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Race, Racism and Genetics: An Elementary STEM Unit

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Introduction

I teach fifth and sixth grade Science at Nathan Hale School in New Haven, Connecticut. My classes represent a diverse, multicultural community of learners that encompass a wide spectrum of achievements, interests, learning and social needs. Children learn and progress best when they can apply the skills, they learn in a manner that befits their abilities and talents. This happens when they participate in interdisciplinary curriculum that not only involves choice but encompasses various learning and assessment strategies that celebrate how they learn. As mentors and role models for children it is extremely important that we integrate and connect their learning to the world around them. This then invites students to be more engaged and take ownership of their learning as it opens up the notion that their understanding and actions affect not only how they live in the present, but also their future.

This unit will teach students about Ethnic Studies, its history and its role in our lives. Students will experience the relevance and need for this common understanding through its integration into curriculum. According to 'Rethinking Ethnic Studies, A Rethinking Schools Publication,' "Ethnic Studies purpose is to respond to students by developing their critical understanding of the world and their place in it, and ultimately prepare them to use academic tools to transform their world for the better."[1] It is the study of the histories, experiences, cultures and issues of racial-ethnic groups.

This unit will provide a deeper understanding that while 'race,' as a cultural, social and historical concept has real life consequences, it does not describe human biological variation from a scientific perspective. Students will learn the history of the concept of 'race' from a social context and what scientific researchers have to say about it.

It is my hope that through this unit, students will gain a deeper understanding that individual humans are genetically the same, by demonstrating how the idea of 'race' fails to represent biological variation and furthermore how culture shapes how we see the world, and how these conceptions have changed over time. Given this foundation, students will see how 'race' and racism is embedded in our lives and can affect our everyday thinking and relationships.

Objectives

'Race, Racism and Genetics' uses research, lesson plans and activities to explain genetic similarity and variation. Biologically speaking, 'race' is not real, but racism is.In this unit, students will discuss sensitive issues based on what they know about genetics and how it pertains to the social construct of 'race' and ethnicity, including the ways in which they identify and are identified. Students should then be able to relate the ideas of which they are learning to the world around them in terms of controversies like 'race' and health, 'race' and IQ and 'race' and sports over the course of four weeks. Weeks 1- 2 will discuss what ethnic studies is as well as its history and impact on how 'race' and ethnicity is defined. Students will begin by reflecting on the meaning and impact of 'race' and ethnicity and will complete a series of readings and watch a related documentary. Students will understand that ethnic studies explore the historical formation of different racial and ethnic groups and its social, economic and political divisions. Students will focus not only on this history and culture, but also make connections between 'race,' class, gender and ability as well as the social movements that arose to contest injustice.

While practicing empathy and engaging in discussions that examine different perspectives and experiences, students will gain a deeper understanding about how race and ethnicity significantly affected our past which continues to impact our daily lives. Weeks 3-4 will cover identity and its various aspects that shape a person's social identity, including the values and ideas embedded and passed through family and the culture in which we live. Students will notice how these values align with and can shape how we see ourselves and each other, the internal and external conflicts that can arise because of them and how they change over time. Armed with this reflective insight, students will compare these insights to that of exploring human variation and genetics. Students will explore the basics of genetics and assess the relationship between genetics and racial identity. Students will use what they learned about human biological variation to understand that all humans share 99.9 percent of the same genetic variation to help them understand the idea that 'race' is a social rather than biological concept.

Why teach about Ethnic Studies?

Ethnic Studies examines the culture, history and experiences of different ethnic groups and encourages participants to engage in the issues of racism, colonialism, global economic and political systems, heath degradation and our geographies of differentiation and discrimination to name a few.[2] It emphasizes the social and historical study of 'race' and racism and raises attention to systemic power relations that arise from institutional, cultural and global productions of "race." It is important that students see how activism and social movements can challenge social inequality. It is my hope that students' will gain a deeper understanding that "race" is not real from a biological standpoint yet is socially constructed. I hope that students will take this new knowledge to help break down their own misconceptions as well encourage them to support social justice and become a part of the change.

