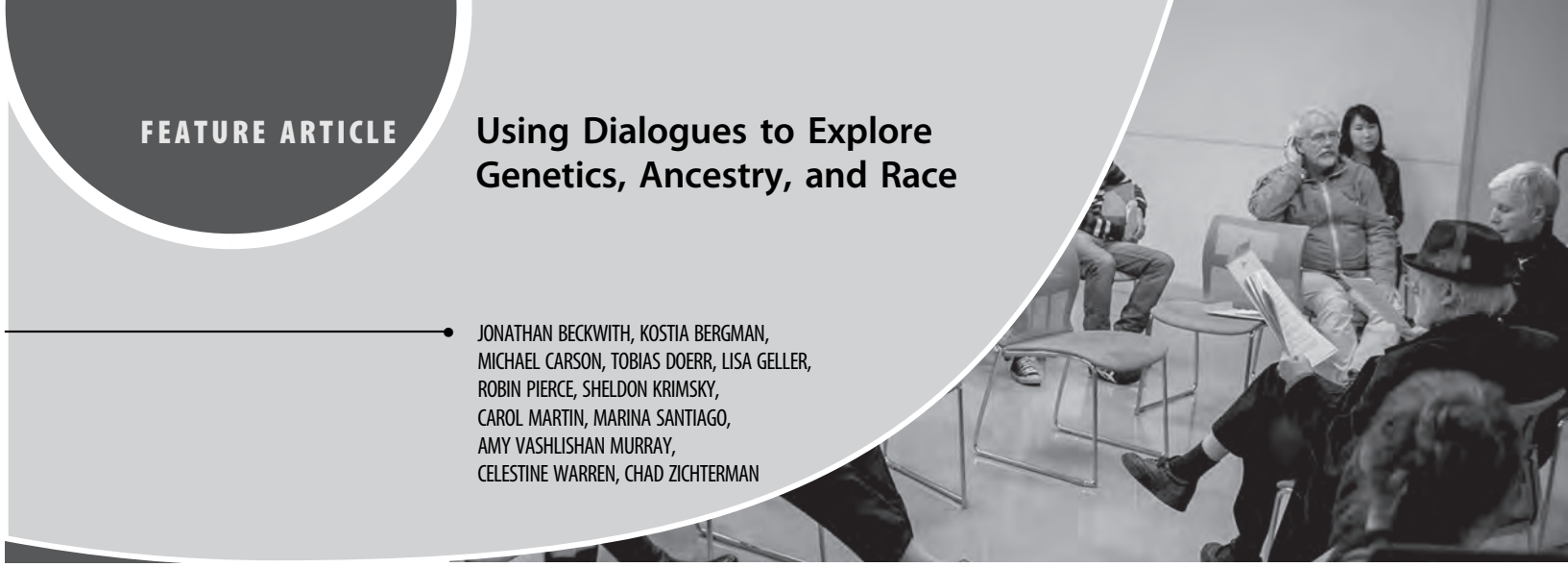
FEATURE ARTICLE

Using Dialogues to Explore Genetics, Ancestry, and Race



JONATHAN BECKWITH, KOSTIA BERGMAN, MICHAEL CARSON, TOBIAS DOERR, LISA GELLER, ROBIN PIERCE, SHELDON KRIMSKY, CAROL MARTIN, MARINA SANTIAGO, AMY VASHLISHAN MURRAY, CELESTINE WARREN, CHAD ZICHTERMAN

Abstract

Teaching the topic of genetics in relationship to ancestry and race generates many questions, and requires a teaching strategy that encourages perspective-based exploration and discussion. We have developed a set of dialogues for discussing the complex science of genetics, ancestry, and race that is contextualized in real human interactions and that contends with the social and ethical implications of this science. This article provides some brief historical and scientific context for these dialogues, describes their development, and relates how we have used them in different ways to engage diverse groups of science learners. The dialogue series can be incorporated into classroom or informal science education settings. After listening to or performing the dialogues and participating in a discussion, students will: (1) recognize misunderstandings about the relationship between DNA and race; (2) describe how DNA testing services assign geographic ancestry; (3) explain how scientific findings have been used historically to promote institutionalized racism and the role personal biases can play in science; (4) identify situations in their own life that have affected their understanding of genetics and race; and (5) discuss the potential consequences of the racialization of medicine as well as other fallacies about the connection of science and race.

Key Words: *genetics education; race; heredity; genomics; history of science, of biology; science and social justice; bioethics; genetic ancestry testing; genetics; race and medicine; teaching with dialogues; race as a social construct; ancestry; scientific objectivity; bias in science.*

○ Historical Context

Throughout history, people have used the concept of race to sort human beings into different groups. Outward physical features such as skin color and body form are often the focus of such grouping. Features like these are influenced by genetics, but there is always a danger that groupings made based on these traits—and assumptions made about other traits of members of these groups, like physical beauty and talents—are culturally based and subjective. As a result, designation of the number and nature of human racial groups has varied over time and from society to society.

Throughout history, people have used the concept of race to sort human beings into different groups.

The assignment of racial categories has never been based on valid science, but instead was strongly influenced by cultural attitudes. These categories were further justified by misuse of scientific methods and measurement. In other words, "race" as it came to be used was a social construct, without a valid scientific basis.

A dramatic new turn in the history of race discussions took place early in the 21st century when scientists began to collect complete DNA sequences of human genomes. Researchers leading this work announced that their results showed that race was not a meaningful biological concept. This conclusion was based on the finding that the DNA sequences of individuals from around the world are remarkably similar to each other; the genomes of any two people are about 99.5 percent identical. Furthermore, the 0.5 percent of DNA that differs between people does not include gene variants that are found only and prevalently in any of the supposed races. In other words, there is no group of "race" genes (Feldman & Lewontin, 2008; Rosenberg et al., 2002, 2011; Templeton, 2013).

Thus, even though the genetic differences among humans are few, much of human genome research has focused on that small 0.5 percent DNA difference between people. Studying the difference provides a way of exploring human origins, migration patterns, and the ancestry of modern populations. These studies have added fascinating information to our understanding of where and when humans originated on earth and, most recently, to the discovery that humans mated with Neanderthals (Green et al., 2010). Yet, some scientists have focused, questionably, on the small number of DNA differences as validating the idea that genetically based health differences exist between distinct races (Burchard et al., 2003; Risch et al., 2002). Moreover, some observers of science, including journalist Nicholas Wade in his book *A Troublesome*

The American Biology Teacher, Vol. 79, No 7, pages. 525–537, ISSN 0002-7685, electronic ISSN 1938-4211. DOI: https://doi.org/10.1525/abt.2017.79.7.525.

Inheritance and white supremacists on the neo-Nazi Internet forum Stormfront, have taken this genetics information to justify the argument that people of certain supposed races have superior qualities (Wade, 2014; Taylor, 2014). A large group of leading scientists responded to this interpretation of human genome research, saying that this was not a valid representation of the science (Coop et al., 2014; Balter, 2014; Altshuler & Gates, 2014).

