Winter 12-2022

DEI without Equity: Lab Coat Culture and Persistent Racism in Bioengineering Laboratories

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DEI without Equity: Lab Coat Culture and Persistent Racism in Bioengineering Laboratories

by

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A thesis presented to
Washington University in St. Louis
in partial fulfillment of the
requirements for the degree
of Artium Magistri

December 2022
St. Louis, Missouri

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Acknowledgments

I am blessed to have so many scholars to learn from in both the streets and the classroom. Thank you Kiara for your wisdom, my sister, mentor, and friend. Dr. Jorge Jimenez and their fierce tenderness. Alondra Nelson and Safiya Noble- I've barely interacted with you in person, and you still have given me tools, resources, and support to explore my passions. Thank you Mama Moore and Dr. Stetten for helping me become a radical scientist. My girls Nadia and Antonia, y'all straight ratchet and never tactless. Akhil Patel for being my very first lab mentor. Myself, I worked my ass for this. My therapist Onika, you hold me down! Thanks to Garrett, for using his white privilege to get me the medical care I needed and being a cool cohortmate. Thank you to the rest of my classmates for spending time with my work and being great people. My Aunt Chelle and my grandparents, for raising me to be critical, protective, and caring. My committee, especially Adia Wingfield and David Cunningham for being patient and investing in my work, even when we disagree on academic politics. My grandma Janet and my mom for making me all of who I am. Rest in peace, I love you. This project was funded through the NSF-GRFP, Spencer T. and Ann W. Olin fellowship, the Center for Race, Ethnicity, and Equity Small Grant, and the Sociology department grant. Thank you Solange, Danesh, Justin and Gaby for trying to get free with me. Thank you Black Coffee and friends for the caffeine, moral support, and a safe space to write. Thank you to the Collective, and STL Pickup Soccer for being my refuge throughout my process. Thank you to my respondents, your work will change the world as we know it.

Rene Canady

Washington University in St. Louis

December 2022

Preface

This project grew out of frustration with dealing with racism both in the classroom and with the medical system as well as passion for bioengineering a better world. The lab is a place of world-building, a place of self-discovery, and a place that reinforced my relationship to the world around me. This project was fueled by 4 years of tension between my lived experiences dealing with oppression and my undergraduate bioengineering program's silence on racism. While I loved being a lab rat (though I never got my own coat), I felt that some of the best changes I could make in the field were from a place where systems of oppression were well-interrogated. In 2020, I got accepted to Washington University Sociology before I even understood what sociology was. I was somewhat lucky. Sociology has allowed me to explore the systemic forces that shaped the world around me, and it has been a very personal journey learning about social structure and agency.

Lastly, Black feminist communities have taught me how to question the legitimacy of institutional power. I have learned about oppression from loved ones more than I ever could in a classroom. As a Black woman, I will never be able to participate in the biomedical field and not be impacted by racism. This work is intentionally political and is birthed out of understanding the personal as political.

Rene Canady

Washington University in St. Louis

December 2022

Dedicated to my mom, grandma, and Aunt Tia.

ABSTRACT OF THE THESIS

DEI without Equity: Lab Coat Culture and Persistent Racism in Bioengineering Laboratories

by

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Artium Magister in Sociology

Sociology

Washington University in St. Louis, 2022

Professor Adia Wingfield, Chair

From biased algorithms to discriminatory devices to medical racism, it is clear that biomedical products are created in ways that reproduce racial disparities in access and use. Yet the most common solutions recommended by biomedical research institutions emphasize diversity, equity, and inclusion practices that research has already proven ineffective and sometimes harmful. In fact, labs rarely scrutinize whether and how their research products reflect racial bias, assumptions, or ideals. In this paper, I shift the focus to consider how bioengineering laboratories function as a site in which racial processes contribute to product outcomes. I ask, what are the racial dynamics in the bioengineering laboratory, and how, if at all do they shape the biomedical innovations that they produce? By interviewing 47 bioengineers and completing 3 laboratory ethnographies, I uncover the racial attitudes and perspectives that exist in the sites of production of biomedical technologies. I show that through the pipeline of biomedical production, race is continually altered in context, resulting in a distinct bioengineering culture around racial health equity. Ultimately, this paper contributes to literature about race in organizational studies and science and technology studies, while emphasizing the construction and reconstruction of race in bioengineering research.

1 Introduction

While it has always been present, medical racism has, of late, become a more visible part of the health care system. Health care practitioners and professional associations representing health care professionals have begun to highlight the ways that biases, presumptions, and stereotypes among health care workers contribute to stark racial disparities in outcomes, care, and even life expectancies. Black Americans are 1.5 times more likely to have peripheral arterial disease, Black women are up to four times more likely to die of pregnancy related complications than white women, and the average life expectancy of African Americans is four years lower than the rest of the U.S. population (Ahmad et al. 2021; Chambers et al. 2019; Virani et al. 2021). These data suggest that medical racism is a significant, pervasive problem that stands to have life threatening consequences for subsets of the population.

Despite that medical racism is well known, most research on how it is perpetuated centers health care providers and excludes biomedical spaces of production. This means that researchers understand how health care workers' perceptions and biases contribute to differential care, but it is much less understood how biomedical devices, products, and tools contribute to the health disparities that persist in the US. Yet bioengineering laboratories are organizations that rely heavily on social interactions and collaborative projects to create biomedical products. The development of both novel and ubiquitous biomedical products has massive impact on the entire biomedical field, including surgery performance, routine medical procedures, and over the counter treatments. Laboratories, typically embedded in research universities, hospitals, companies, and other institutions, are key spaces that produce these products that are widely used in health care and perpetuate racial disparities (Benjamin 2019; Challen et al. 2019). Thus, in

order to gain a more comprehensive look at how medical racism is perpetuated, it is essential to look at labs as sites of production and their role in perpetuating medical racism through the devices they create.

In this study, I examine the racial dynamics in the bioengineering laboratory in order to assess how these dynamics shape the production of biomedical devices. By examining bioengineering laboratories as racialized spaces that grapple with DEI initiatives in highly contextual ways, I show that interactions in the lab are critical to the production of devices that perpetuate the social construction of race. Consequently, this work sheds light on an understudied aspect of medical racism by highlighting the process by which biomedical products are created and perpetuate racial disparities.

2 Theoretical Framework

2.1 Racial Diversity in Organizations and Occupations

2.1.1 Organizational Culture

Organizational culture in labs is understudied but has implications for how biomedical products perpetuate disparities. Organizational culture is conceptualized as the set of widely shared norms that can shape members' attitudes and behaviors as a system of control (Chatman and O'Reilly 2016) and its literature has been robustly developed to both understand and change workplace dynamics. To accomplish tasks, organizations rely on collective values that rationalize the expected behavior of its members, who defer to authority. Behaviors are reinforced by social approval and disapproval, where members avoid the risk being alienated by the group. Because organizations have implicit and explicit norms that are shaped by race, gender, and class systems, they reproduce those hierarchies amongst their members.

2.1.2 Racialized Organizations

While most extant descriptions of organizational culture say little about the role of race and racism in the workplace (Cameron and Quinn 2011; Chatman and O'Reilly 2016), we know that organizations are far from race neutral (Timmermans and Kaufman 2020). Ray (2019) expands on organizational culture by revealing that organizations have norms and values steeped in whiteness and racism. Ray (2019) argues that organizations become racialized due to segregation of resources, a decoupling of organizational rules from actual practices, whiteness as a credential, and diminished agency for racial minorities (Ray 2019). White institutional spaces are characterized by racialized exclusion, racial symbolism, explicit and tacit discrimination, as

white norms and practices that shape the subjective experience of organizations (Evans and Moore 2015; Moore 2008; Ray 2019).

For example, an entry level engineer can only gain promotions by having good rapport with management; members of which who are vast majority white. The promotion decisions that affect the engineer will reproduce racial disparities because management is likely to base promotion on subjective standards and are biased towards those like themselves (Whysall 2018). These practices are decoupled from institutional policies, which neglect race altogether, or explicitly ban racial discrimination, creating a large tension between organizations stated culture around racial equality and the lived experience of its racial minorities. Black professionals regularly report perceiving discrimination that prevents job promotion and increased salaries (Mong and Roscigno 2009; Pager and Shepherd 2008; Roscigno, Garcia, and Bobbitt-Zeher 2007; Whysall 2018; Wingfield 2009), stifling career mobility. Thus, both hiring and retention practices result in underresourced and unstable careers for minorities that leave them with little agency to influence workplace decisions. While equal opportunity practices are the stated interests of employers, their hiring standards ultimately favor those with greater connection to white people, making whiteness a credential.

2.1.3 Diversity as a Historical Barrier to Racial Equity

The racialization of organizations is not only mediated through, but institutionalized by contemporary diversity, equity, and inclusion (DEI) efforts (Rahim 2020). Despite their stated intentions, DEI measures have created and maintained barriers to racial equity within the workforce since their infancy in the post-Civil Rights era. The Civil Rights movement, though fueled primarily by working class activism, spurred organizational measures affecting mostly white-collar workers and the middle class (Morris 1984). Legislation in the sixties included the

1965 Affirmative Action executive order and the 1964 Civil Rights Act. Politicians who shaped the legislation required equal opportunity in law, education, housing, and employment, but intentionally neglected to provide a tangible definition of what compliance would look like (Dobbin 2011). When minorities laid charges against organizations for non-compliance, courts and law enforcement subsequently sided with elite institutions, such as in the Bakke decision, where racial quotas in organizations were deemed unconstitutional. This decision, among other court cases, turned power into the hands of hiring managers by letting companies determine how affirmative action would tangibly be applied.

Additionally, the federal government decided to not form a regulatory agency for workplace equity. Instead hiring personnel created their own programs on diversity, equity and inclusion, selectively applying information from activists and scholars (Dobbin 2011). Rapidly expanding, DEI programming became the standard for workplaces and personnel created careers for themselves. At the same time, unions were decreasing in presence, changing the conversation and action around workplace racial equality (Rosenfeld and Kleykamp 2012). This separation between the original goals of advocating for affirmative action and the practice of racial equity and inclusion allowed discrimination to continue—alongside the building of DEI institutions.

The Bakke decision weakened affirmative action legislation and set the stage for DEI as it is today (Dobbin 2011; Moore and Bell 2011; Rahim 2020). While striking down the use of racial quotas and ignoring historical discrimination as a compelling justification to use race in higher education admissions, Justice Lewis Powell suggested the ambiguous goal of diversity instead. Bell and Hartmann (2007) argue that diversity discourse has continued within a frame that fundamentally excludes racial inequality, white power, white privilege, and the racial hierarchy that exists within organizations (Bell and Hartmann 2007). Moore and Bell (2011)

argue that diversity discourse has gravely stalled racial reform by imposing boundaries around discourse on progressive racial policies, leading to understandings of "diversity without oppression" (Moore and Bell 2011). Decoupling common law tradition and the power to enforce equity has allowed DEI to grow rapidly as a profession, while organizations largely continue to remain nondiverse, unequitable, and exclusionary.

This research indicates that organizations, far from being neutral, bureaucratic spaces, are actually racialized in their allocation of resources and agency, credentialing, and organizational practices. Yet many organizational spaces fail to deal directly with these implications, and instead prefer to import measures that focus broadly on diversity rather than addressing systemic racial issues that perpetuate disparities. Bioengineering laboratories best illustrate this phenomenon because not only do they produce products and processes that contribute to racial health disparities, but their organizational norms and values suggest commitment to solving social problems without attention to systemic oppression. This study considers these implications for bioengineering labs that create biomedical innovation by examining how labs function as racialized spaces, and the implications for the products they create.