As Sleeter and Zavala write in "What the Research Says About Ethnic Studies:" "An established body of research affirms: interdisciplinary ethnic studies, or the study of the social, political, economic and historical perspectives of our nation's diverse racial and ethnic groups, help foster cross-cultural understanding among

both students of color and white students and aids students in valuing their own cultural identity while appreciating the differences around them. These studies also confirm that students who participate in ethnic studies are more academically engaged, develop a stronger sense of self-efficacy and personal empowerment, perform better academically and graduate at higher rates."[3]

In my classroom, I found that student misconceptions surrounding 'race' were broad and needed attention in order to reaffirm what the studies proved. Recently I gave a brief survey to my students prior to beginning our unit on Human Body Systems to assess my students' understanding of the issues we planned to discuss. It asked questions including "What do you know about genetics?" "Is 'race' a real and accurate human trait?" "Is your IQ a predetermined trait?" "Is your ability to perform in sports a genetic trait?" "Are physical and behavioral traits between and within 'races' biologically determined?" "Does the environment in which someone grows up in, affect his or her trait development?"

This gave me a quick snapshot of what my students were thinking. I learned that all students believed 'race' to be a pre-determined biological trait. All students also believed all physical traits to be biologically predetermined but seventy percent felt behavioral traits were not. Forty-five percent of my students felt that environment did influence development while others argued that it did not affect actual traits and that traits were non alterable but the environment could affect behavior. About forty percent of students thought IQ and sports ability was in part linked to genetics, thirty percent were unsure and ten percent thought they were not genetically tied.

Students responded to the survey with a general thought that genetics is what you get passed to you from your parents and how we are a combination of their traits. I added an additional question at the end that invited students to list any questions that came to mind as they were taking the survey. Many added that they haven't really thought about these concepts before and simply accepted what they thought to be true, while others who were unsure about IQ or sports ability to be genetically linked asked how could we determine the answer to that. Other questions addressed how the environment could shape the traits you already have within you.

Based on these discussions, I developed this unit to foster critical thinking within my students and help facilitate a greater purpose of advocating change in the way they see and respond to the world around them.

Content Background

The following information is intended to aid the teacher as well as students in providing substance and purpose for the lesson plans.

'Race' Versus Ethnicity

Although sometimes used interchangeably, 'race' and ethnicity are not the same thing. They are typically misunderstood. 'Race' is narrowly thought of as rooted in similar physical or biological attributes while ethnicity is more broadly based on cultural expression and place of origin.

"'Race' and ethnicity have been and continue to be used as ways to describe human diversity," explains Nina Jablonski, an anthropologist and paleobiologist at The Pennsylvania State University, who is known for her

research into the evolution of human skin color. "'Race' is understood by most people as a mixture of physical, behavioral and cultural attributes. Ethnicity recognizes differences between people mostly on the basis of language and shared culture."[4] This is to say that ethnicity is referred to as something that is acquired while 'race' is perceived as biological, inherited. The way in which these terms are defined and loosely used, reveals many flaws that have had and continue to contribute to its social impact. "Both are social constructs used to categorize and characterize seemingly distinct populations."[5]

What is Ethnicity?

Ethnicity is defined as "large groups of people classed according to common racial, national, tribal, religious, linguistic, or cultural origin or background."[6] It is usually connected with identification and cultural expression. Ethnicity is a broader term to categorize groups of people in accordance with their cultural expression or identification by race, nationality, religion, language or origin. "In more recent colonial and immigrant history, the term ethnic falls under the dichotomy of 'Us' and 'Them.' The 'Us,' the majority, are viewed as non-ethnics and the 'Them,' new immigrants or minorities, as ethnic. Variations of the term have developed, including ethnic identity, ethnic origin, ethnocentrism, and ethnicism."[6]

Ethnic identity refers to an ancestral heritage and ethnocentrism is believing your culture or ancestry is superior to others, resulting in a dislike or hatred of any material, behavioral, or physical characteristics different than your own. Ethnicism is defined as a "movement of protest and resistance on behalf of [ethnics] against oppressive and exploitative outsiders"[6]