Personal biases or beliefs that are entrenched in a society can influence the practice of science and can be used to justify social policies with terrible consequences. For example, some scientists in societies with significant class and racial conflicts have, consciously or unconsciously, supported the idea of superior and inferior classes of humans. Such ideas have been used to justify the enslavement of some groups of people (Carson & Beckwith, 2016; Gould, 1981).

The eugenics movements of the twentieth century presented so-called scientific ideas from the field of genetics and converted them into social policy. Based upon the belief that all human qualities were inherited, eugenicists developed controlled breeding and sterilization programs aimed at "improving" a gene pool that they believed to be deteriorating because of racial mixing. Some American scientists attributed social issues, including criminality, poverty, and "feeblemindedness," to genetics based on little more than their own prejudices, and stood by quietly when policy makers adopted their beliefs (Kevles, 1985; Lombardo, 2008). "Racial types" were ranked in order of their supposed worth and were said, based on poorly done research, to have certain negative character traits. These ideas were used to justify the eugenic policies of Nazi Germany and its "racial hygiene" movement that led to wholesale genocide based on "race" (Müller-Hill, 1988; Cohen, 2016).

Even today, ideas or information on human genetic variation, while potentially helpful in bettering the human condition, can still be used to justify discrimination. How are we to understand this new science, much less know what conclusions drawn from it are valid? This is particularly important when the science purports to explore human conditions using the lens of "race."

○ Dialoguing to Learn

Is it possible to separate legitimate scientific claims from spurious ones, good science from bad, when issues such as race are raised? Information about human genetic variation is often so complex that it is difficult even for many scientists well versed in genetics to understand. We, members of the Genetics and Society Working Group (GSWG), have collectively discussed research on human genetic variation and the social impact of such information for more than twenty years (Alper et al., 2002; www.genesandsociety.org). The GSWG is composed of scientists, students, and professionals trained in a variety of disciplines, including genetics, sociology, ethics, and the law. GSWG aims to promote the idea that scientific results in genetics, and science in general, should be clearly presented to all members of society, placing scientific results in a context that anticipates possible misinterpretation and promotes the use of results to benefit all.

Through discussion of genetics, ancestry, and race, we developed this work into a set of three dialogues (Appendix A). The dialogue format aims to make the material more accessible, encourage people to ask questions, and promote discussion. Social psychologists and science educators have discovered how the use of dialogues in the classroom and at public presentations breaks down barriers to learning science. For example, educators have employed dialogue journal writing with the purposes of counteracting passivity learned from disaffirming experiences with science and promoting science literacy (Hanrahan, 1999). Dialogue promotes engagement by helping to draw out different perspectives in science (Paulus & Roberts, 2006) and, in the case of historical dialogues, allows for alternative perspectives by scientists of the past to offer a range of different explanations for a given phenomenon (Lockhead & Dufresne, 1989). In fact, European educators of the early 20th century believed that the "soundest laws of science have to be revived by being integrated into dialogues between voices" (Kubli, 2005). Additionally, "science based stakeholder dialogues" build on theories of social decision making and organizational learning, serving as structured communications between scientists and social actors (stakeholders) (Welp et al., 2006). This emphasizes the critical value of dialogues in public engagement with science as a means of mutual learning (Davies et al., 2009). Thus, building upon grounded theory, upon which learning by dialogue is built, these dialogues (Appendix A) provide a pedagogical instrument not only for the classroom but also for any group of people with an interest in starting a discussion about race, genetics, and society.

Existing mechanisms for exposure to ideas about race, genetics, and society often perpetuate common myths about the informativeness of DNA ancestry tests and the relevance of DNA to the concept of race. We see this in popular television programming like the *Faces of America* series, in which the host and celebrity participants frequently ascribe racial meaning to DNA ancestry testing results. For example, Stephen Colbert is provided with ancestry results in the form of a pie chart that reads, not European, but "white man," and African American poet and professor Elizabeth Alexander is asked by host Henry Louis Gates how it feels to be "mostly white." Similarly, on a recent episode of the George Lopez show, Lopez also conflates ancestry and race as he explains test results to actress Jessica Alba, saying, "The test results can be broken down into four ancestral groups. One is European, which is White . . . ; one is East Asian, which is Asian. . . . One is Sub-Saharan African, which is Black; and one is Native American." Thus, our dialogues were developed out of an awareness that there are general public misconceptions about genetics, ancestry, and race, and are positioned to potentially dispel the erroneous ideas that (1) DNA-based ancestry testing can describe one's ancestry with precision, and that (2) ancestry information from these tests can be informative about one's race.

○ The Dialogues in Action

We presented the dialogues (Appendix A) at the City of Cambridge's annual Science Festival in April 2015 and again in April 2016. We also utilized the dialogues in an undergraduate non-majors genetics course at Emerson College and in an undergraduate biology capstone course at Northeastern University.

In the Cambridge Science Festival performance, all six characters were seated in chairs facing the audience without props. This format focused the audience on the content of the dialogue and supported a connection with the audience that resulted in excellent audience participation in the form of new questions and comments. The discussion following the dialogues was lively, and audience members both asked new questions and related their own experiences with

ancestry testing. For example, one audience member, a physician, felt that it was very important to know the race of a patient so he could "adapt my treatment to him," revealing misconceptions about the value of racialized medicine in practice. Another audience member raised the question of a prospective employer using genetic tests instead of interviews, stimulating a dialogue among audience members about the merits (and lack thereof) of such an approach. This discussion revealed genetic determinist assumptions that there are genetic predictors of aptitude that facilitators were able to refute.

Undergraduate students from one of our classes who attended the event supported our observations of lively audience discussion in post-event reflections. "I was surprised by how open people were to discussion after the script reading," said one student, commenting that she would expect people not to be so interested in talking opening and politely "after learning their scientific assumptions may be wrong." Students also commented on the format as supportive for engagement. "Seeing other non-scientist audience members respond to the information presented, ask questions and debate the social and political ramifications of genetics was fascinating and really got me excited about . . . science," reported another student. In the words of a third student, discussing the dialogue was effective because it was "informal and intimate," making this treatment of complex ideas "less intimidating for people who perhaps aren't academically involved in science but still interested in it."

We also used the dialogues in undergraduate classrooms. Students volunteered to read for characters in each dialogue or listened to an audio recording of the dialogues, and then discussed their responses to what they read or heard. Students drew relationships between the dialogues and their own experience, commonly citing personal or family interest or experience with examining their family origins and using or considering DNA testing as a supplement to the paper trails of genealogical study. For example, in post-discussion reflections one student explained: "I personally could connect to the discussion because my mom uses Ancestry.com and is very interested in genetic testing." Interestingly, this student identified similarity between the dialogue and real-life conversations she had had with her mother after learning about common misconceptions of ancestry testing in class. In a related comment, another student viewed another one of the dialogues as a "guide" that she could apply to arguments about genetics and race that she had experienced with family members. This highlights a potential use of the dialogues for organizing common arguments about genetics and race, and relevant responses to each.