2.2 Critical Race Code Studies and the New Jim Code

Due to both intersectional and interdisciplinary approaches, critical thought on the impact of race, class, and gender floats in the margins of scientific, biomedical, and technology studies (Benjamin 2016, 2019). Sociologists have only recently begun to collectively consider the racialization of science and technology and how technological advancements can perpetuate racial hierarchies and inequalities. Coined by Ruha Benjamin, race critical code studies combine critical race theory with science and technology studies. Race critical code studies scholars are all ultimately skeptical of technology as a fix to racism and have assessed the role of technology

in maintaining oppressive and carceral systems (Benjamin 2016; Hamilton 2020; Noble 2018; Roberts 1998, n.d.). Benjamin defines the New Jim Code as: "The employment of new technologies that reflect and reproduce existing inequities but that are promoted and perceived as more objective and progressive than the discriminatory systems of a previous era" (Benjamin 2019). As a part of race critical code studies and the New Jim Code, Benjamin (2019) carves out 4 levels of racialized technology design that range from biases produced by explicit intention to more insidious reproduction of harmful assumptions and reifications.

2.2.1 Engineered Inequity

Engineered inequity, the first level of the New Jim code is defined as the explicit amplification of social hierarchies. This is best demonstrated by the redesign of the spirometer, the biomedical device for lung capacity. Though invented in Britain, a setting for race was added by recommendation of insurance companies in the United States so that the readings would produce lower for Black Americans (Braun 2015). The companies would then justify the cancerous pollution of Black communities and deny their health risks with the new reading (Braun 2014).

2.2.2 Default Discrimination

The next level of the New Jim code is default discrimination, in which the process of discrimination grows out of socially and historically ignorant design processes. For example, voice recognition devices often fail to comprehend Ebonics that African Americans and other groups (Topaz et al. 2018). Other English dialects are also misread, but this issue is misrepresented as a “glitch” in an algorithm that is otherwise perfect (Benjamin 2019). However, failure to understand the diversity of American language is a huge problem that would require the retraining of voice detection algorithms everywhere (Mengesha et al. 2021). While medical

malpractice is a consequence of default discrimination, designers of such technologies pay attention to quick technological fixes instead of the systemic nature of their design flaws.

2.2.3 Coded Exposure

Coded exposure is the third level of The New Jim code, where race is explicitly addressed in technology design, but in a way that fundamentally reproduces the current racial order. Coded exposure is best represented by biometric databases, which store DNA samples, fingerprints, and photos of people for surveillance. While biometric databases are regularly redesigned to serve a variety of institutions, national governments use the same technology for carceral purposes, including the denial of British citizenship to Africans, the de-enrollment of Native Americans from tribes, and the building of biased suspect databases for police (Benjamin 2016, 2016; Eubanks 2019; Roberts 2011). Additionally, visual technologies that can analyze pale faces but register dark skin as "other" provide only certain forms of visibility to racial minorities also demonstrate default discrimination. This visibility is amplified by the designer's desire to exploit race for financial gains (Benjamin 2019; Noble 2018; Roberts 2011).

2.2.4 Technological Benevolence

Technological benevolence is the most insidious level, where "tech products that offer fixes for social bias yet still reproduce or deepen social bias" (Benjamin 2019). The potential for biomedical devices and other technologies to cause harm in communities of color is well documented. Technological benevolence is best exemplified in genetic engineering advances, which have been well-documented as intense attempts to remedy social issues (Benjamin 2009; Bliss 2012; Nelson 2018; Rodríguez-Muñiz 2016). Nelson (2018) detailed several racial reconciliation projects that aimed at social inclusion of African Americans through genetic

testing, including slavery reparations lawsuits, social inclusion in the pan-African world, and global citizenship.

While race reconciliation projects exist for the stated goal of social justice, critical code race scholars explicitly caution the uncritical use of biomedical products and list their failures and limitations. For example, genetic testing is frequently praised as the future of personalized medicine, yet it has been repeatedly stated that scientists cannot identify distinct races within one's genetic code (McLean 2021b; Nelson 2018; Roberts 2011). Additionally, countries of origin identified by personalized genetic testing are not accurate, and do not change the racial ideas of Black individuals or White nationalists (Nelson 2018; Panofsky and Bliss 2017). This data suggests that genetic testing produces mixed results and can simultaneously reinforce and oppose racial hierarchies. Activists, scientists, corporations, and the public are all subject to consumption and other capitalist influences when participating in genetic testing, regardless of their personal goals (Bliss 2012; Nelson 2018; Roberts 2011).

2.2.5 Liberatory Design

Finally, some researchers also note that there is a pathway towards using technology to erase rather than widen racial inequalities. While race critical code studies scholars eschew the use of technology as a standalone fix to social issues, the same scholars recognize the tradition of using biomedical products, processes, and technology to solve racial injustice (Eglash 2019). For example, the Black Panther Party performed Sickle Cell testing on Black communities in the 60s using Sickledex machines (Nelson 2011). Additionally, the Party built several institutions providing holistic therapies, health screening, and other biomedical services to serve the Black and poor community, which likely contributed to the awareness of Sickle Cell Disease, which affects the African American community at a higher rate than other racial and ethnic groups in

the United States (Bassett 2016; Nelson 2011). Policies supporting Sickle Cell research arrived just 5 years after the Party's inception, underscoring the power of their campaign to address and eradicate health inequalities. Such systemic practices are omitted from in traditional biomedical design settings.

While not exempt from the guise of technological benevolence, Black Panther Party's success in utilizing biomedical technology for racial justice offers an example of liberatory design. Benjamin (2019) states that technology designed for liberation must be "humane" and engage in enough "cultural specificity" in its design. Race critical code studies describe the way race has been embedded into science, technology, engineering, and medicine in order to reproduce and disrupt the current social order, but combined with anti-racist literature in laboratories and other biomedical settings, the literature only offers patchwork support into racialized design processes. The current literature on racial health inequality remains disconnected from racial discourse about biomedical researchers, engineers, scientists, and other professionals. Information such as how stakeholders engage in the biomedical innovation process is needed to understand how race is embedded in bioengineering design (Bailey and Peoples 2017; Benjamin 2013; Hamilton 2020). Race within the sociopolitical context of society will continue to shape the biomedical field, and it is important to analyze this shaping in a systemic manner in order to make systemic shifts towards equity, justice, and liberation.

2.3 Bioengineering Laboratory Settings

2.3.1 Bioengineering Laboratory Organization

Given that organizations are racialized spaces wherein scientific and technological advancements can perpetuate or minimize racial inequality, it is useful to know where bioengineering labs fall in this process. Bioengineering, which integrates engineering and

medicine, often creates hybrid understandings of health. Bioengineers often simplify bodily systems to equations and mechanics so that the body can be analyzed at precise levels. For example, they could create a stent, a medical device for heart valves, using equations on derived fluid flow laws. Bioengineers and biomedical engineers apply math, science, and engineering principles to biology and medicine. In doing so, they work to improve human health through research and innovation, often combining skillsets from other fields to create devices, tools, algorithms, and systems.

Typically bioengineers work in laboratories formerly defined in research and manufacturing facilities. Compared to other engineering disciplines, bioengineering is a new field that is rapidly expanding in the sectors of technology and healthcare. The laboratories are typically physically located in academic, industry, or hospitals and other medical settings, but remote work is increasingly popular after the COVID-19 pandemic.

2.3.2 Racial Diversity in Bioengineering

Demographic data suggests biomedical institutions generally are not racially diverse. The 2020 Biotechnology Innovation Organization bias report revealed that in a survey of 98 biotechnology companies, only 32% of employees and 15% of executive teams were people of color. While useful, a single metric of employee diversity does not fully reveal the racial stratification within companies. While Native American and Pacific Islander workers made up 0% of each company (Anon 2020), Black and Hispanic biotechnology workers make up less than 10% of the employment and 4% of leaders while accounting for over 30% of the population. Asians make up 22% of employees, and 9% of CEOs despite being 6% of the population (Anon 2020). Thus, underrepresentation status in biomedical institutions is not equally applicable among all racial minorities.

Biotechnology Workforce Demographics by Race/Ethnicity						
	Native American / Pacific Islander	**Black**	**Hispanic**	**Asian**	**White**	**Total**
All workers	3.77%	6.87%	6.11%	19.89%	59.66%	96%
Management	1.82%	3.05%	3.83%	16.35%	74.95%	100%
Board of Directors	0.26%	5.17%	1.65%	14.54%	79.07%	101%
United States Population	0.58%	11.22%	22.72%	5.46%	55.67%	95%

2.3.3 Racial (In)equity and Inclusion in Bioengineering Spaces

Even beyond this numerical underrepresentation, these institutions remain racialized spaces. Just over half of these organizations had DEI policies and 82% had programs and policies about accountability and reporting of harassment or bias, yet Black and Brown bioengineers have consistently protested against inequitable research funding and racist lab climates (Aguado and Porras 2020; Platt 2020; Stevens et al. 2021).

Additionally, race also becomes relevant in the creation of biomedical products: depending on the level of analysis (molecular, organ system, biomechanical), race is incorporated when it is assumed to be relevant by researchers. Bioengineers may use biological

and social concepts of race that often reproduce racism (McLean 2021a; Roberts and Rollins 2020; Timmermans and Kaufman 2020). While grant agencies typically require the collection of race data for human subject researchers, little explanation or analysis of race data is performed in most bioengineering studies. Best put in Roberts and Rollins (2020), "the conceptualization of race in biomedical research is an imprecise and flexible process." Thus, scholars, practitioners, and innovators must seize the opportunity to further clarify race in bioengineering as a process of racial interactions in the biomedical field more broadly.

This study offers such an intervention by exploring how bioengineering labs, as racialized organizations, function as sites that shape the creation of products that can potentially exacerbate or minimize racial health disparities. I do so by highlighting the interactions within the lab and the ways that these organizations grapple with questions of race and diversity, as well as the outcome this has on product creation.

3 Data and Methods

I collected data through 48 total semistructured interviews with those who had experience with bioengineering laboratories and case studies of 3 distinct bioengineering laboratories. The average interview lasted 75 minutes. Interviews were recorded and transcribed. The methodological appendix details the procedure timing and can be found in the appendix.

3.1 General Interviews of Bioengineers

After making initial contacts through email and flyer postings, I then used snowball sampling techniques to select additional respondents. Respondents were intentionally sampled based on interest in racial justice, racial diversity, gender diversity, as well as job title. I conducted in-depth, semi-structured, individual interviews with respondents virtually. Respondents were asked about their journey to bioengineering, their laboratory social climate, DEI work, policies and culture affecting their lab work, and their outlook on the future of health equity. Because each interviewee had experiences from multiple labs, I captured a wide breadth of laboratory experiences. These interviews produced 30 transcripts. The data was then analyzed by coding and comparison through grounded theory (Strauss and Corbin 1994). The limitations of general interviews included a lack of depth into each laboratory, so ethnography allowed for richer data around the cultures of specific laboratories. Additionally, while interviews allowed for individuals to divulge personal attitudes and opinions, ethnographic observations allowed me to examine the behaviors of respondents and see each laboratory function as an organization with interacting members.

3.2 Case Studies: Ethnographic Interviews of Laboratory Members

3.2.1 Recruitment

In order to find laboratories, I relied on my personal background as a politically active bioengineer with a network of racially diverse bioengineers. I recruited the first and second laboratory through an event dedicated to minorities in bioengineering. I recruited the third laboratory through personal connections in the Diversity, Equity, and Inclusion arena of engineering. All laboratories were recruited on their involvement in DEI, although the degree of involvement differed between each lab. The first was selected for its DEI work influencing its research, the second for a patent on a medical device for people of color, and the third for its leadership having a long-term commitment to mentoring racially underrepresented students in STEM as well as performing health disparities research.