Ethnicity therefore, has been defined in numerous ways including 1. a common proper name, to identify and express the "essence" of the community; 2. a myth of common ancestry that includes the idea of common origin in time and place and that gives an ethnic sense of fictive kinship; 3. shared historical memories, or better, shared memories of a common past or pasts, including heroes, events, and their commemoration; 4. one or more elements of common culture, which need not be specified but normally include religion, customs, and language; 5. a link with a homeland, not necessarily its physical occupation, only by its symbolic attachment to the ancestral land, as with diaspora peoples; and 6. a sense of solidarity on the part of at least some sections of the ethnic's population.[6]

On a broader scale, ethnicity has been defined as a level of social stratification or inequality that includes 'race,' class kinship, age, estate, caste and gender. "Ethnicity is linked in a dichotic relationship with 'race.' It is differentiated from 'race' in that racial stratification is associated with birth-ascribed status based on physical and cultural characteristics defined by outside groups. Ethnicity is also ascribed at birth, but the ethnic group normally defines its cultural characteristics itself. Thus, racial categorizations, which are defined by the outsider, are normally laced with inaccuracies and stereotypes, while ethnic classification is normally more accurate of a cultural group because it is defined by the group itself. Yet, ethnic classifications can also be defined and used by outside groups to stereotype an ethnic community in ways that are often oversimplified and that view ethnicity as a static cultural process.

Ethnicity is differentiated from class in that "social class membership and ranking . . . is based on attributes regarded as extrinsic to the people who comprise the class. . . . such as amount of income, occupation, education, consumption patterns, and 'life-style.' Thus, an individual's class is not predetermined at birth; an individual's accomplishments during his or her life can help an individual to rise or fall in social status within the community."[11] Overall, ethnicity is a product of self and group identity, formed in extrinsic/intrinsic contexts and social interaction and it is not the same as culture. "Ethnicity is in part the symbolic

representations of an individual or a group that are produced, reproduced, and transformed over time."[6]

What is Race?

'Race' is usually associated with biology and physical characteristics. Genetic studies however have since refuted the idea that biogenetically distinct 'races' exist. Geneticists now argue that "Races are cultural interventions reflecting specific attitudes and beliefs that were imposed on different populations in the wake of western European conquests beginning in the 15th century."[7]

Anthropologists and philosophers described 'race' using phenotypic traits and geographical location. It is from here that arose the idea of different racial types as well as the notion that it was inherent in our genetics. The idea of race further evolved in the 17th century after European colonization during which the premise that human differences were associated with different populations brought together in the New World which later emerged as a mechanism of social division. This gave rise to the thought that some 'races' were superior to others. The term 'race' with reference to humans suggested a way to categorize people by their physical differences, often connected with their geographical location based on distinctive features such as skin color, hair texture facial features and eye formation. The term 'race' has also been applied to linguistic groups, religious groups, political, national and ethnic groups. "For much of the 20th century, scientists in the Western world attempted to identify, describe, and classify human 'races' and to document their relationships between them. Some scientists used the term race for subspecies, subdivisions of the human species which were presumed sufficiently different biologically that they might later evolve into a separate species."[7]

The exact number of so-called 'races' has never been agreed upon, ranging from 3 to 60 allegedly based on physical characteristics, therefore the term race does not have a precise or objective meaning. The National Human Genome Research Institute explains the term this way. "Race is a social construct used to group people. Race was constructed as a hierarchal human-grouping system, generating racial classifications to identify, distinguish and marginalize some groups across nations, regions and the world. Race divides human populations into groups often based on physical appearance, social factors and cultural backgrounds."[8]

Despite what some still may believe or think it is now argued that human physical variations do not fit in one model, and often they overlap. Genetic variation does not identify groups into race categories as DNA analysis has proven that all humans have more in common genetically than they have differences "Because of the overlapping of traits that bear no relationship to one another, such as skin color and hair texture, and the inability of scientists to cluster people into discrete racial packages, modern researchers have concluded that the concept of 'race' has no biological validity."[9]

'Race' is now understood as a social and cultural construct rather than a biological grouping. It is important to understand the differences outlined above because many of us associate these ideas when it comes to our own identity, who we say that we are versus how the world perceives us. Many people do not fit into such categories or they can identify with multiple racial and ethnic backgrounds.