Student comments also underscored the benefits of engagement and exploration of perspective described in the body of literature on learning by dialogue. One (non-major) student observed that "people were very open to discussion, which I think is encouraging because people can get very attached to genetic [explanations]. Script reading/discussion is a very accessible way for people who don't usually think critically about the scientific data they are given to learn to take their own observations and discoveries from it." Relevant both to the role of dialogue in exploring alternative perspective and to the importance of communicating how science works to lay audiences, one student remarked that it was valuable that one of the dialogues depicted an exchange between two different scientists who disagreed with each other: "I thought [this] was important to see as someone in a non-scientific community, because people often simplify and glorify scientists as this single, all-knowing force, but in reality they are people trying to make sense of the world and do so in varying ways."

Because the undergraduates who encountered these dialogues at one college (Emerson College) were majors in disciplines of communication and the arts, engagement was also fostered by discussion of the dialogue format itself in comparison to expository, descriptive, or logical-scientific communication on the same subject matter (e.g., Lee et al., 2008; Dupré, 2008; Barbujani & Colonna, 2010; Innocent, 2013) and in comparison to non-academic dialogue of the entertainment media. Student inclination toward this critical analysis became an impetus for an assignment that asked students to outline the main arguments of one of the dialogues and create a version of it that better represented how they imagined two people would talk about these ideas (Appendix B). This type of engagement with the dialogues left a lasting impression as an activity for exploration that will continue to develop rather than as a static mechanism for content delivery. "Something that resonated with me was [our] treatment of science as being an ongoing discussion with the public," said one student. The "discussion was a dialogue to raise questions about genetic testing and information in the future."

○ Using Our Dialogues

Our dialogues (Appendix A) were developed to explore important questions related to human biological variation, race, ancestry, and medicine. Recent research in science education demonstrates that students harbor essentialist misconceptions on the biology of human race, overestimating the amount of biological variation across races and underestimating the variation within a race. This essentialist view is correlated with poorer performance in biology and has been shown to increase with repeated exposure to racial terminology in the modern biology curriculum (Donovan, 2016). Having presented our dialogues to audiences at a local science festival and subsequently in two college classrooms, we offer them for use in informal educational settings or to supplement the high school or college biology curriculum, helping students develop a better understanding of human biological variation and challenge essentialist perceptions.

Teachers will recognize that the science that informs knowledge about human biological variation in this age of genomics is very complex and that topics involving race and race relations may be controversial. Therefore implementation of our dialogues within any existing curriculum in human biology will rely on the expertise of the teacher and existing professional development supports. Below, we provide a few additional points and sources of information specific to each dialogue to help educators with this process.

Dialogue 1: My DNA Ancestry Test Says What?

In this first dialogue of the series, two friends explore the link between DNA and self-identified race. Kelly identifies herself as black and reports this identity on her latest U.S. Census. Upon completion of a DNA-based ancestry test, she discusses with Michael the "unexpected" finding that her ancestry is predominantly European. This begins a discussion of DNA ancestry testing, raises questions related to the science behind the tests, and leads to a larger question of how race is constructed in society.

Incorporating this dialogue and a facilitated discussion within a lesson on human biology will encourage students to explore their own misconceptions on biological essentialism related to human

biological variation and race. The context of DNA-based ancestry testing should be a familiar topic to capture interest. Therefore, this dialogue may work as an engagement piece before beginning a unit on human genetic variation or the origins and historical migration patterns of modern humans. Television shows such as *Faces of America* or *Lopez Tonight*, in which celebrities are presented with their genetic ancestry test results, may be shown as clips to further heighten interest in the topic. Opportunities and challenges of genetic ancestry testing have been presented elsewhere (Royal et al., 2010). Additionally, we provide sample discussion questions at the end of the dialogue that may be selected or modified based on the intended audience, as a way of beginning facilitated discussions.

Dialogue 2: Two Scientists, Two Perspectives

In this second dialogue in the series, two scientists explore the question of whether or not human race is biologically meaningful, tracing some of the history of alternative perspectives in their field. In the 18th and for much of the 19th century, scientists relied on physical traits as a means of identifying human racial groups. With the development of DNA technology, studies of the genetic basis of "race" became much more sophisticated, and differences between people from different parts of the world could now be roughly quantified. Jon argues that "race" has no biological basis. Tobi disagrees, arguing that there are distinct biological races that can be separated on the basis of physical characteristics and genetic information. As in the first dialogue, DNA-based ancestry tests are discussed, further developing the science behind the tests and some of the exciting things that can be learned about human history and migrations using DNA. Importantly, the dialogue also discusses how scientific information on human differences has been used incorrectly for making broad claims of the superiority or inferiority of people from different races.

Utilizing this second dialogue will develop more advanced concepts of human biological variation than those in the first dialogue. Additionally, this dialogue introduces the historical context of human biological categories, the use of science to promote racism, and highlights the different perspectives within the scientific community on the biological basis of race. The characters of Jon and Tobi represent different positions within the scientific community on the biological reality of race. Presenting how these different interpretations can be derived from the same human population data can be used to support the "arguing from evidence" core idea in the Next Generation Science Standards (Donovan, 2015a). The science content that this dialogue is built on is complex, and educators may need to access new knowledge. Four different components of subject matter knowledge to support teachers implementing this dialogue and teaching about race have been described elsewhere (Donovan, 2015b). These include: (1) knowledge of psychological essentialism and the misconceptions that students have about human genetic diversity; (2) understanding how data can be interpreted in different ways by scientists regarding the biological reality of race; (3) philosophical arguments on the reality of race; and (4) knowledge on human behavioral genetics in context of false essentialist claims.

Some possible ideas for framing discussions from the topics introduced in this second dialogue are provided as sample questions. Several of these questions steer discussion toward scientific content on phenotypic expression, such as these questions: What is the difference between "biological" and "genetic"? and, What reasons would explain why African Americans from West Africa have higher blood pressure than the people of West Africa itself? Both of these questions are intended to stimulate discussion on how genetic information influences traits (phenotype). Teachers could reveal that the effects of environment, including racism and diet, have profound effects on traits such as blood pressure, arguing against genetic determinism. Other suggested questions focus the discussion on cultural and social aspects of science and explore how different interpretations can be made from similar data, as discussed above.

Dialogue 3: Racial Profiling in Social Science and Medicine

In this third and final dialogue, a social scientist and a skeptic explore the risks and benefits of using self-identified racial categories in medical research and treatment. In most studies the variable being used is "self-identified" race, though this is sometimes connected to race as may be measured through DNA ancestry testing. This conversation takes place between Sedgwick, who has used racial categories in his research, and Lisa who believes that using racial categories in this way may reinforce the erroneous belief that "race" is biological, possibly resulting in medical racial profiling.