3.2.2 Data Collection

The case study data collection occurred with three bioengineering laboratories as the field sites. At each site, I first observed laboratory meetings to understand its social climate and see its weekly routine. I then completed in person tours of each laboratory to view the daily interactions between bioengineers and their projects. After observing the social climate of the laboratory, I conducted interviews of laboratory members, which followed the same structure as the general interviews. This produced 18 transcripts. I then performed a content analysis the race-focused elements of laboratories' research publications and similar work as an additional data source. These three qualitative methods helped overcome attitudinal fallacy, whereas respondents' behavior may not directly be explained by what they say (Jerolmack and Khan 2014). Social pressures around race at the time of the interviews were salient in respondents' answers. By

triangulating laboratory data, I contrasted race discussion in interviews with race discussion in laboratory meetings to understand collective views and decisions of race in the lab as well as diverging opinions on race. Triangulating data also allowed for analyzing the racial implications of respondents' work whenever they failed to mention or explicitly denied racial implications in their interviews.

3.3 Data Interpretation

After a few general interviews, I realized that most of the respondents recruited as individuals were advocates for DEI in bioengineering. My recruitment flyer, attached in the appendix requested for respondents to be able to speak of race in bioengineering, so many respondents reached out with the intention of supporting this project, which they perceived as a racial equity project. I hope that this work lives up to that description. In contrast, the laboratory members were recruited with the help of a point of contact from their laboratory. One laboratory was known for its exceptional incorporation of DEI work and most of its members were active in DEI in their laboratory. The other two labs had DEI advocates as their main point of contact, but most of their members did not participate in DEI activities. One of the methodological advantages of interviewing both bioengineering DEI advocates and non-advocates is that I was able to see difference between the longstanding accepted norms in bioengineering, such as thinking of the lab as devoid of race, and the more progressive norms, such as DEI discussions and speaking of race outside of the lab. Settled in universities, hospitals, and companies, this study is able to address the evolving racial logic of biomedical and scientific spaces and elucidate medical racism.

This project was done through the standpoint of a queer Black woman. It was clear that my respondents received me in a comfortable way due to racial and gendered expectations in

conversation. By the subject matter of my project being something that pulls socially desirable responses out of people, it was clear also that some respondents strove to showcase a commitment to racial equity. Respondent's responses do not merely reflect bias towards social desirability but help contextualize the social and political climate of laboratories, universities, and in the workforce. By understanding the workplace discussions about race as something that was integrated within lab work, I could visualize the norms and practices that construct racialized design.

3.4 Respondent Demographic Summary

Respondents were at least age 18 and ranged from undergraduate students to late-stage career professionals. Respondents were allowed to self-identify race, ethnic background, or ethnicity. Answers were then recategorized as Black (10), White (17), Asian (9), and Hispanic (6). Those who were multi-racial were prioritized as Hispanic, then Black, then Asian. No Native American or Pacific Islander respondents were interviewed. Respondents were allowed to self-identify gender. Respondents were also allowed to self-identify gender and were categorized as man (17), woman (29), or non-binary (2). Non-binary individuals were not recategorized, but those who said they were female or male were recategorized as woman or man. 38 individuals identified as straight, and the remaining 10 individuals identified as either queer, bisexual, or gay and were categorized as LGBTQ+. Similar to the practicing population of bioengineers, respondents' geographic locations were largely concentrated in the northeast area of the United States, followed by the west. Fewer respondents came from regions where the discipline is less prominent, following demographic representation. All data was collected between January and July 2022.