Identity

Identity is defined as the distinguishing character or personality of an individual: individuality, the relation established by psychological identification or the condition of being the same with something described. "Who am I?" is a question nearly everyone asks themselves at one point. Am I who I say I am? Am I defined by the people who came before me, my family, the friends I keep, my situation, my decisions, past and present? Who

says I am who I am?

In the eb and flow of daily life, these thoughts can often filter through our mindset and can overwhelmingly shape our own social, moral and intellectual development. Our identity is complex, changing and often intersectional. “The Matrix of Social Identity and Intersectional Power, by Tolteka Cuauhtin, found in “Rethinking Ethnic Studies provides a powerful visual resource for classroom use that breaks down eight levels of social identity across twenty-nine intersections. It can be downloaded at https://www.fredhutch.org/en/about/education-outreach/science-education-partnership/sep-curriculum/race-racism-genetics.html. At the center is “Who are We?” and with it carries many identities we have as humans but then goes on to analyze the “related dynamics of power invisible.”[10] “Ethnic Studies programs work to understand and analyze intersectional identity, relationships, and dynamics of power in order to resist oppression and help actively change the world for the better.”[10] This is imperative as we live in a society that often uses particular labels often based on particular beliefs about ‘race’, ethnicity, religion, gender, sexual orientation and economic class to name a few, that can alter the way we see and appreciate ourselves and others.[11]

Although there are others, the big eight identities are defined as follows. Racial identity, identifies a group that is socially defined by physical criteria. It can both shape a person’s status or undermine it. Ethnic identity relates to a person or large group that share a common culture or language. Sexual orientation is defined as an emotional, romantic, sexual, spiritual or affectional attraction to another person or persons. Sexual orientation evolves over time and can change. It is not necessarily associated with gender identity and can be unrelated. Self-labels may include gay, lesbian, heterosexual, bisexual, pansexual, queer or straight to name a few. Gender identity describes how a person views themself as, but may not conform to their birth gender. Ability identity identifies individuals based on a person’s capacity to physically or mentally perform. Spiritual identity can be institutionalized or a person’s personal or system of beliefs in a higher power. Nationality identity is expressed by the person’s country of origin. Socioeconomic Identity refers to a person’s social status based on income and/or position in society.[12]

“Social identities are a result of shared constructions and social relations of the people who created it based on societal norms. Dominant and subordinated identities can affect an individual’s experience of privilege and oppression. A person’s identity is how the person defines who they are. While there are many identities that can describe a person there are some that are more salient than others.”[12]

According to Goodman and Graves, “Athletics, IQ and Health: Three Myths of Race,” the “Big 8” socially constructed identities are: race, ethnicity, sexual orientation, gender identity, ability, religion/spirituality, nationality and socioeconomic status.”[13] Many of these we are born into, but not all. Understanding who we are, as well as others will help us honor human dignity and set the tone for an inclusive society that recognizes the basic genetics from which we are formed, intertwined with the experiences and environment that which helps form us versus conceding to an inherent exclusive mindset whose history lies in the desire to create a dominate species, separated by ‘race’ and driven by misconceptions that health, IQ, sports ability and even poverty are inherently genetic.