This final dialogue focuses attention on recent calls from genomic scientists, social scientists, and ethicists to abandon the use of racial categories in human genetics studies and medical research (Lee et al., 2008). There are, of course, important exceptions. The use of the social category of race in studies of racism and the resulting health effects is one such exception (Krieger, 2005). Additionally, the inclusion of racial categories in studies of human health has been supported as a way of addressing racial health disparities. However, it has been suggested that inclusion of racial categories in descriptions of disease, such as reporting a frequency of sickle cell anemia as 1 in 500 African Americans, may reinforce biological essentialism among students, and lead them to the conclusion that genetic differences are responsible for the observed racial differences in behaviors or abilities (Donovan, 2016). Discussion following this dialogue may be informed through a recent article in which influential scholars call on the U.S. National Academies of Sciences, Engineering, and Medicine to convene a panel to "recommend ways for research into human biological diversity to move past the use of race as a tool for classification in both laboratory and clinical research" (Yudell et al., 2016).

○ ACKNOWLEDGEMENT

We thank Brian Donovan for discussing his work with us and providing critical feedback on this project. We are also grateful to Emerson student Emeralda (Emmy) Ross for providing valuable insights on improvisation that contributed to the development of the dialogues.

References

Alper, J. S., Ard, C., Asch, A., & Beckwith, J. (Eds.). (2002). *The Double-Edged Helix: Social Implications of Genetics in a Diverse Society*. Baltimore: Johns Hopkins University Press.

Altshuler, D., & Gates, H. L., Jr. (2014, June 6). Race in the Age of Genomics: Uncomfortable truths must be dealt with, but we should stick to facts and call out rampant speculation. *Wall Street Journal*.

Balter, M. (2014, August 8). Geneticists decry book on race and evolution. *Science Magazine*. Retrieved from http://www.sciencemag.org/news/2014/08/geneticists-decry-book-race-and-evolution?rss=1

Barbujani, G., & Colonna, V. (2010). Human genome diversity: Frequently asked questions. *Trends in Genetics*, *26*(7), 285–295.

Burchard, E. G., Ziv, E., Pérez-Stable, E. J., & Sheppard, D. (2003). The importance of race and ethnic background in biomedical research and clinical practice. *The New England Journal of Medicine*, *348*(12), 1170.

Carson, M., & Beckwith, J. (2016). "Race," IQ and Genes. *eLS*, 1–5. doi:10.1002/9780470015902.a0005689.pub3

Cohen, A. (2016). *Imbeciles: The Supreme Court, American Eugenics, and the Sterilization of Carrie Buck*. New York: Penguin Press HC.

Coop, G., Eisen, M., Nielsen, R., Przeworski, M., & Rosenberg, N. (2014, August 8). Letters: A troublesome inheritance. *The Sunday New York Times Book Review*.

Davies, S., McCallie, E., Simonsson, E., Lehr, J. L., & Duensing, S. (2009). Discussing dialogue: Perspectives on the value of science dialogue events that do not inform policy. *Public Understanding of Science*, *18*(3), 338–353.

Donovan, B. M. (2015a). Reclaiming race as a topic of the U.S. biology textbook curriculum. *Science Education*, *99*(6), 1092–1117. doi:10.1002/sce.21173

Donovan, B. M. (2015b). Putting humanity back into the teaching of human biology. *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences*, *52*, 65–75. doi:10.1016/j.shpsc.2015.01.011

Donovan, B. M. (2016). Learned inequality: Racial labels in the biology curriculum can affect the development of racial prejudice. *Journal of Research in Science Teaching*, *54*(3), 379–411. doi:10.1002/tea.21370

Dupré, J. (2008). What genes are and why there are no genes for race. In B. A. Koenig, S. S.-J. Lee, & S. S. Richardson (Eds.), *Revisiting Race in a Genomic Age* (pp. 39–55). Piscataway, NJ: Rutgers University Press.

Feldman, M., & Lewontin, R. C. (2008). Race, ancestry, and medicine. In B. A. Koenig, S. S.-J Lee, & S. S. Richardson (Eds.), *Revisiting Race in a Genomic Age* (89–101). Piscataway, NJ: Rutgers University Press.

Gould, S. J. (1981). *The mismeasure of man*. New York: W.W. Norton.

Green, R. E., Krause, J., Briggs, A. W., Maricic, T., Stenzel, U., Kircher, M., . . . Pääbo, S. (2010). A Draft Sequence of the Neanderthal Genome. *Science*, *328*, 710–722.

Hanrahan, M. U. (1999). Rethinking science literacy: Enhancing communication and participation in school science through affirmational dialogue journal writing. *Journal of Research in Science Teaching*, *36*(6), 699–717.

Innocent, T. (2013, March 7). Sense About Genetic Ancestry Testing." Retrieved from http://archive.senseaboutscience.org/data/files/resources/119/Sense-About-Genetic-Ancestry-Testing.pdf

Krieger, N. (2005). Stormy Weather: Race, gene expression, and the science of health disparities. *American Journal of Public Health*, *95*(12), 2155–2160. doi:10.2105/ajph.2005.067108

Kubli, F. (2005). Science teaching as a dialogue—Bakhtin, Vygotsky and some applications in the classroom. *Science & Education*, *14*(6), 501–534.

Kevles, D. J. (1985). *In the name of eugenics: Genetics and the uses of human heredity*. No. 95. Cambridge, MA: Harvard University Press.

Lee, S. S.-J., Mountain, J., Koenig, B., Altman, R., Brown, M., Camarillo, A., . . . Underhill, P. (2008). The ethics of characterizing difference: Guiding principles on using racial categories in human genetics. *Genome Biology*, *9*(7), 404.

Lockhead, J., & Dufresne, R. (1989). Helping students understand difficult science concepts through the use of dialogues with history. Retrieved from eric.ed.gov/?id=ED312158

Lombardo, P. A. (2008). *Three generations, no imbeciles: Eugenics, the Supreme Court, and* Buck v. Bell. Baltimore: Johns Hopkins University Press.

Müller-Hill, B. (1988). *Murderous science: Elimination by scientific selection of Jews, Gypsies, and others, Germany 1933–1945*. Oxford: Oxford University Press.

Paulus, T. M., & Roberts, G. (2006). Learning through dialogue: Online case studies in educational psychology. *Journal of Technology and Teacher Education*, *14*(4), 731.

Risch, N., Burchard, E., Ziv, E., & Tang, H. (2002). Categorization of humans in biomedical research: genes, race and disease. *Genome Biology*, *7*, comment 2007–1.

Rosenberg, N. A. (2011). A population-genetic perspective on the similarities and differences among worldwide human populations. *Human Biology*, *83*(6), 659–684.

Rosenberg, N. A., Pritchard, J. K., Weber, J. L., Cann, H. M., Kidd, K. K., Zhivotovsky, L. A., & Feldman, M. W. (2002). Genetic structure of human populations. *Science*, *298*(5602), 2381–2385.