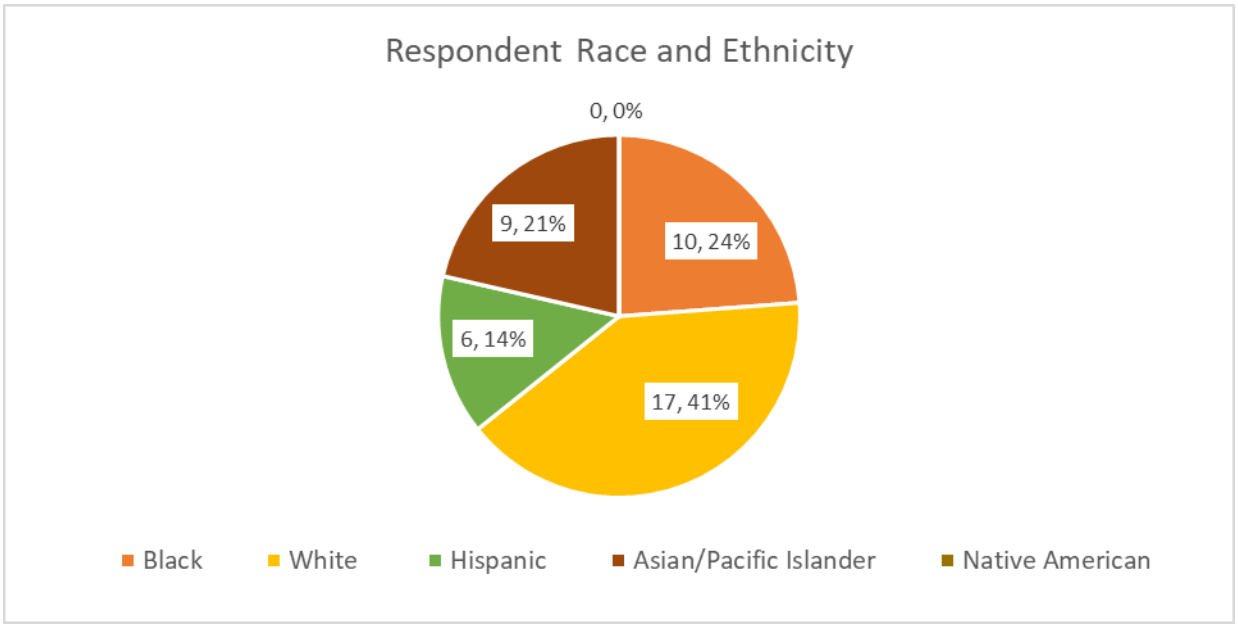


Figure 2.1 Respondent Race and Ethnicity

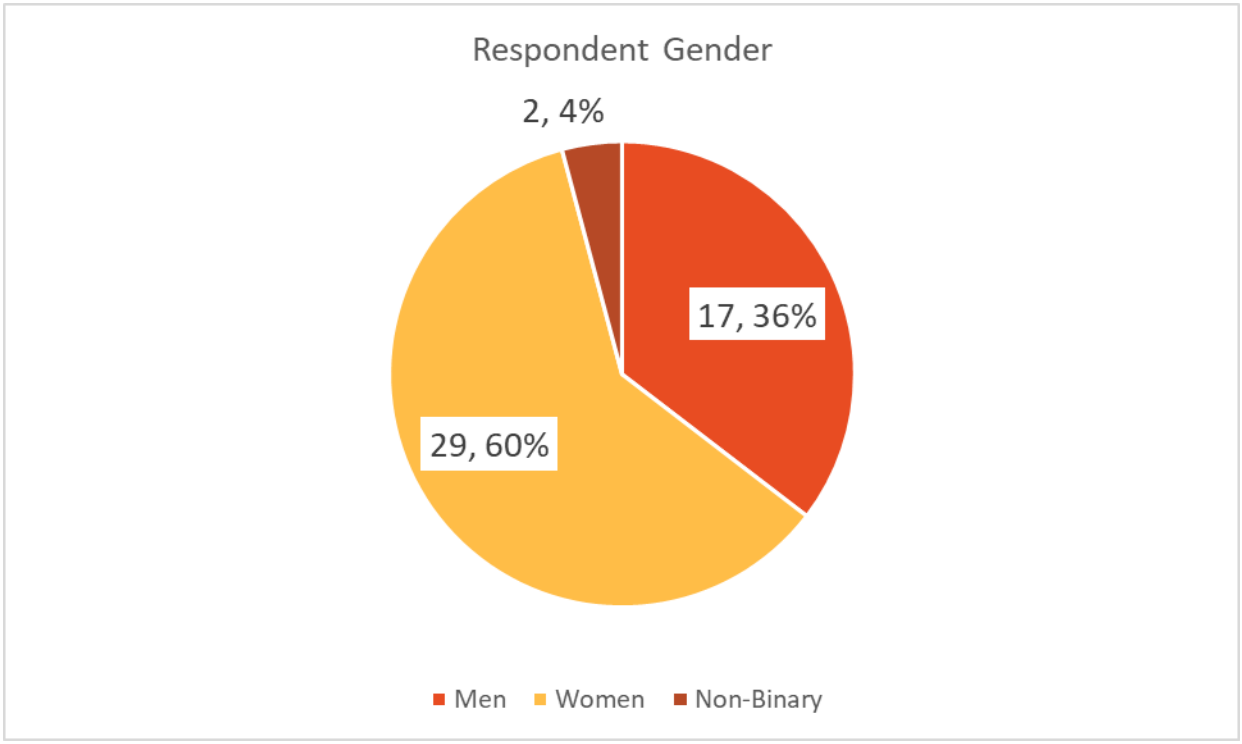


Figure 2.2 Respondent Gender

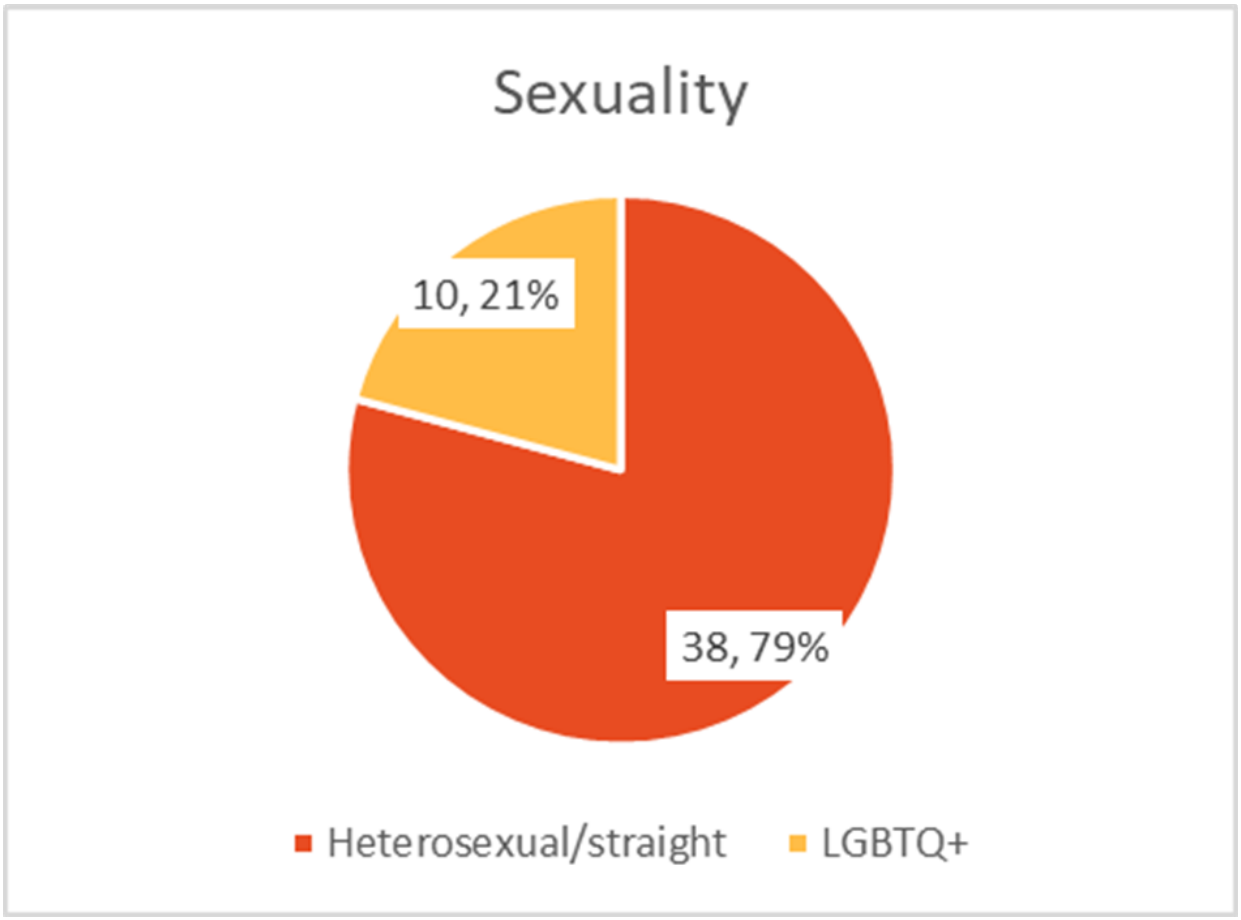


Figure 2.3 Respondent Sexuality

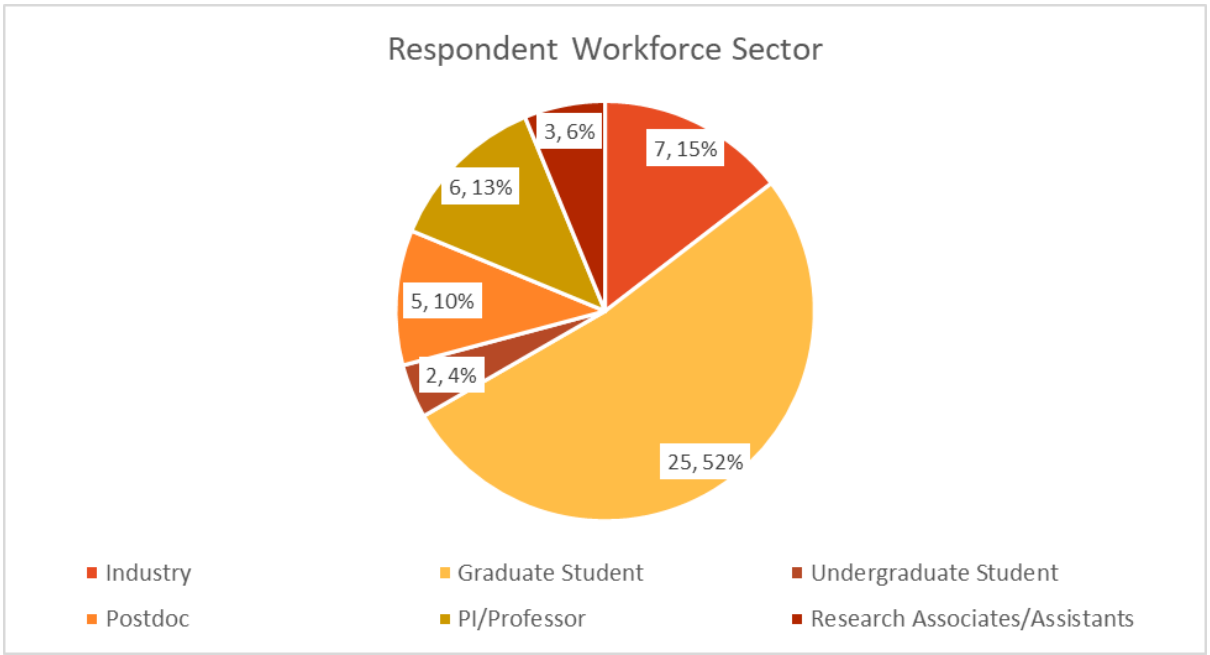


Figure 2.4 Respondent Workforce Sector

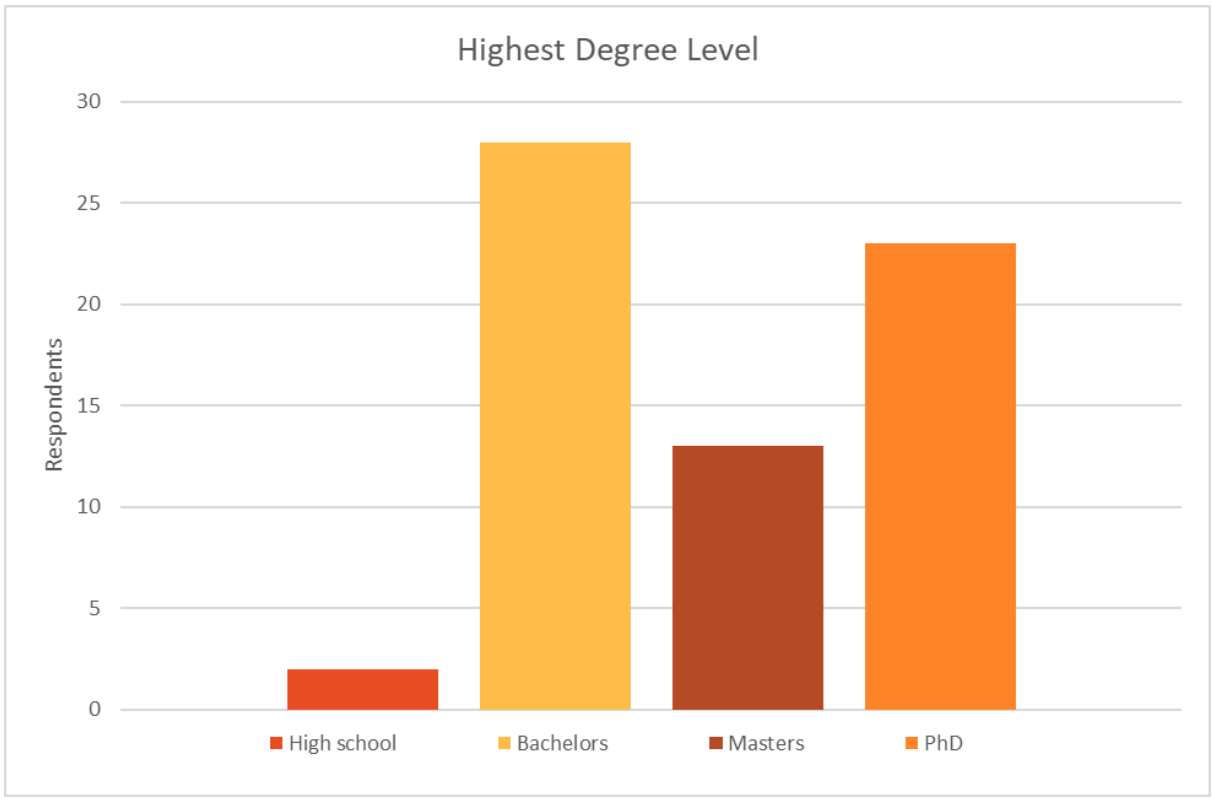


Figure 2.5 Respondent Education by Highest Degree Obtained

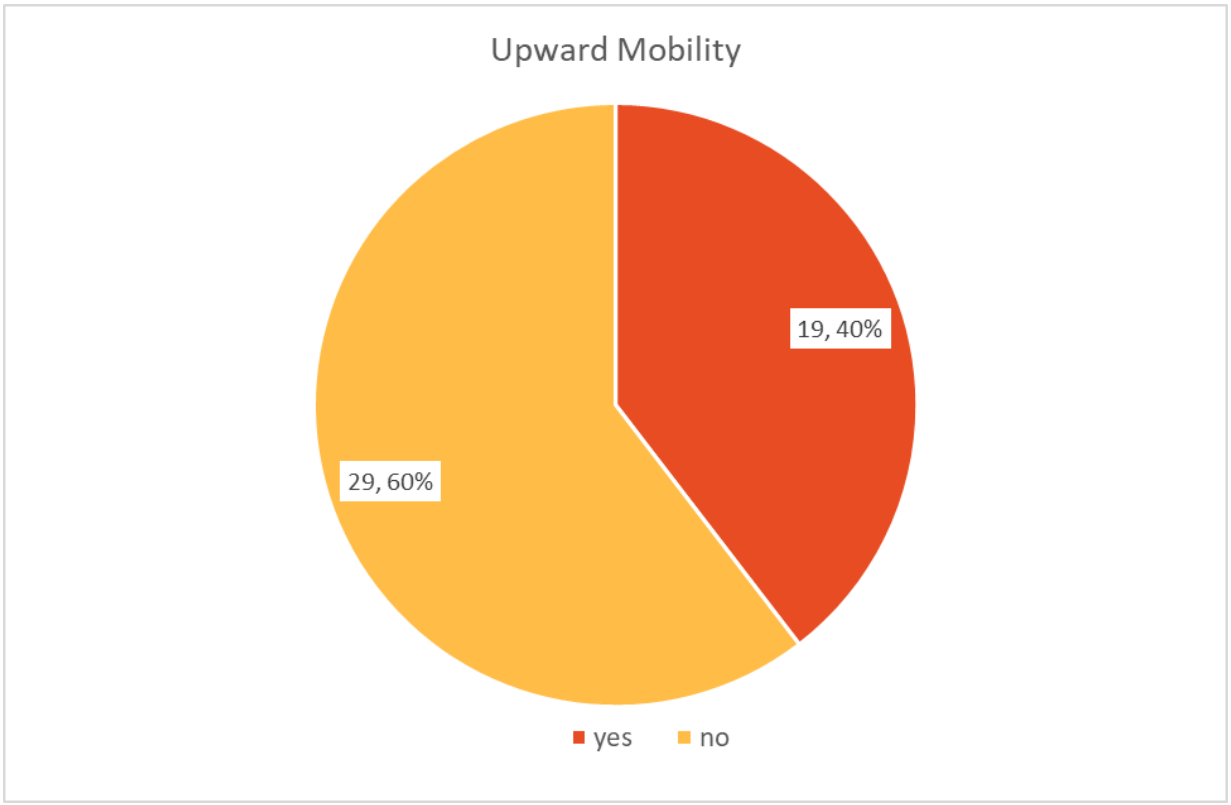


Figure 2.6 Respondent Upward Mobility Status

Figure 2.6 Respondent Geographic Location

My results show bioengineers view racial equity as something that is pertinent to the professionals themselves and do little to prevent inequity amongst the patients affected by their research. By constraining discussions on race to racially diverse representation of biomedical professionals, obstacles such as racist biomedical products and retention issues through a hostile racial climate are rarely addressed. Diversity, equity, and inclusion work remains a large part of underrepresented minorities coping and persistence mechanisms for staying in the field. However, the lack of connection that respondents could draw between DEI work and the impact of their product shows that DEI largely does not disrupt systems of health inequality. Respondents continually recontextualized race throughout the interviews, from believing that race isn't relevant to their sampling methods yet claiming racial equality as a social impact in their funding applications, to desiring a racially diverse subject pool, to stating scientifically

inaccurate beliefs about physiological differences in race as guiding logic for their experiments. Despite the rhetoric of DEI, race and racism infuses the entire process of biomedical design.

4 Results

The results of this study indicate that bioengineering laboratories reflect and reproduce racial inequality in product design and outcomes. Each laboratory has its own organizational culture, with its own values and widely shared norms that can shape members' attitudes and behaviors towards racialized product design. Each lab's culture is an important factor in shaping the types of products it creates and the ways the products replicate racial inequalities. Three different types of culture emerged in these labs: race-external, DEI Friendly, and race critical. These cultures included different racial practices, behaviors, and interactions, all of which contributed to products that perpetuated or challenged racial inequalities.

