collective disruption of guest/host relationships through allied political struggle*. The responsibility for disruption and change is on all members of the learning community (not just the marginalized).

(Calabrese Barton & Tan, 2020).

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Taking a Political Turn

Politicizing Genetic Populations

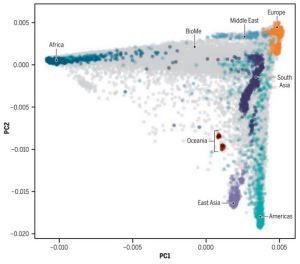
Groupings of humans into distinct genetic populations are not natural. They are the consequence of categorizations developed by geneticists for the purposes of their research (Lewis et al., 2022). The search for genetic differences among populations can yield problematic findings that naturalize social hierarchies.

Such these efforts are socio-political and serve to unify or differentiate the population often as part of a larger national 'branding' process (Benjamin, 2009).

Reproduced with permission from Anna C. F. Lewis et al., Getting genetic ancestry right for science and society. *Science* **376**,250-252 (2022).

The continuous, category-free, nature of genetic variation

Colored dots ($n = 4149$) are reference panel individuals from 87 populations representing ancestry from seven continental or subcontinental regions projected onto the first two principal components (PC1 and PC2) of genetic similarity. Gray dots ($n = 31,705$) are participants from BioMe, a diverse biobank based in New York City. Clearly delineated continental ancestry categories (five islands of color) are shown to be a by-product of sampling strategy. They are not reflective of the diversity in this real-world dataset, which is made evident by the continuous sea of gray.

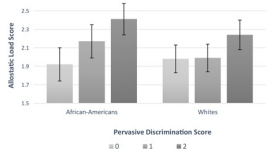


Politicizing the Environment

The environment is not neutral. It is experienced differently by different people. For example, in the U.S. people of color show higher allostatic load (cumulative burden of chronic stress) compared to whites even when adjusted for age and poverty rates; these differences amount to aging almost a decade faster due to discrimination and oppression.

Differences in environments are not benign; the racial health disparities in the U.S. largely stem from living in hostile environmental conditions both physically and socially. Thus, systemic racism is at play in shaping both the environment and the physiological responses to it within individuals and across generations.

Van Dyke, M. E., Baumhofer, N. K., Slopen, N., Mujahid, M. S., Clark, C. R., Williams, D. R., & Lewis, T. T. (2020). Pervasive Discrimination and Allostatic Load in African American and White Adults. *Psychosomatic medicine*, *82*(3), 316–323.



Associations between pervasive discrimination and allostatic load by race in the MIDUS II Biomarker Project (n=1,204) MIDUS=Midlife in the United States; Values are estimated marginal means from linear regression models adjusted for demographics (age, sex, marital status, and employment status), SES, medications , health behaviors, and personality covariates.

Axiological Commitments

Complexifying the Genetics We Teach:

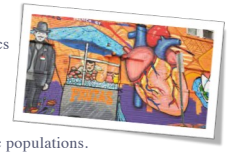
- Focus on multifactorial genetics and population genetics
- Explicitly counter essentialist and deterministic views

Taking a Political Turn in Genetics Education:

- Promote students' socio-political awareness regarding the political nature of environments, genes, and genetic populations.

Valuing Students' and Communities' Ways of Knowing and Being:

- Fostering consequential learning through rightful presence- valuing and elevating students' lived experiences and ways of knowing as central to learning in genetics



Justice Oriented High School Unit

Design Features

Addressing NGSS Disciplinary Core Ideas and Scientific Practices:

Unit builds on middle school standards and addresses the high school standards for inheritance and variation of traits. Focusing on multifactorial inheritance, continuous variation (no clear delineation between populations), and the role of the environment. Students will engage in investigation, data analysis, modeling, and argumentation.

	6-8	9-12
LS3.A Inheritance of traits	Genes chiefly regulate a specific protein, which affect an individual's traits.	DNA carries instructions for forming species' characteristics. Each cell in an organism has the same genetic content, but genes expressed by cells can differ
LS3.B Variation of traits	In sexual reproduction, each parent contributes half of the genes acquired by the offspring resulting in variation between parent and offspring. Genetic information can be altered because of mutations, which may result in beneficial, negative, or no change to proteins in or traits of an organism.	The variation and distribution of traits in a population depend on genetic and environmental factors. Genetic variation can result from mutations caused by environmental factors or errors in DNA replication, or from chromosomes swapping sections during meiosis.

Consequential Anchoring Phenomenon:

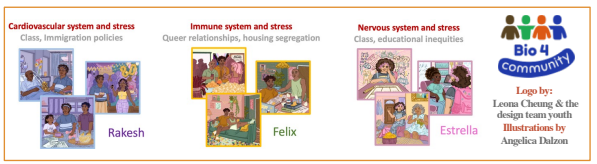
The unit explores the phenomenon of elevated risk for, and increased prevalence of, diabetes in an Hispanic community. Through the story-driven investigation (see below), students will explore the cellular and molecular basis of diabetes, the impact of environmental risk factors (social determinants), and the Hispanic Paradox, highlighting the protective effects of community and culture.

Story-Driven Investigations:

Building on an approached we used in a related NSF project unit design – Bio4Community: *Stressed Out!* We will craft one or more stories through which students develop their understandings of the genetics and social determinants of diabetes in their local Hispanic community.

The story will:

- Explicitly highlight the sociopolitical context
- Include community-based knowledge along with normative scientific evidence
- Avoid, as much as possible, a deficit view of minds, bodies, and people
- Shift blame and responsibility from marginalized individuals and communities to the system and the inequities it creates and sustains.



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