Royal, C. D., Novembre, J., Fullerton, S. M., Goldstein, D. B., Long, J. C., Bamshad, M. J., & Clark, A. G. (2010). Inferring genetic ancestry: Opportunities, challenges, and implications. *The American Journal of Human Genetics*, *86*(5), 661–673. doi:10.1016/j.ajhg.2010.03.011

Taylor, J. (2014, March 2). Nicholas Wade attacks the Regime. Stormfront Blog. Retrieved from https://www.stormfront.org/forum/t1027136/

Templeton, A. R. (2013). Biological races in humans. *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences*, *44*(3), 262–271.

Wade, N. (2014). *A Troublesome Inheritance: Genes, Race and Human History*. New York: Penguin.

Welp, M., de la Vega-Leinert, A., Stoll-Kleemann, S., & Jaeger, C. C. (2006). Science-based stakeholder dialogues: Theories and tools. *Global Environmental Change*, *16*, 170–181.

Yudell, M., Roberts, D., Desalle, R., & Tishkoff, S. (2016). Taking race out of human genetics. *Science*, *351*(6273), 564–565. doi:10.1126/science.aac4951

JONATHAN BECKWITH is an American Cancer Society Professor Emeritus, Harvard Medical School, Department of Microbiology and Immunobiology, HIM 1047, 77 Avenue Louis Pasteur, Boston, MA 02115; e-mail: jon_beckwith@hms.harvard.edu. KOSTIA BERGMAN is an Associate Professor in the Department of Biology, Northeastern University, 413 Mugar Life Sciences Building; e-mail: k.bergman@neu.edu. MICHAEL CARSON is a Professor in the Department of Biological Sciences, Bridgewater State University, Bridgewater, MA 02325; e-mail: mjcarson@bridgew.edu. TOBIAS DOERR is an Assistant Professor in the Weil Institute for Cell and Molecular Biology/Department of Microbiology, 361 Weill Hall, Cornell University, Ithaca NY 14853; e-mail: tdoerr@cornell.edu. LISA GELLER is a Principal in Intellectual Property Strategy LLC, Watertown, MA; e-mail: lgeller8@gmail.com. ROBIN PIERCE is a Senior Lecturer in the Brunel University Department of Politics History and the Law, Brunel Law School, Elliott Jaques Building, London, Uxbridge UB8 3PH, UK; e-mail: pierce7@post.harvard.edu. SHELDON KRIMSKY is a Professor in the Department of Urban and Environmental Policy & Planning, Tufts University, Medford, MA 02155; e-mail: Sheldon.Krimsky@tufts.edu. CAROL MARTIN is a Harvard Catalyst Program Manager, Harvard Medical School, Harvard Catalyst Program for Faculty Development and Diversity Inclusion, 25 Shattuck Street, Boston MA 02115; e-mail: Carol_Martin@hms.harvard.edu. MARINA SANTIAGO is a Research Scientist at Finch Therapeutics, 200 Inner Belt Road, Somerville, MA; e-mail: marina.joy.santiago@gmail.com. AMY VASHLISHAN MURRAY (correspondence author) is an Associate Professor at the Institute for Liberal Arts and Interdisciplinary Studies, Emerson College, 120 Boylston Street, Boston MA 02116-4624; e-mail: a_vashlishan_murray@emerson.edu. CELESTINE WARREN is a MD candidate at the Geisel School of Medicine at Dartmouth, 45 Kellogg Bldg, Hanover, NH, 03755; e-mail: celestinewarren@gmail.com. CHAD ZICHTERMAN is a student and freelance animator at Makaio Media, 30 Cambridgepark Dr. #5104, Cambridge, MA 02140; e-mail: chadmakaiozichterman@mac.com

Appendix A: Dialogues on Genetics, Ancestry, and Race

Developed by the Genetics and Society Working Group based upon an improvised performance at the Cambridge Science Festival, April 2015.

The setting for the following three dialogues could be a cafeteria or coffee shop. The characters in the first dialogue are having a conversation that is overheard by the characters in the second dialogue. The third dialogue is independent and begins when the second dialogue ends. In the Cambridge Science Festival performance, all six characters were seated in chairs facing the audience without props. This format aimed to focus the audience on the dialogue.

Dialogue 1: My DNA Ancestry Test Says What?

In this first dialogue of the series, two friends explore the link between DNA and self-identified race. Kelly identifies herself as black and reports this identity on her latest U.S. Census. Upon completion of a DNA-based ancestry test, she discusses with Michael the "unexpected" finding that her ancestry is predominantly European. This begins a discussion of DNA ancestry testing, raises questions related to the science behind the tests, and leads to a larger question of how race is constructed in society.

KELLY: My DNA ancestry test just came in!

MICHAEL: What did you find out?

KELLY: Let me see. This result says that I'm 76% European, 14% West African, and 10% Native American. I guess that means that I'm White.

MICHAEL: Why is that?

KELLY: Well, according to these DNA tests I'm more white than anything else. But still . . .

MICHAEL: Wait something doesn't make sense here. What category did you check off on the last census?

KELLY: Black, Not-Hispanic. But now I have this document that says that I am more White than I am African. I wonder if I should change my race and ethnicity category now. And wouldn't it be nice if this meant that I wouldn't be followed around when I go into shops anymore?

MICHAEL: Wait, how much do you know about how these DNA tests even work?

KELLY: I did my homework. I read a lot about it on some family history websites when I began researching my family ancestry. I'm assuming that my DNA is being compared to DNA of people from different places around the world looking for the similarities and differences.

MICHAEL: But I read a while back that all people were over 99% similar in their DNA, no matter where in the world they come from.

KELLY: Yes, but that small percent of difference is what is tested. For example, think of DNA as represented by many letters, sort of like spelling a really long word.

MICHAEL: OK, and when you compare the DNA from two people, you might find a spelling difference.

KELLY: That's right.

MICHAEL: But wait! "spelling difference" sounds scary. I know that a spelling difference in the DNA of a gene might lead to genetic disease—like cystic fibrosis, sickle cell anemia, or even color blindness.

KELLY: "*Color blindness"—that's a good one.* You're right though, sometimes a spelling change in a gene does contribute to a genetic disease. But often it does not. You brought up a good example: How do you spell the word "color"?

MICHAEL: c-o-l-o-u-r.

KELLY: Oh, that's right, you're from Canada, I would spell it c-o-l-o-r. Same word, different spelling.

MICHAEL: OK. But with your DNA ancestry tests, they must look at more than one place in the DNA with a "spelling difference."

KELLY: Absolutely, I chose a testing company that claims to look at nearly a million places in the DNA that have possible spelling differences

MICHAEL: Possible spelling differences???

KELLY: Yes, if I were only to look at the DNA at just one of those million places, my DNA letter might be the same as a person from Europe, but different from a person from Africa . . .

MICHAEL: Do you mean to say that a person from Europe will always have one of the DNA spellings and a person from Africa will have another spelling?