Three such myths about ‘race,’ include but is not limited to the following: Myth 1, Africans and those of African descent are genetically predisposed to run faster and jump higher than Europeans and Asians. Myth 2, People of Asian descent achieve the highest levels of education in the United States because of higher IQs. Myth 3, African Americans are predisposed to certain complex disease primarily because of genetics.[13]

Myth 1, often we think of racial divisions on athleticism when we envision elite male athletes in sports. African American athletes make up about 75 percent of professional NBA players, which can lead people to assume that since they dominate the sport, they must have a biological or genetic basis. This hasn't always been the case. Irish Americans lead the sport in the 1930's. It wasn't until after WWII in the late 1940's that basketball began to emerge as a sport of choice in urban African American communities, mainly because it didn't require a lot of equipment or space. "Over time, as scholars of sport have shown, the myth of the "natural Black athlete" took hold of the U.S. imagination. African American youth facing limited economic and social opportunities gravitated toward professional sports such as basketball (and football) as a path to success. As sports journalist Reagan Griffin Jr. put it, "The fact of the matter is, Black athletes have collectively achieved what they have because society presented them with few other options. Today the composition of professional basketball is again changing following the increase in popularity of the sport in Eastern Europe and around the globe."[13] Other sports as well, confirm that 'race' is not associated with athleticism. Swimming and skiing use similar muscles as basketball, and Europeans and Australians tend to dominate these fields. "At the 2022 Winter Olympics, for instance, White athletes from Norway, which only has a population of around 5 million people, continued their now century-long dominance in skating and skiing."[13] Athleticism combines strength, coordination and other skills often influenced by 120 different genetic markers found across the globe in conjunction with a variety of environmental and cultural factors. Patterns of differences in elite competition relate more closely to economic, social and cultural factors not genetic ones.

Myth 2: The idea that certain populations or races are inherently more intelligent than others is not uncommonly heard. This is heard historically it was thought that the ancient Romans attributed greater intelligence of the British, Germans or French but then was argued the opposite in the 1600's when Sir Francis Bacon defended the Europeans. Today, many stereotypes exist such that the cognitive ability of certain racialized groups such as the groundless and harmful myth that "Asians are good at math."[13] Scientists have yet to provide evidence of natural selection for what constitutes as greater intelligence among various groups. "Modern genome-wide association studies—a standard method in genomics research—demonstrate that only a small fraction of the variation in cognitive performance across human populations can be explained by genes. Scientists have also not found any genetic variants associated with cognitive performance that vary dramatically across populations around the world."[13] Racialized differences lie more in educational attainment and structured inequalities, not by genetics. "Asian Americans, taken as a racialized group, do tend to test higher on standardized tests and are more likely to complete high school and attend elite colleges in comparison to White students.

However, there is no scientific evidence to show this group is naturally more intelligent; rather, studies show these students' success may be due to a complex mix of factors, including attending better schools, U.S. immigration policies that favor highly educated immigrants, and students exerting more academic effort."[13] Cognitive performance differences associated with early child development exist primarily due to environmental situations such as living in poorer communities with less access to quality education, poorer nutrition, psychological stress, and being exposed to toxic materials.

Myth 3: African Americans are more at risk for disease such as diabetes, congestive heart failure, various cancers and even Covid 19 infections. African American babies are also more likely to die in their first year and their mothers are two and a half times more likely to die during childbirth. Although scientists have attempted to find genetic differences among 'races' in an effort to explain these disparities in health, they have yet to be uncovered. "That line of reasoning begins with a false assumption: The idea that 'races' are genetically coherent groups, and therefore one 'race' will have a predominance of the gene that increases risk

of disease and others will not. Note that this faulty reasoning is also behind the myths of athletic and intellectual differences. All three of these myths are entirely unsupported by the data. In this gene-centric era, it is not surprising that biomedical researchers might seek out simple, genetic explanations for variations in risk of disease and death. Genetic differences among individuals can play a role, but risks of complex diseases are, well, complex. Until recently, researchers have largely ignored the far more significant social, environmental, and economic causes of racial disparities in health outcomes."[13]

Environmental conditions associated with increased rates of diabetes, cancers and other diseases contribute to this myth as it is apparent, but not genetic. "A Black woman, for instance, may carry in her body a lifelong history of stress caused by everyday exposure to racism—what public health expert Arline Geronimus has termed 'weathering' that makes her more susceptible to conditions such as hypertension. A black child from a poor family is more likely to grow up in a food desert and close to a source of pollution—environmental conditions associated with increased rates of diabetes, cancers, and other diseases."[13] How did these ideas become what so many believe as truths? It's often easier to accept things as truth when it has become such a part of the way society functions, as it just evolves into something that must be true as it is rooted in history and made evident in lives lead throughout history.