4.1 Race-External Laboratory Culture

STEM fields have long fostered a culture that downplays or ignores the existence of systemic racism in society. For example, research and technology environments are known to have distinct cultures centering value-free science (Benjamin 2015; Mitchem 2007), and scientists in those environments consider race to be irrelevant to the work that they do (Dupree and Kraus 2022; Shah 2017). In recent years, however, the field at large has away shifted from the previous cultures that ignore racism to now acknowledging race and racism as a part of broader society. In a race-external culture, lab participants focus on racial issues only as matters that occur outside of the lab space. In these labs, there is little attention to race as a matter that could affect product design or creation. There is also minimal focus on the ways that interactions and dynamics in the lab could potentially perpetuate racial inequality.

This is not to say, however, that racial discourse is never present in these lab spaces. Instead, labs with a race-external culture acknowledge and identify racial matters and

inequalities as issues that exist outside of the lab space. Respondents in these labs point to examples of police violence against Black communities as an example of where they see racial issues present. For instance, when asked when he felt aware of racial issues, James, a white man PhD student in a lab at an ivy league university, commented,

> "In terms of specific events, I mean after George Floyd was killed, I really was like, 'ok, I should get better. I'm trying to get better. And I think that is when I started to become more aware. Obviously I'm still not aware of a lot of things, but that's when I started to become more aware than I was." For James, racial issues occurred, but he associated them with matters of police violence and brutality that occurred in the broader society. He did not define his lab as a racialized space or discuss the ways interactions or routine processes could reproduce racial inequalities.

However, James did recall of an incident with the head of his laboratory calling him out for mostly citing white men in a project on publication citations. After she suggested that he diversify his authors, and the problem was quickly resolved. Even in a race-external culture, researchers may occasionally consider race in lab work. Yet, this doesn't change the organizational culture of his laboratory, and their products and creations do not challenge health disparities or racial hierarchies in research.

Marissa, a straight Asian woman PhD student, offered a perspective highlighting a more hostile race-external organizational culture. When I asked her about DEI initiatives in her university, she first replied, "Since the racial reckoning of George Floyd's murder, the bioengineering department has sent out an email talking about that. And then they said they might have a Diversity Council before …That effort didn't really go anywhere." Once again, a respondent emphasizes the murder of George Floyd as the center of race discussions among bioengineers. She cites this as the only acknowledgement of racism by her department yet provides numerous issues of racial conflict within her classmates' laboratories. When I ask

Marissa, if she can think of any examples of racial issues affecting labs that she knows of, she says

> Okay, so I know, four main cases and I'll say that they're either underrepresented minorities or women and that they are either department conflict or advisor conflict.. The third student who I was very close to when she was having a lot of issues [and] she was crying all the time, basically had a co mentorship situation, and she wanted to use microfluidics for her research and then got convinced to do a solely computational project by an advisor that the department knows has kicked out students in their third year. She was newer faculty and a female professor, and by the way, the diversity council chair. Also she tried to prevent to nanoengineering students from graduating and filed a plagiarism report against one of them.

Marissa exposes the subtle racism of students of color being forced to do research in a subarea outside of their expertise without guidance. Marissa then details several other conflicts with students of color being unfairly removed from the program through unfair qualifying exams judges, being denied PhD candidacy after 8 years of research, and having plagiarism reports filed against them. Two of the four students left their laboratories. As one of the largest academic bioengineering departments in the country, this department's choice to ignore racism within its many laboratories reflects the persistence of race denial in scientific spaces despite recent culture changes.

Leland, an Asian postdoctoral student offers the most direct example of race-external culture. He states:

> We have an annual meeting with the head of the lab every year. I told her we have too much non-scientific topic discussion (laughs), So I say to [head of lab's name], I need to write a paper. Diversity is important, but for me it's not priority. For me the priority is the project and process. So, I am also a minority in United States. Also in China I grew up minority. I'm Korean Chinese, you know, we only have a 2 million population in China! I grew up a minority, so I totally understand diversity is important. It's one big country, right? But in research labs I told her my current position is post-doc I don't have enough time to spend on other things.

Leland explicitly defines his laboratory as somewhere racial diversity should not be prioritized in contrast to "the project and the process." To him, race and other social structures are relevant to his personal experience, but not to the bioengineering process.

Respondents in race-external labs also identified racial issues as matters that emerged towards the end of the bioengineering process—after they themselves no longer were involved with product creation. They felt that at the stage at which they created products, the process was race neutral. Yet they noted that at the final point of product creation, race could be incorporated into the process by way of projected product utilization. Manny, a gay Black man and reliability and quality engineer at one of the top 3 largest medical device companies in the world, reflects on his work. In a response to a question about how company culture impacts the racial implications of his research, he says,

> Yeah unfortunately because I'm so far early in the process, as in years, nothing I've really worked on has ever made it out the door. If it has, it's so far removed that I can't really speak well to it… What I can say is the biggest impact, I have seen has been income level for sure. So medical devices remain premium… Well if you consider the performance and efficacy of certain devices you do see a slight correlation between would be curious if someone has looked at the average reliability of a device that someone on Medicare gets versus someone in private insurance. These things aren't really data points that I wish were considered.

Despite Manny knowing racial conflict impacting the products he evaluated as a midlevel engineer, he initially says that his work in reliability and quality engineering does not consider the implications because he works on the earlier stages of device development. As he continues through the interview, he then brings up the reliability of devices by social class as a potential way for his own work to challenge racial inequality. Throughout the interview, he contends that patient income and insurance status as factors affecting the reliability of devices for Black patients, but finally admits that his work could examine look at those factors towards the end of

his response. While understanding how racial inequality impacts bioengineering is important, bioengineers must actually disrupt cultures of racism in order to reduce health disparities.

Product Creation

Given that race-external labs rarely focused on racial dynamics and potential inequalities in the lab space, the products that came out of these labs could and did perpetuate racial inequalities. Some race-external labs are in the process of creating blood pressure monitors that fit over the fingertip. These monitors are supposed to be less invasive than the traditional monitor, which fits over the arm. Yet these monitors serve to perpetuate racial health disparities. They measure heart rate less accurately on darker skin than pale skin because they use photoplethysmography signals, which detect light.

By constructing heart sensors in this way, these labs create devices that perpetuate default discrimination, where the very basic functioning of the product contributes to discriminatory outcomes, but its designers see the discrimination as a minor error. (Benjamin 2019). By using technology that is previously proven to measure more effectively on lighter skin, darker-skinned individuals do not have access to convenient heart monitors. Other commonly used devices such as fitness watches and pulse oximeters also are inaccessible to darker-skinned people. While these devices are created to increase the ease of monitoring patient health, they discriminate against a large part of the population (Colvonen et al. 2020).

In addition to default discrimination, these devices also may reflect techno benevolence of the New Jim Code because the intended creation of this device was to improve the accessibility of an existing problem. Yet, by attending to accessibility by only focusing on one design feature of the project and deprioritizing race, they perpetuate existing inequalities in their attempts to address a social problem. The visual technology that makes these devices work is

continually used despite the growing protest of consumers and researchers about its racial consequences.

Other labs with a race-external culture are creating machine learning models to evaluate the effectiveness of prosthetic limbs for veterans. This technology also reveals default discrimination because model creation depends on categories of successful and unsuccessful limb implementation, which is heavily racialized (Resnik and Borgia 2015). African Americans veterans are systematically underprescribed prosthetics, so an algorithm developed based on prior data will reiterate discrimination without the programmers explicitly accounting for race. A potential harm of this development is a Black veteran being incorrectly denied a prosthetic limb, which would continue the same discriminatory process determined by manual evaluations.

Made in this way, assistance devices, again, perpetuate default discrimination (Benjamin 2019). While the culture of these laboratories fuels the creation of discriminatory products, little attention is given to the responsibility of bioengineers in amplifying health disparities. Race-external laboratories render historical and social realities that keep people unequal irrelevant to their work, thus bioengineers continue to produce devices that work best for those white and rich.

4.2 DEI Friendly Lab Culture

In contrast to race-external labs, other labs display a culture that I describe as DEI friendly. In these spaces, the organizational culture is more attuned to racial dynamics and inequalities that can occur in the lab space. Unlike race-external cultures, these labs do not describe racial inequalities as processes that occur outside of the lab in the broader society. The culture here acknowledges the ways that racial inequalities can be present in labs.

With this awareness, labs with a DEI friendly culture attempt to address and identify racial issues that can affect lab workers. However, they do this by focusing on DEI initiatives and the ways that these can create more of a pipeline of underrepresented workers into the field. In other words, labs with a DEI friendly culture do acknowledge racial inequality, but they focus on highlighting mechanisms to attract more scientists of color into the lab, and occasionally to improve their experiences once there.

Chantel, a straight Asian American woman working as a senior systems engineer manager at a large biotechnology company, described some of the DEI efforts in her lab, stating, that they did "had employee resource groups and outreach events for high school and even middle school students." Michael, a queer Hispanic man who just finished his PhD, also shared that in his lab, initiatives included outreach to encourage youth to enter bioengineering, He states, "Some folks in my group are involved in in sort of like outreach and that's generally looking at local high schools. The outreach usually are activities or doing lab work, like doing demos of polymer synthesis or agarose beads, stuff like that."

Most of the activities favored outreach, but there were some cultural celebrations inside of laboratories that celebrated a variety of holidays. These examples highlight that labs are attuned to focusing on creating diversity inside the lab and on the experience that underrepresented scientists, especially those of color, have in these spaces.

Yet the culture of DEI Friendly laboratories does not extend to attention to product development itself. Many respondents noted that these DEI efforts had limited utility. They established a culture where labs acknowledged the existence of racial inequality in STEM but did little to resolve disparities that resulted from product creation. As Michaela, a Black woman PhD

student stated, “[These efforts] play out in our lab culture. People now are different and more conscious of race and how people are different in our personal interactions in the lab. But when it comes to the actual research, it’s the same old research.”

From Michaela’s viewpoint, the DEI efforts succeeded in changing the culture and the interactions in the lab. That success did not extend to lab workers’ attention to product design and creation, and the way these could replicate inequalities.

Chelsea, a Hispanic woman PhD student, also noted this disconnect. After she emphasized that diversity in the laboratory is valuable, I asked her what impact it would have on her research. She replied,

> Personally haven't seen at least on my side of research. I haven't seen anything; except I've seen them setting up stuff to make it happen. Like, they have the Chair of Diversity, Equity and Inclusion with BMES, so I know they're trying to make it a priority, but I haven't seen it implemented on the research side, at least in a way that I personally can see.

Chelsea stated the importance of diversity early into discussion, reflecting a common sentiment in laboratories. By embracing diversity at the surface level, laboratories are able to respond to outside pressures about racial injustice without changing their work.

Product Creation

Labs with a DEI Friendly culture also created products that perpetuated racial inequality. The focus on occupational opportunities meant that lab workers did not spend much time focusing on how the products they developed could and did also have racial implications. Consequently, products that were designed still advanced racial inequality.

One lab with this particular culture created a COVID-tracking project. This project received sample swabs from elementary schools and tested them for COVID-19 at the height of

the pandemic. Samples had to be collected by teachers, janitors, or other staff at each school and then would be picked up by a lab member. Most of the schools contacted primarily served Hispanic students. While racial justice was not the motivation of this project, one lab member expressed frustration and confusion about the lack of participation from schools.

Yet this project perpetuated racial inequalities, particularly through coded exposure of race, where minorities are simultaneous rendered hypervisible and invisible. The project required extra labor from staff at participating schools, while stigmatizing schools who didn't participate as hesitant to science. Scientific authorities who attempt to do research with minority populations often expect resources, including money and time, that these groups simply do not have. By rendering underrepresented minorities who do not participate in science as non-compliant, they marginalize them from research. Additionally by requiring that minorities participate in research at a significant cost and no direct benefit, this lab renders them visible only for surveillance. This study and several other studies cited by respondents recruited underrepresented minorities for their convenience while avoiding discussing racism in their research. By establishing inequalities in this way, bioengineering research makes communities of color more subject to heightened scrutiny without recognizing systems of race and racism (Benjamin 2019).