KELLY: No. You can find both spellings amongst people from Europe and people from Africa. The difference is *how often* one letter occurs in people from Europe compared to people of Africa. For example, for this one place in the DNA, it says that the DNA letter "G" occurs in 68% of Europeans but in only 40% of Africans.

MICHAEL: So if you have the letter "G" at that place in the DNA, that means that you could be from either Europe or Africa . . . But maybe there is a slightly greater chance that you are from Europe . . .

KELLY: "Slightly" is correct. So the DNA ancestry test that I took, looks at many, many places on the DNA where there *may* be a spelling difference and compares my DNA to the DNA found in people from around the world.

MICHAEL: And if enough of your DNA letters are those that are found in high frequency in a given population, then it assigns you to that group.

KELLY: Yes. Or as my test shows, the computer program can take all these differences into account and give me the overall estimate of how much of my ancestry is from one group and how much from another.

MICHAEL: OK, but if your ancestry test result says that your DNA is 76% likely to be from European ancestors, and yet you claimed on the 2010 census to be Black, what does this all really mean??

KELLY: That's a really good question. If the tests say one thing and society says another, which is right? Do these tests mean anything? Do they really change anything . . . ?

Discussion Questions

- Do you think these ancestry tests have value? If so, what could it be?
- What do you think these tests tell us?
- Why is ancestry testing appealing; why do you think people get these tests done?
- Would you decide to get this test done? Why or why not?
- Who, if anyone, would you share this information with?
- Can you think of some instances where this data might be used as "proof" of anything (nationality, paternity testing, etc.)?
- Can you think of how these tests might be misinterpreted (by individuals, historians, politicians, employers, online dating sites, etc.)?

Dialogue 2: Two Scientists, Two Perspectives

In this second dialogue in the series, two scientists explore the question of whether or not human race is biological, tracing some of the history of alternative perspectives in their field . In the 18th and for much of the 19th century, scientists relied on physical traits as a means of identifying human racial groups. With the advent of DNA technology, studies of the genetic basis of "race" became much more sophisticated, and differences between people from different parts of the world could now be quantified. Jon argues that "race" has no biological basis. Tobi disagrees, arguing that there are distinct biological races that can be separated on the basis of physical characteristics and genetic information. As in the first dialogue, DNA-based ancestry tests are discussed, further developing the science behind the tests and some of the exciting things that can be learned about human history and migrations using DNA. Importantly, the dialogue also discusses how scientific information on human differences has been used incorrectly for making broad claims of the superiority or inferiority of people from different races.

JON: Did you hear what those guys were talking about? I have a real problem with these genetic ancestry tests.

TOBI: Why do you say that?

JON: Because people are told what percentage of each race they are as though that has some biological meaning.

TOBI: Of course, race has a biological meaning. Scientists long ago established that there are 5 distinct races.

JON: Uh-oh. Looks like we're going to get into an argument. Maybe, we first ought to define what we mean when we use the word "race."

TOBI: Well, that's easy. We can distinguish 5 racial groups on the basis of their different physical traits.

JON: Really? So which traits do you use to distinguish them?

TOBI: The 5 racial groups are Africans, Native Americans, Eurasians, East Asians, and Pacific Islanders. They differ in characteristics such as skin color, bone structure, physique etc., all traits with a genetic basis.

JON: This seems an arbitrary way to group people. If you define races according to skin color you get a different list of groups than if you group them by bone structure or height. How do you choose these traits? Just because they are easy to see?

TOBI: You seem to have an ideological problem with this. Why do you have an issue with the fact that people are different?

JON: I don't have a problem with people being different from each other. I just wonder why people should be categorized according to genetic differences?

TOBI: Good question. I think that understanding the genetics of race could be useful. We don't know yet what most of the differing genes do. But, races may differ in their likelihood of getting certain diseases. That could be useful for medical treatments. Maybe, races differ in their personalities and their abilities. That could be useful for social policies, such as job placement or educational policies.

JON: But, there have been horrendous consequences of social policies that were based on assumptions that people are born with different skills and behaviors that cannot be changed. This kind of thinking helped support such destructive social policies as slavery, discrimination, eugenics, and imperialism.

TOBI: Fair enough, but you shouldn't reject scientific truth because it might be harmful.

JON: True. But, most of the science in this field that I know about was pretty shoddy. How did it get started anyway?

TOBI: Colleague, this research has a long and honored history. Some trace its beginnings to the 18th century when European scientists came up with ideas about the 5 classical races. Later, U.S. scientists contributed further support for the theories.

JON: Hmmm! Don't you think that these white European and U.S. scientists might have brought their own biases into their studies?

TOBI: Biases? Scientists don't let their biases affect their work. Scientists gather data and analyze them objectively.

JON: Yes, that is certainly an ideal of science. But not always held to. For instance, in the 18th century European scientist Johann Blumenbach studied race and concluded that white Caucasians were the most beautiful of races, and Linnaeus, a scientist active around the same time, defined Africans as the most capricious of races. What criteria were they applying? Evaluating those qualities can be pretty subjective!

TOBI: You can worry about that. But, science works properly when scientists propose theories and other scientists test these theories. In fact, researchers continued to provide evidence that humans could be divided into different races with different characteristic traits. Harvard Professor Louis Agassiz, in the 19th century, proposed that Africans and whites had evolved separately. And Dr. Samuel Morton in Philadelphia measured the skull capacity of different supposed racial types. His estimations of brain size supported the race theories of his predecessors.

JON: But I think this is actually a good example of strong bias. Agassiz had no evidence for his ideas other than his own personal negative feelings about black people. Likewise, Morton's opinion that, quote, "blacks are the nearest approximation to the lowest animals" makes it highly unlikely that he was able to study human races in an unbiased fashion. Remember that Morton's work was used as support for slavery in the South.

TOBI: OK, scientists have to be careful in separating their biases from their research. But I insist that most scientists do exactly that. At any rate, with new tools and more rigor, 20th- and 21st-century scientists have continued to provide support for the conclusions about races we have been talking about.

JON: I have some doubts about genetics in the early 20th century. What about the eugenics movement in the United States in the first half of the 20th century, which claimed that genetics research justified forced sterilization, and supported immigration restrictions for certain racial or ethnic groups? Not to mention the Nazi's extermination of different groups based on arguments of genetic inferiority.

TOBI: Again, you shouldn't blame misuse of science on the scientists. These are old examples. Why don't we talk about what's happening now. What I want to show you is that recent scientific studies of the genomes of people from around the world provide the icing on the cake for my position. These studies show that the conclusions about race from four centuries of scientific work in this field were correct.

JON: How is that? My understanding is that sequencing the DNA of human genomes showed that two people picked from any place in the world share about 99% of their DNA sequences. That seems to me to say that we are all pretty much the same. Or, did they find specific genes in the 1% differences that allowed them to distinguish certain racial groups?

TOBI: That's it: most of these 1% differences in DNA are found in all human populations and geographic places. However, each population differs in what percentage of the people in that population have the variants.

JON: I think I get what you are saying. You mean that if you look at the DNA sequence from different groups of people, you would see that, for example, 60% of people in an African population may have a certain DNA sequence, whereas only 35% of Europeans have the same DNA sequence?

TOBI: Yes, that's how it works. These frequencies were studied by genome scientists who developed a computer program to sort people into different groups using these similarities and differences in their DNA sequences. The computer program was able to take DNA sequence data and neatly group people into their geographical regions of origin based on those differences. And, the computer reported that it could sort the populations into 5 groups, corresponding to the geographical regions of the 5 classical races.

JON: So you are saying that the unbiased computer actually generated 5 racial groups from looking at a large number of human genome sequences?

TOBI: No, it doesn't quite work that way. The scientists were able to ask that the computer tell them what the groups would look like when the sequences are analyzed to divide people into 2, 3, 4, 5, or 6 groups. When they asked for 5 groups, the computer program reported those 5 geographical races that fit best. Other numbers yielded different groupings with more or fewer peoples classed together.

JON: Wait, this sounds pretty murky. Did they get a full sampling from all regions of the world? If not, what happens when you feed even more people's DNA sequences into the computer?

TOBI: Well, there have been subsequent studies based on more sequences that neatly split people into 18 groups by geographical regions.

JON: 18?! So, depending on how we look at the data and follow your definition of race, we can actually distinguish 18 races? This gets confusing.

TOBI: Well, no, in this study, 14 groups were within Africa and the 4 remaining groups within the rest of the world. So I would say that there are still the 5 racial types, but maybe the African race can be further divided into 14 groups within Africa alone.

JON: So, now you have to further divide a particular race to make this work. This reminds me of the Russian nesting dolls, where each doll can be opened up to find a smaller doll inside . . . . Hmmm, why end at 18 groups instead of a much larger number. Is it a matter of convenience? Or does the number have a scientific rationale? I assume that this means that two people who were put in the same African group in the earlier studies wouldn't necessarily share the same variants.

TOBI: Correct.

JON: That means two people could be grouped in the same race by their DNA even though they have a different set of sequence changes, as long as those changes were collectively more common in people in their geographical region.

TOBI: Yes.

JON: So, how can we generalize that there is any biological meaning to race when people within the races you've defined can still have such different DNA sequences?

TOBI: OK. I'll admit that a large number of genetic differences can be found between two people of the same race. But the computer programs are still accurate in grouping people into races based on their DNA. Isn't that compelling?

JON: Well, given its use in developing models of things like human migration, it is pretty impressive, and it's exciting to learn that history. But what does it tell us about race, particularly, since there is extensive genetic similarity between people

from different groups, and most of the genetic differences can be found within a single group? I have to go back to my original question: What use is it to define human races if the genetic diversity is so fluid and thus the boundaries so fuzzy?

TOBI: The use lies in the fact that genetically defined races might have common features that are potentially useful to know. Let's assume East Asians have a high frequency of a version of a gene that causes a disease that can be treated if recognized early enough. Wouldn't it be great for doctors to know they need to screen their East Asian patients for this disease since they are at high risk?

JON: After hearing about this work, it is not clear how useful this would be. To do that, a doctor would have to categorize their patient as East Asian in the first place. According to what you told me, they would only be able to do that through measurement of genetic differences—so why not screen the patient just for the disease gene without any need for a pre-categorization? Also, do you have any specific examples for this, any specific disease that is found at a very high frequency in a very specific "race"?

TOBI: But of course! Many African Americans with origins in West Africa have a strong tendency to have high blood pressure. Researchers found a mutation in a gene that is responsible for the condition.

JON: Very interesting! I suppose the researchers tested people actually living in West Africa for the susceptibility gene, and they were prone also to high blood pressure?

TOBI: Ah, well, no, just African Americans seem to exhibit high blood pressure. Those tested in West Africa who had the same susceptibility gene did not have high blood pressure.

JON: So what you just told me is that high blood pressure in West Africa is not determined by genes. How does this relate to biological race? For me, this is an example of where this categorization by DNA causes harm. Rather than looking at what environmental factors (for example, systematic discrimination, poverty, etc.) might cause a phenotype like high blood pressure, you try to see it all from a misleading genetic perspective.

TOBI: Well, just the same, there are still medical researchers who are seeking such race-based genetic conditions with perfectly good intentions.

JON: We'll have to see how far that gets.

Discussion Questions

- What influences in society argue that race does and does not have a biological meaning?
- Can you think of some ways that family and culture are used as a proxy for genetics?
- What is the difference between "biological" and "genetic?"
- Are there some cases where we say that things are genetic even though they may be the result of family upbringing or culture? (For example: "I am Italian, of course I like garlicky tomato sauce." or "You're just like your father.")
- How does cultural context inform both study design and understanding of the results?
- What are some steps you take in your life to reduce your personal bias? Could these be applied to science?
- Do you agree with Tobi that science can be bias-free?
- If so, what are some steps scientists could use to ensure that their personal biases do not impact their work?
- What are the responsibilities of scientists to ensure that their work is not misinterpreted?
- What reasons would explain why African Americans from West Africa have higher blood pressure than the people of West Africa itself?

Dialogue 3: Racial Profiling in Social Science and Medicine

In this third and final dialogue, a social scientist and a skeptic explore the risks and benefits of using self-identified racial categories in medical research and treatment. In most studies the variable being used is "self-identified" race, though this is sometimes connected to race as may be measured through DNA ancestry testing. This conversation takes place between Sedgwick, who has used racial categories in his research, and Lisa, who believes that using racial categories in this way may enforce the belief that "race" is biological, possibly resulting in medical racial profiling.

LISA: Mr. Sedgwick, you compare people according to their race in your studies, is that correct?

SEDGWICK: I do. I have published papers on race and intelligence, race and discrimination, and race and health disparities.

LISA: But there is no scientific definition of race. So how can you engage in research where race, a key variable you are studying, isn't defined?

SEDGWICK: I use "self-identification." I recruit participants in my studies, sometimes students, and ask them which race they feel they belong to.

LISA: But that means that a person *considers themselves* either black or white. What if an individual had one African American grandparent and all other relatives were white. What do you do?

SEDGWICK: If they say they are black, we accept them in that group for our study.

LISA: Self-identification can change with circumstance. A person can self-identify as black in the U.S. and white in Brazil. The results of your research shouldn't depend on where in the world you or your subjects are from, should they?

SEDGWICK: Sometimes it does and for good reason. For example, if I am measuring racial attitudes, specifically how white people treat black people, the place in the world will determine a black person's self-identification. People who are treated by society as black, will (and probably should) self-identify as black, and we will include them in our study as subjects in the black group.

LISA: President Obama had a black father (African) and a white mother. He could self-identify as either black or white. Where would you place him in your study?