Whereas coded exposure theory emphasizes devices and technologies that use computer vision, I argue that processes in biomedical production which surveil racial minorities also provide undesirable forms of visibility and invisibility. Biomedical experiments, for example, are processes that allow for participants' data to be accessible to researchers and not the participants themselves. One researcher reported receiving tissue samples that were predominantly marked as African American male without them requesting racial data. A few other researchers relied on the cells derived from Henrietta Lacks, a Black woman with the most commonly used immortal

cell line. Prior data shows that people of color are concentrated in higher risk and low compensation studies (Petryna 2009), and two different engineers claimed that they found it more convenient to working class African American and Hispanic subjects because they fit the study criteria. Many DEI friendly laboratories collect minorities data or report racial difference as required by funding agencies or out of convenience, yet do not consider racism their results. Worse, these labs attribute racial differences in data to negative behaviors or defective genes- both of which stigmatize minorities as anti-science and a threat to their own health (Aronson et al. 2013; Benjamin 2014; Devakumar et al. 2020).

Through experiments that privilege the researcher, minority patients are visible when convenient to researchers. Bioengineers can see readily identify racial minorities when it is convenient, but do not recognize the racism in the first place that led to their racialized recruiting. They also fail to see the racial implications of their work. While the New Jim Code used coded exposure and other tenets to describe mostly computer software and hardware, I argue that that more general processes, such as data collection give rise to these specific technologies. In the appendix is a list of racial implications of biomedical products discussed in each individual interview.

Additionally, this and other DEI friendly laboratories can have carceral consequences for the population. By creating surveillance on Hispanic communities, this research makes students from undocumented backgrounds even more vulnerable. Immigration enforcement has historically used biotechnology such as genetic technology, facial recognition, and risk algorithms, for harms such as detainment, deportation, and the denial of the rights of Black and Brown immigrants. Ignoring the social conditions that minorities face in the United States in bioengineering laboratories causes harm to those communities.

Another lab with this culture studies sodium channels in heart disease using animal models. After studies, the laboratory meets with doctors and provides recommendations on behavior changes for patients who have hypertension, a disease heavily dependent on sodium channels. Although this laboratory finds racial equality generally important, it ignores the longstanding biomedical research on how hypertension affects African Americans more prevalently. The laboratory has recommended exercise as the main behavior change for hypertensive patients.

This research, too, perpetuates inequalities by solely putting responsibility on patients to change their behavior and ignoring the factors that cause racial inequity in hypertension. Historically, researchers attributed the cause of hypertension to diet, genetic mutations caused by slavery, and other historical factors related to race without accounting for present day racism. Many behavioral programs pathologize the behaviors of Black communities, leaving little room for patients to protest structural barriers to their health. Both hypertension and heart disease remain high and are responsible for large amounts of preventable Black death in America.

Consequently, this research model is an example of engineered inequity. This research privileges people who have access to exercise, and are able-bodied, when hypertension and heart disease affect those who have decreased access to either. Economic and racial disparities may minimize Black Americans' access to organized physical activity, and persistent neighborhood segregation and heightened patterns of surveillance and scrutiny may mean that even basic forms of exercise like jogging may be less safe or available to Black people (Edwards and Cunningham 2013; Ray 2014, 2017; Richardson et al. 2017). The tragic case of Ahmaud Arbury shows that running for exercise is enough to get a Black person killed in America, and while there are other barriers to exercise that aren't as explicitly dangerous, harm is still the outcome (Ray 2020). By

developing blanket solutions that are not as feasible for Black folk because of structural barriers, this laboratory engineers inequity by amplifying structural inequalities and explicitly reproduces health disparities.

While DEI friendly laboratories reflect a commitment to diversity, equity, and inclusion programming, their happy talk often stops short of their design decisions. Some DEI friendly laboratories even make public statements about racial violence, and without critical attention to the meaning of race in the biomedical design process, these labs still create racial harm from the technologies they produce. In fact, many DEI friendly laboratories even engage in explicit efforts towards racial problems, but avoid the long-standing context of race, resulting in coded exposure of the New Jim Code. The increased surveillance for Black and Brown communities, combined with the preconceived notions of race (such as scientific authorities believing that minorities are uninterested in scientific progress), result in technology that is carceral, even when used outside of jails, policing, and prisons. Biotechnology has been consistently used to expand the prison-industrial complex in America through tracking, detaining, and convicting, and will continue to cause harms until bioengineers examine their roles in the system.

4.3 Race Critical Laboratory Culture

The third type of organizational culture that emerged among labs was a race critical culture. Unlike race-external, but similar to DEI Friendly culture, labs with a race critical culture explicitly acknowledged racial inequality. They also established journal clubs, outreach efforts, and community education. However, these labs also took the additional steps of assessing how the products they created either replicated inequality or could be redesigned in ways to minimize it. In this way, lab leaders structured a culture that led to products that avoided perpetuating discrimination through tech.

Keyshia, a white woman PhD student, described some of the conversations that occurred in the lab.

> Some brainstorming ideas were to think about where we're getting cells from, how the donors impact what we're seeing and thinking about, what disorders we're choosing to study, and who they represent- like who mainly suffers from what we're studying. Are we accidentally picking a disease that all of the research currently done and all the knowledge we have is biased toward a certain demographic when there are other demographics that suffer from it? I think it's being intentional about how we do outreach, what kind of data we're using to justify our experiments, where it's coming from, where it's incorporated, things like that.

As Keyshia shows, the culture of the lab encourages workers to discuss openly the ways that they may inadvertently engage in the default discrimination model Benjamin (2016) describes by creating products that center white hegemony and thus perpetuate racial inequality. By establishing a culture where these discussions are normalized, lab workers can avoid this potential outcome.

Michael, the queer Hispanic professor referred to earlier, offered a counterexample with a culture contrary to race-critical labs. Yet, he provides a thorough path for it to become more intentional with its racial impact. He states,

> I don't think the lab culture plays a big role. I don't think that we're basing research projects on concepts that are originating from DEI movements, and I myself sometimes look at our results to say some of these things can relate to the DEI concerns. So, for example, we have research that looks at reducing or minimizing refrigeration for drugs, which would have equity implications, by reducing costs for getting to areas that have less infrastructure for refrigeration. But we generally didn't kind of go into that project thinking we're going to develop technology to make it easier to transport drugs. It's just kind of like that's what came out and we're like well that has a lot of value for things that are relevant for equity.

Because he considers positive implications for his work as an unintended consequence, the culture of his laboratory neglects to thoroughly consider racial equity in the production of biomedical research. He assumes that his labs design decisions will increase accessibility for

those from socioeconomically disadvantaged backgrounds but does not consider other factors such as insurance costs, racial disparities in the diseases he treats, or disparities in the uses of the drugs he aims to change. Yet, Michael's notion of basing research projects on concepts that are originating from social movements is quite innovative and embodies the work of race-critical laboratories.

Unlike the first two types of labs, race critical laboratories take a holistic approach to engineering where the traditional laboratory power structure is subverted. In these laboratories, members have more equal opportunity to produce, disseminate, and exchange knowledge, instead of concentrating decisions making authority to the heads of labs. While most minority lab workers are concentrated in the lowest level positions and have little decision-making authority, race critical labs are open to input from all laboratory members. In contrast to race-external laboratories, members of these laboratories understand race beyond individual identity and social phenomenon outside of the lab, but how they choose to subvert the current racial order.

This culture is very different from DEI friendly laboratories, which often recruit underrepresented minorities, but then struggle to support their careers as bioengineers. In these laboratories, the lowest ranking members lead projects, make major design decisions, and have an influential role in the laboratory. Because laboratories are heavily hierarchical with the leaders being mostly white, straight, men, race critical laboratories give power to underrepresented minorities, LGBTQ+ people, and women and gender minorities. In these laboratories, those most affected by racial justice, and therefore most aware of racial injustice, are empowered to make decisions about design equity. These understandings of race reflect direct opposition to the standards of racialized organizations.

In addition to race and power structure, race critical laboratories are also conscious of gender, sexuality, and class. In these laboratories, DEI work relies on members having knowledge of systems of oppression that affect society broadly and then interrogating their design practices, stakeholders, data sources, and other parts of the bioengineering process. For example, one of the laboratories that I observed held weekly laboratory meetings, where diversity journal club was a mandated part of each meeting. Of the meetings I attended, half of them consisted of the laboratory speaking about race, sex, and gender in within and as an implication for their design. One meeting was a journal club about maternal mortality rates for Black women. In another meeting, the laboratory discussed the implications of assuming that people with uteruses are all are female sex. This lab the decided to produce research that used the term 'people with uteruses' include intersex populations and transgender people who receive hormonal treatment (and thus do not fit into the biological category female). In 5 laboratories represented in my interviews there was discussion of sex differences, but only this laboratory's research included populations outside of the binary of male and female.

Product Creation

Labs that had a race critical organizational culture created decidedly different products than ones with race-external or DEI Friendly cultures. These labs were able to create products that sought to minimize, rather than exacerbate, racial disparities. One lab with this culture created a hospital device for people of color. This device, created by and patented to a Black woman, accounted for Black hair in the detection of brain activity. Upon going to market, this device would expose the current brainwave detection system as something that works only for straight hair phenotypes—primarily confined to the white and Asian populations. This product thus creates more racial equity by ensuring that Black patients have more access to technology

that accounts for their physical features, thus potentially reducing neurological conditions that might otherwise go untreated or unresolved.

Another lab with this culture engineered a technology to support patients with vocal, voice, and swallowing disorders. This lab worked with patients directly to test how the technology works and one of its members ensured the study served Hispanic respondents by speaking Spanish and allowing respondents to consent in Spanish. The laboratory also gave resources for treatment. Additionally, the laboratory considers that the working conditions of Black and Latino people have impact on throat disorders and generates data different from the existing research that is on white men. By considering the social conditions of racial minorities on throat conditions, they are able to create technology that is accessible and addresses health disparities directly.

Products created in these labs thus offer more insights into ways the creation of biomedical products can be used to create racial equity rather than disparities. By establishing and maintaining a race critical culture where lab workers consistently attend not just to DEI, but to the ways products can have potentially unequal outcomes, they are able to produce devices that both acknowledge and include various racial groups and can potentially help offset some of the persistent racial disparities in health care.

5 Conclusion

Like many other organizations, bioengineering labs attempt to address race and racism with a focus on diversity, equity, and inclusion practices. While laboratories have always been white, heteronormative, and man dominated, the racial ideas within them have evolved to fit social pressures and often take up DEI activity and conversation about race. Through requirements from funding agencies, policies from academic instructions, pressure from social critics, and legal protective measures from corporations, researchers are led to engage with DEI work in spaces that are traditionally/historically nondiverse, hierarchical, and gatekept. Operating under racial capitalism, neoliberalism, and other social, political, and economic structures and movements, bioengineering is a new field that cannot consider itself neutral (Bliss 2012; Đoàn et al. 2020). When racial ideas are embedded in design that cause more harm to the marginalized, it is an act of white supremacy. When designs are created out of intent and effort towards racial justice, they represent liberatory engineering. Further research should be conducted on creating a racially just biomedical pipeline.