SEDGWICK: President Obama chose to self-identify as black because he knows that society will treat him that way. So, in a way, it makes sense for him to self-identify according to the way others view him.

LISA: You may be making something as complex as racial identity sound a little simple here. But, I can understand your point. If a person is treated as black and self-identifies as such, then for social science research that allows us to ask whether race is a factor in a particular phenomenon.

SEDGWICK: That's correct.

LISA: But suppose you are measuring health differences between races. How likely somebody is to get a certain disease shouldn't depend on how other people view that person. If you are studying disease frequencies, why would you use race as a way to identify differences if it's not concretely defined and based on self-identification?

SEDGWICK: It may not be a perfect variable, but it can be a useful substitute for aspects of the lifestyles and genetics of the two groups that may be important. People who self-identify as black are tested against people who self-identify as white. Suppose we find that there is a higher frequency of heart disease among those who identify as black. That is useful information, and treatments can be adjusted to those different segments of the population.

LISA: But what does self-identification have to do with race? The person who self-identifies as black may have 1/16 or less of his or her heritage of African peoples. It may just be an accident that there is a statistical correlation between self-identification and disease, since you do not have a biological marker. How can you correlate the vague notion of what group somebody thinks they belong to with a clear-cut biological disease?

SEDGWICK: While strictly speaking, what you are saying is true, it doesn't mean that we cannot use certain racially identifiable phenotypes, like skin color, to help the medical and public health communities determine disease patterns within populations.

Epidemiologists describe how rates of an illness vary with race. Doctors consider the race of their patients when deciding whether to test them for sickle cell anemia, or what drug to use to treat their high blood pressure. Ideally, we would like to know what genetic, cultural, or environmental characteristic might cause a higher risk of certain diseases. Those are hidden variables. In the meantime we can get value out of using race to classify groups of people when it offers medical benefits to those groups.

LISA: What evidence is there that there is value? Isn't it a form of racial profiling? Just because someone is black, they are treated for so-called black diseases. Sickle cell anemia is a recessive genetic disease. It is much more common in blacks than whites or Asians in the United States. It was so common among blacks and rare among whites that for many years sickle cell anemia has been called a black disease.

SEDGWICK: That seems like a practical use of racial disease profiling since the statistics bear it out.

LISA: During most of the 19th and much of the 20th century, many physicians were convinced that sickle cell is a black disease and the sickle cell gene, a black gene. They refused to diagnose the disease in white patients and reasoned that apparently white patients with the disease must be black. The doctors were mistaken. Having one copy of the sickle cell version of the gene protects carriers from getting malaria; whites with origins in the malarial regions of Europe are more likely to carry the gene than blacks from regions of Africa in which the risk of malaria is slight. The proportion of blacks in the United States from a malarial region of Africa is larger than the proportion of whites from a malarial region of Europe. Therefore, incidence of sickle cell anemia is greater among blacks than whites here in the United States.

SEDGWICK: Science had been mistaken but, in the meantime, doctors were allocating their resources responsibly by making the inference that blacks had more sickle cell.

LISA: But the racialization of disease, when race has no fundamental meaning, does some bad things. For example, in 1972, Kentucky made a rule requiring blacks applying for a marriage license to undergo a blood test to determine whether they were carriers of the sickle cell gene, but no such test was required of whites even though, by the 1970s, sickle cell disease was understood to occur in both blacks and whites. The health screeners continued to target blacks, while whites, no matter what their origins, were typically ignored. This generalization has lead to stigmatization of the disease and of the African American population. I think the risk of abuse is too great to justify the limited usefulness of your results.

Discussion Questions

- Do you agree with the Sedgwick's point about using race as a substitute for lifestyle and genetic aspects when determining where to most effectively spend public money?
- How do you imagine this approach could be abused, as the Lisa suggests?
- Can you think of some other questions that could be used to identify group-specific health risks?
- How would you compare these to the race-based questions?

Appendix B. Dialogue Enhancement or Re-design Assignment

Take Home Assignment 3

SC215 (Genetics and Identity), Emerson College, Spring 2017 (Examples of student work at www.genesandsociety.org/dialogues/)

Instructions

These dialogues on genetics, ancestry, and race were developed as an alternative strategy for approaching and exploring complex content. The dialogue feature proposes arguments that can be made and questions that may be common as one tries to understand the relationships between these ideas and the implications of understanding and misunderstanding them.

However, there are many ways you might imagine they could be improved, developed, or re-imagined to better resonate with you and support your learning.

As a final project-based, take-home assignment, you will use or develop the material from one of these dialogues in one of the following ways:

A. WRITTEN: REVISE OR RE-WRITE: Revise or re-write the second dialogue (the one between two scientists, Jon and Tobi) using your perspective as a media-maker. You can change the characters, or focus on their phrasing, or both, but you should include the same ideas and content areas. If you revise, track your edits so they are apparent, and if you re-write, track (annotate) the arguments so they're apparent in their new form. In either case, provide a paragraph giving the rationale for your edits/approach.

B. ANNOTATED GUIDE: Develop the second dialogue (the one between two scientists) as a teaching tool by annotating key ideas and providing background information and context or explanation where it is useful, including keys for the discussion questions (or edits to them). You should use your course materials as a guide for the level of elaboration or depth expected; you are not expected to research or add detail beyond what we covered but could contextualize the information or provide additional background or implications using our class notes. Imagine your product as a study guide or a teacher's copy.

C. VISUAL COMMUNICATION: Develop any of the three dialogues, visually communicating the ideas in illustrations, storyboard, or animation. Aim to include the same ideas and content areas, and provide a paragraph of rationale for your approach. If you edit out or refine content or make major revisions to the language (for example, moving away from the dialogue approach to an explainer style), describe your thinking in the paragraph.

You can complete this part of the assignment alone or in small groups of up to 4. If you elect to work collaboratively, please describe with your submission what each group member contributed.

Finally, if you have another idea for developing or re-imagining these dialogues that you would like to propose, do so in writing by [due date].

Submissions will be due along with additional take-home questions on [due date].

Evaluation

20 pts	**Description and convincing/compelling rationale of changes.** For options A and C, this will be in the form of an additional reflection paragraph. For option B, unless undertaken collaboratively (in which case you'll need the additional paragraph to describe how you divided and accomplished the work), this description and rationale will be included in the project itself, as the ideas that you highlight and extract to annotate will discuss the importance of the idea.
20 pts	**Content.** The same core ideas are included (except where rationale convincingly validates their exclusion) and represented accurately. Significant and/or substantial changes have been made to improve or enhance the communication of the ideas.
20 pts	**Clarity.** Edits or re-imagining communicates the ideas about genetics ancestry and race with precision and clarity.
20 pts	**Execution.** Submission is on time and according to instructions. Work shows polish, is free of typographical errors, and formatted in a way that is clean and finished.
20 pts	**Style.** The re-write or re-imagining of the "dialogues" evidences your unique style and approach, and you have created a product that is distinct from your starting material. The piece is memorable and interesting.