By focusing on bioengineering labs and the ways that these spaces construct an understanding of DEI, this study is able to add to our understanding of how and why medical racism persists. By highlighting how race is present, yet hidden, in biomedical production, I am able to capture how the lab, as a unique site, contributes to both the advancement of and challenges to systemic racism. This work thus builds literature on how race is embedded in biomedical products. Bioengineering spaces serve as a perfect example of how racism is carried out by seemingly neutral actors. It applies sociological theories of organization to bioengineering laboratories, which serve as the sites of racialized processes. This broader contribution shows

how moves towards racial inequality and racial equality may inspire activism in bioengineering laboratories in uneven ways. This work is intended to encourage activism in the bioengineering community and illuminate opportunities for positive social change that should be made within the field.

References

Aguado, Brian A., and Ana M. Porras. 2020. "Building a Virtual Community to Support and Celebrate the Success of Latinx Scientists." *Nature Reviews Materials* 5(12):862–64. doi: 10.1038/s41578-020-00259-8.

Ahmad, Farida B., Jodi A. Cisewski, Arialdi Miniño, and Robert N. Anderson. 2021. "Provisional Mortality Data — United States, 2020." *Morbidity and Mortality Weekly Report* 70(14):519–22. doi: 10.15585/mmwr.mm7014e1.

Aronson, Joshua, Diana Burgess, Sean M. Phelan, and Lindsay Juarez. 2013. "Unhealthy Interactions: The Role of Stereotype Threat in Health Disparities." *American Journal of Public Health* 103(1):50–56. doi: 10.2105/AJPH.2012.300828.

Bell, Joyce M., and Douglas Hartmann. 2007. "Diversity in Everyday Discourse: The Cultural Ambiguities and Consequences of 'Happy Talk.'" *American Sociological Review* 72(6):895–914. doi: 10.1177/000312240707200603.

Benjamin, Ruha. 2014. "Race for Cures: Rethinking the Racial Logics of 'Trust' in Biomedicine." *Sociology Compass* 8(6):755–69. doi: https://doi.org/10.1111/soc4.12167.

Benjamin, Ruha. 2015. "The Emperor's New Genes: Science, Public Policy, and the Allure of Objectivity." *The ANNALS of the American Academy of Political and Social Science* 661(1):130–42. doi: 10.1177/0002716215587859.

Benjamin, Ruha. 2016. "Catching Our Breath: Critical Race STS and the Carceral Imagination." *Engaging Science, Technology, and Society* 2:145–56. doi: 10.17351/ests2016.70.

Benjamin, Ruha. 2019. *Race After Technology: Abolitionist Tools for the New Jim Code*.

Bliss, Catherine. 2012. *Race Decoded: The Genomic Fight for Social Justice*. Stanford: Stanford University Press.

Braun, Lundy. 2014. *Breathing Race into the Machine: The Surprising Career of the Spirometer from Plantation to Genetics*. University of Minnesota Press.

Braun, Lundy. 2015. "Race, Ethnicity and Lung Function: A Brief History." *Canadian Journal of Respiratory Therapy: CJRT = Revue Canadienne de La Thérapie Respiratoire : RCTR* 51(4):99–101.

Cameron, Kim S., and Robert E. Quinn. 2011. *Diagnosing and Changing Organizational Culture: Based on the Competing Values Framework*. John Wiley & Sons.

Challen, Robert, Joshua Denny, Martin Pitt, Luke Gompels, Tom Edwards, and Krasimira Tsaneva-Atanasova. 2019. "Artificial Intelligence, Bias and Clinical Safety." *BMJ Quality & Safety* 28(3):231–37. doi: 10.1136/bmjqs-2018-008370.

Chambers, Brittany D., Rebecca J. Baer, Monica R. McLemore, and Laura L. Jelliffe-Pawlowski. 2019. "Using Index of Concentration at the Extremes as Indicators of Structural Racism to Evaluate the Association with Preterm Birth and Infant Mortality-California, 2011-2012." *Journal of Urban Health: Bulletin of the New York Academy of Medicine* 96(2):159–70. doi: 10.1007/s11524-018-0272-4.

Chatman, Jennifer A., and Charles A. O'Reilly. 2016. "Paradigm Lost: Reinvigorating the Study of Organizational Culture." *Research in Organizational Behavior* 36:199–224. doi: 10.1016/j.riob.2016.11.004.

Colvonen, Peter J., Pamela N. DeYoung, Naa-Oye A. Bosompra, and Robert L. Owens. 2020. "Limiting Racial Disparities and Bias for Wearable Devices in Health Science Research." *Sleep* 43(10):zsaa159. doi: 10.1093/sleep/zsaa159.

Devakumar, Delan, Sujitha Selvarajah, Geordan Shannon, Kui Muraya, Sarah Lasoye, Susanna Corona, Yin Paradies, Ibrahim Abubakar, and E. Tendayi Achiume. 2020. "Racism, the Public Health Crisis We Can No Longer Ignore." *The Lancet* 395(10242):e112–13. doi: 10.1016/S0140-6736(20)31371-4.

Đoàn, Lan N., Adrian M. Bacong, Kris Pui Kwan Ma, and Brittany N. Morey. 2020. "Epidemiologists Count: The Role of Diversity and Inclusion in the Field of Epidemiology." *American Journal of Epidemiology* 189(10):1033–36. doi: 10.1093/aje/kwaa108.

Dobbin, Frank. 2011. *Inventing Equal Opportunity*. Princeton, NJ: Princeton University Press.

Dupree, Cydney H., and Michael W. Kraus. 2022. "Psychological Science Is Not Race Neutral." *Perspectives on Psychological Science* 17(1):270–75. doi: 10.1177/1745691620979820.

Edwards, Michael B., and George Cunningham. 2013. "Examining the Associations of Perceived Community Racism With Self-Reported Physical Activity Levels and Health Among Older Racial Minority Adults." *Journal of Physical Activity and Health* 10(7):932–39. doi: 10.1123/jpah.10.7.932.

Eglash, Ron. 2019. "Anti-Racist Technoscience:: A Generative Tradition." Pp. 227–51 in.

Evans, Louwanda, and Wendy Leo Moore. 2015. "Impossible Burdens: White Institutions, Emotional Labor, and Micro-Resistance." *Social Problems* 62(3):439–54. doi: 10.1093/socpro/spv009.

Jerolmack, Colin, and Shamus Khan. 2014. "Talk Is Cheap: Ethnography and the Attitudinal Fallacy." *Sociological Methods and Research*.

McLean, Shay-Akil. 2021a. "Du Bois Meets Darwin." Thesis.

McLean, Shay-Akil. 2021b. "Isolation by Distance and the Problem of the Twenty-First Century." *Human Biology* 92(3):167–79. doi: 10.13110/humanbiology.92.3.04.

Mengesha, Zion, Courtney Heldreth, Michal Lahav, Juliana Sublewski, and Elyse Tuennerman. 2021. "'I Don't Think These Devices Are Very Culturally Sensitive.'—Impact of Automated Speech Recognition Errors on African Americans." *Frontiers in Artificial Intelligence* 4.

Mitchem, Stephanie. 2007. *African American Folk Healing*. New York: NYU Press.

Mong, Sherry, and V. Roscigno. 2009. "African American Men and the Experience of Employment Discrimination." *Qualitative Sociology* 33:1–21. doi: 10.1007/s11133-009-9142-4.

Moore, Wendy Leo. 2008. *Reproducing Racism: White Space, Elite Law Schools, and Racial Inequality*. Rowman & Littlefield.

Moore, Wendy Leo, and Joyce M. Bell. 2011. "Maneuvers of Whiteness: 'Diversity' as a Mechanism of Retrenchment in the Affirmative Action Discourse." *Critical Sociology* 37(5):597–613. doi: 10.1177/0896920510380066.

Morris, Aldon D. 1984. *The Origins of the Civil Rights Movement: Black Communities Organizing for Change*. New York, London: Free Press ; Collier Macmillan.

Nelson, Alondra. 2011. *Body and Soul: The Black Panther Party and the Fight against Medical Discrimination*. University of Minnesota Press.

Nelson, Alondra. 2018. "The Social Life of DNA: Racial Reconciliation and Institutional Morality after the Genome." *The British Journal of Sociology* 69(3):522–37. doi: 10.1111/1468-4446.12607.

Pager, Devah, and Hana Shepherd. 2008. "The Sociology of Discrimination: Racial Discrimination in Employment, Housing, Credit, and Consumer Markets." *Annual Review of Sociology* 34:181–209.

Panofsky, Aaron, and Catherine Bliss. 2017. "Ambiguity and Scientific Authority: Population Classification in Genomic Science." *American Sociological Review* 82(1):59–87. doi: 10.1177/0003122416685812.

Petryna, Adriana. 2009. *When Experiments Travel: Clinical Trials and the Global Search for Human Subjects*. Princeton University Press.

Platt, Manu O. 2020. "We Exist. We Are Your Peers." *Nature Reviews Materials* 5(11):783–84. doi: 10.1038/s41578-020-00248-x.

Rahim, Asad. 2020. "Diversity to Deradicalize." *California Law Review* 108(5):1423.

Ray, Rashawn. 2014. "An Intersectional Analysis to Explaining a Lack of Physical Activity Among Middle Class Black Women." *Sociology Compass* 8(6):780–91. doi: 10.1111/soc4.12172.

Ray, Rashawn. 2017. “Black People Don’t Exercise in My Neighborhood: Perceived Racial Composition and Leisure-Time Physical Activity among Middle Class Blacks and Whites.” *Social Science Research* 66:42–57. doi: 10.1016/j.ssresearch.2017.03.008.

Ray, Rashawn. 2020. “The Killing of Ahmaud Arbery Highlights the Danger of Jogging While Black.” *The Conversation*, May 7.

Ray, Victor. 2019. “A Theory of Racialized Organizations.” *American Sociological Review* 84(1):26–53. doi: 10.1177/0003122418822335.

Resnik, Linda, and Matthew Borgia. 2015. “Predicting Prosthetic Prescription after Major Lower-Limb Amputation.” *Journal of Rehabilitation Research & Development* 52(6):641–51. doi: 10.1682/JRRD.2014.09.0216.

Richardson, Andrea S., Wendy M. Troxel, Madhumita Ghosh-Dastidar, Gerald P. Hunter, Robin Beckman, Natalie Colabianchi, Rebecca L. Collins, and Tamara Dubowitz. 2017. “Pathways through Which Higher Neighborhood Crime Is Longitudinally Associated with Greater Body Mass Index.” *International Journal of Behavioral Nutrition and Physical Activity* 14(1):155. doi: 10.1186/s12966-017-0611-y.

Roberts, Dorothy. 2011. *Fatal Invention: How Science, Politics, and Big Business Re-Create Race in the Twenty-First Century*. New Press/ORIM.

Roberts, Dorothy E., and Oliver Rollins. 2020. “Why Sociology Matters to Race and Biosocial Science.” *Annual Review of Sociology* 46(1):195–214. doi: 10.1146/annurev-soc-121919-054903.

Roscigno, Vincent J., Lisette M. Garcia, and Donna Bobbitt-Zeher. 2007. “Social Closure and Processes of Race/Sex Employment Discrimination.” *The ANNALS of the American Academy of Political and Social Science* 609(1):16–48. doi: 10.1177/0002716206294898.

Rosenfeld, Jake, and Meredith Kleykamp. 2012. “Organized Labor and Racial Wage Inequality in the United States.” *American Journal of Sociology* 117(5):1460–1502. doi: 10.1086/663673.

Shah, Niral. 2017. “Race, Ideology, and Academic Ability: A Relational Analysis of Racial Narratives in Mathematics.” *Teachers College Record* 119(7):1–42. doi: 10.1177/016146811711900705.

Stevens, Kelly R., Kristyn S. Masters, P. I. Imoukhuede, Karmella A. Haynes, Lori A. Setton, Elizabeth Cosgriff-Hernandez, Muyinatu A. Lediju Bell, Padmini Rangamani, Shelly E. Sakiyama-Elbert, Stacey D. Finley, Rebecca K. Willits, Abigail N. Koppes, Naomi C. Chesler, Karen L. Christman, Josephine B. Allen, Joyce Y. Wong, Hana El-Samad, Tejal A. Desai, and Omolola Eniola-Adefeso. 2021. “Fund Black Scientists.” *Cell* 184(3):561–65. doi: 10.1016/j.cell.2021.01.011.

Strauss, Anselm, and Juliet Corbin. 1994. “Grounded Theory Methodology: An Overview.” Pp. 273–85 in *Handbook of qualitative research*. Thousand Oaks, CA, US: Sage Publications, Inc.

Timmermans, Stefan, and Rebecca Kaufman. 2020. “Technologies and Health Inequities.” *Annual Review of Sociology* 46(1):583–602. doi: 10.1146/annurev-soc-121919-054802.

Topaz, Maxim, Adam Schaffer, Kenneth H. Lai, Zfania Tom Korach, Jonathan Einbinder, and Li Zhou. 2018. “Medical Malpractice Trends: Errors in Automated Speech Recognition.” *Journal of Medical Systems* 42(8):153. doi: 10.1007/s10916-018-1011-9.

Virani, Salim S., Alvaro Alonso, Hugo J. Aparicio, Emelia J. Benjamin, Marcio S. Bittencourt, Clifton W. Callaway, April P. Carson, Alanna M. Chamberlain, Susan Cheng, Francesca N. Delling, Mitchell S. V. Elkind, Kelly R. Evenson, Jane F. Ferguson, Deepak K. Gupta, Sadiya S. Khan, Brett M. Kissela, Kristen L. Knutson, Chong D. Lee, Tené T. Lewis, Junxiu Liu, Matthew Shane Loop, Pamela L. Lutsey, Jun Ma, Jason Mackey, Seth S. Martin, David B. Matchar, Michael E. Mussolino, Sankar D. Navaneethan, Amanda Marma Perak, Gregory A. Roth, Zainab Samad, Gary M. Satou, Emily B. Schroeder, Svati H. Shah, Christina M. Shay, Andrew Stokes, Lisa B. VanWagner, Nae-Yuh Wang, Connie W. Tsao, and null null. 2021. “Heart Disease and Stroke Statistics—2021 Update.” *Circulation* 143(8):e254–743. doi: 10.1161/CIR.0000000000000950.

Whysall, Zara. 2018. “Cognitive Biases in Recruitment, Selection, and Promotion: The Risk of Subconscious Discrimination.” Pp. 215–43 in *Hidden Inequalities in the Workplace: A Guide to the Current Challenges, Issues and Business Solutions*, *Palgrave Explorations in Workplace Stigma*, edited by V. Caven and S. Nachmias. Cham: Springer International Publishing.

Wingfield, Adia. 2009. “Racializing the Glass Escalator: Reconsidering Men’s Experiences with Women’s Work.” *Gender and Society* 23(1):5–26.

Appendix

Recruitment Flyer

Racial Dynamics of
Bioengineering Study

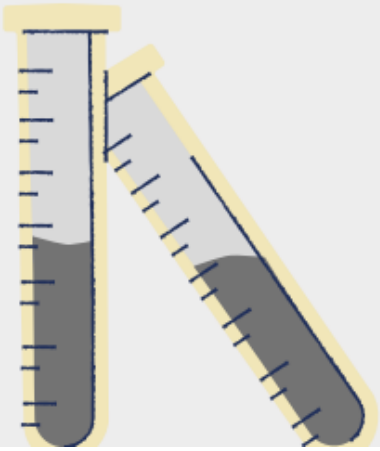
BIOENGINEERS NEEDED

The purpose of this study is to understand bioengineers' perception of race as it relates to the field.

Participation involves a 60 minute virtual interview

Eligibility:
+18 Years Old
Bioengineering experience

To learn more or sign up, please contact Rene Canady at c.janet@wustl.edu



Methodological Appendix

1. Recruited general interviewees through flyers posted in online bioengineering communities (4), direct email (13), events for minorities in bioengineering (4), and snowball referral (9) (December 2021 – June 2022)
    a. I performed interviews with zoom, recorded interviews and maintained transcripts. These interviews took 75 minutes on average.
    b. Throughout the interview process, I adjusted interview techniques to reach saturation on the range of racial opinions and behaviors of respondents. With this method, I compared individual racial views across lab role, demographic, and educational status. After identifying lab role, race, and gender were identified as salient factors, I adjusted recruitment to find respondents with diverse backgrounds in those categories.
    c. I interviewed bioengineers about their experiences in laboratory spaces and asked them to describe their lab values, lab racial and gender dynamics, attitudes towards their own projects, how they saw their projects contributing to health equity, and how bioengineering broadly contributed to disparate health outcomes.
2. **Completed ethnography for laboratories 1, 2, and 3 (March – April 2022)**
    a. First, I observed lab meetings for laboratories virtually so that I could identify elements of laboratory culture before completing in person observations. I was able to identify major projects in the laboratory and obtain documentation on the progress and logic of those projects.
    b. Once in person, I observed each laboratory over the span of a week through meeting and research presentation attendance, shadowing laboratory work, and participating in laboratory socials. I was able to observe collaborative processes happening at each organization and observe the norms around lab work as well as values that mattered most within the lab.
    c. Throughout my week in person, I interviewed laboratory members and asked them to describe their lab values, lab racial and gender dynamics, attitudes towards their own projects, how they saw their projects contributing to health equity, and how bioengineering broadly contributed to disparate health outcomes. These themes were coded in my analysis.
3. Analyzed projects, processes, and products
    a. After obtaining, cleaning, and coding the transcripts from each general interview, I coded racial implications of each respondent's research, whether implicitly or explicitly stated. For respondents who did not identify any racial implications, I looked for publications of their research online and found similar research about the components of their research. For each respondent, I was able to find as least one aspect of their work that was racialized. For example, many of the devices created were not as accessible to poor communities of color or were created to assist with patient populations of one race. The list of implications is below.

List of Racial Implications

List of respondents' work and the racial implications that I found through direct questions, follow-up questions, or researching their technology post-interview:

1. Characterizing nanoparticles to potentially treat bacterial vaginosis during pregnancy, which has higher rates among African Americans. Was asked how'd she incorporate race into an animal model oddly.
2. Designing technology on patients who suffer from vocal, voice or swallowing disorders. And then analyze and verify data obtained from assays so that then they can be submitted to the FDA or sold to another company for a partnership or another shareholder. She's gathered Hispanic respondents by speaking Spanish and denoted that working conditions of Black and Latino people have impact on throat disorders, but we don't know because of the research. Existing research is on white men.
3. Working on building an environmental monitoring program for source code- and are using data from Hispanic schools in California. Many schools turn them down- there are issues with collection labor and surveillance.
4. Using 9 different cell lines for sex differences research and it's a mix of Black and white respondents and males and females without recording race as a factor. This could be advantageous because hormonal differences due to race would be picked up.
5. Creating a machine learning device in an ultrasound lab to test the correlation between the image and muscle elasticity for elderly populations- didn't get a report on patient race.
6. Creating a qualitative analysis coder for an adolescent sleep study with another student, but their results have been overruled by the PI whenever they contradicted their believes. The interpretation of qualitative data is often drawn on racial lines.
7. Creating a noninvasive and blood pressure monitor using a light detection method that literature says works with the majority of people, but if he's using the usual green light for detection, it's not working for dark skin.
8. Studies actin binding protein and its contribution to cardiovascular disease. Didn't discuss research sample population, but there are disparate outcomes by race in heart disease and in ABP presentation.
9. Creating a machine learning model to improve rehabilitation outcomes for prosthetics the lab is working on, but the prosthetics are for veterans and only those deemed eligible through a fitness evaluation can get them. Veterans of color have significantly less access to prosthetics than their white counterparts.
10. Looking at adults with obesity comparing physically active and inactive adults with obesity and trying to understand if there are differences in their movement patterns and their functional mobility. This project seeks to undo the inaccurate stigma that associates obesity with health issues, which has been racialized intensely in America. This project will likely have positive racial implications!
11. Performing ovarian cancer research on metastasis that uses previous research that is all white subject pools. There are racial implications to this due to the hormonal differences and medical treatment differences caused by racial experiences
12. Produced material for left ventricle failure in heart attacks and regenerative medicine for extra-cellular matrix. Disparities in heart disease could mean that this treatment is used heavily for those most affected or that this treatment skips those marginalized. There are consequences for health disparities either way.
13. Accumulating a list of 85% white men for a self-citation project and got called in by PI. Also, participated in a trustworthy machine learning project that prevents data from

being manipulated which was portrayed as a great opportunity to protect vulnerable populations. Yet, AI has mainly sped up racial bias in its implementation.

14. Producing genetic products. Calls for diagnostic testing at a younger age and healthcare coverage that pays off in the long run. But did believe genetics were the ultimate authority in terms of classification and medical treatment. Implications could go either way- where either racial hierarchy are reproduced in genetics are then decoupled with social inequality altogether and thus racism is not fundamentally addressed because its factors aren't considered, or genetics are addressed more accurately because people better understand the limitations of racial categories in bioengineering.
15. Creating a device for the blind that is designed to be low cost ($100) but middle tech because it requires a smart phone. Talks to a diverse testing population.
16. Makes a polymer band for AML therapy to become more effective. She mentioned the frustration of doing the research of the majority. There are disparities in the outcomes of this disease, and they could be exacerbated if their research doesn't benefit the minority.
17. Researches on slip and fall in workplaces has behavior-based campaign. But these injuries disproportionately impact Black and Brown blue color workers, and as of now they have to pay for shoes (unlike other personal protective equipment)
18. Researches drug delivery for cystinosis- a European mostly disorder. The delivery method is likely going to be expensive they say. Also this will be fast-tracked in the commercialization pathway and be only accessible to those who can afford it.
19. Manages team with coders (mentions race and bioinformatics/AI) and biologists. Her group is using HeLa cells, didn’t know until recently. Named a project about women and birth and how the pool was all white.
20. Ran a whole development neuroscience project that produced null results- and he didn't account for any social factors on alcoholism. But he does add a social constructionist definition of race.
21. Trying to vascularize tissues with growth factors and other materials for heart disease, which is a racialized disease. Using a 60-year-old white woman's cell for her project.
22. Developing proteins for cancer drug but said that its uptake on humans is mostly an afterthought. Also says drug development for cancer is decided by business- diseases impacting minority populations get cut because it's business first.
23. Has human tissue samples and doesn't know where from. Also studied Duchenne muscular dystrophy, which affects white males disproportionately, said the rest weren't genetically different.
24. Produces cards which test for certain bacteria and supports epidemiology lab testing. Could favor bacteria that affects specific populations more.
25. Created an accessible blood pressure taker sold for cheap in senior design- thought it was important because African Americans have heart disease more commonly.
26. Has a research goal of minimizing whole chain which makes drug delivery cheaper. Equity is an unintended consequence. Could be more intentional about it in the pipeline and he thinks early on.
27. Studies the sodium channels of action potentials in mouse hearts and mutations with it. Implications based on what racist ideas exist on heart function. Also racialized consumption of salt may also have brought about mutations. Respondent’s role is also

to tell doctors recommendations on how exercise and other behavioral changes work for hypertensive people so that they'll tell their patients to change their behavior.

28. Mostly works with Medicaid patients, who are disproportionately Black and Brown. Lead engineer thinks Black people all live in the inner city. Does risk mitigation and cost is his biggest thing he notices- which is drawn along racial lines.