What does Science have to say?

Neither ethnicity nor 'race' is detected in the human genome. Although humans have genetic variations, they cannot be linked to distinct biological categories. 'Race' and ethnicity cannot be traced in a genetic test. "To understand why the idea of race is a biological myth requires a major paradigm shift - an absolutely paradigm shift, a shift in perspective. And for me, it's like seeing what it must have been like to understand that the world isn't flat. The world looks flat to our eyes. And perhaps I can invite you to a mountaintop or to a plain, and you can look out the window at the horizon, and see, "Oh, what I thought was flat I can see a curve in now." And that 'race' is not based on biology, but rather an idea that we ascribe to biology. That's quite shocking to a lot of individuals. When you look and you think you see 'race,' to be told that no, you don't see 'race,' you just think you see 'race,' you know, it's based on your cultural lens - that's extremely challenging."[14] Let's look beyond the cultural lens and explore the science behind it.

Heredity and DNA

The passing on of physical or mental characteristics from one generation to another is known as heredity. It explains why offspring may resemble, but are not identical to their parents. Heredity refers to the mechanisms that the traits are passed via genes. The genes are what encode the information for making specific proteins responsible for the individual traits. The genes are made up of several variants known as alleles and reside in a cell's chromosome, each which contains many genes. Every cell of an individual organism contains an identical set of chromosomes that transfers to the offspring during reproduction. For species that reproduce sexually, each cell contains two variants of each chromosome, one from each parent. Environmental as well as genetic variation and the dominance of the gene in a pair also contribute to how the traits develop within an individual.[15]

When living things produce offspring they pass traits to them, known as inherited trats. This passing of traits known as heredity, and the field of biology that studies it is known as genetics. Is this why may have similar characteristics as our parents? Why are some of our physical traits and behaviors a bit different between them and our siblings? Why are some siblings similar in appearance or behavior and others different? How do our genes determine our features and physical characteristics? Can our genes also predict our health or the

probability that we will get a disease? The key to answering these questions, lies in our deoxyribonucleic acid or DNA. DNA molecules contain the coded instructions for how an organism develops and functions. These instructions are stored in chromosomes, which are then replicated throughout the cells of the body.

According to Amy Cowen's 'Teach Hereditary and Genetics with Hands-On Lessons,' Almost all cells in an organism contain a copy of the organism's DNA. An organism's DNA is specific to the genome of the species but also unique in many ways to the individual. Offspring will have DNA that contains specific features from the DNA of both parents. The traits an offspring presents depend upon the recessive and dominant genes from the parent DNA.[16] The model, discovered by James Watson and Francis Crick, showed that DNA looks like a twisted ladder with thousands of steps that form a genetic code. The code determines the kind of gene that is formed and the different genes determine the kinds of inherited traits an organism receives. A gene controls the inherited traits, each located in a different part of the chromosome. Genes control the life processes of your cells and determine eye color, hair color and many other characteristics.[16]

Genes and Genetics

Genetics is the study of heredity, particularly genes, including the ways in which they act in the cell and the way that they are transmitted from parents to offspring. The focus of modern genetics is the chemical substance that genes are made of and the ways in which it affects the chemical reactions that ignite the living processes within the cell. Information carried in genes gets passed from one generation to the next. This study stems from the work of Gregor Mendel in the 19th Century who suspected traits were inherited. Inheritance can be described by the process by which a child receives genetic information from the parents, making the offspring similar to that of the parent. Mendel's laws of inheritance were developed as a result of a series of hybridization experiments on garden peas between 1856- 1863. By conducting cross pollination and artificial pollination with peas, Mendel modeled trait inheritance. From these experiments, Mendel found that certain factors were always transferred to offspring in a stable way. These factors were later called genes and are referred to as the units of inheritance. The two main experiments, Monohybrid Cross and Dihybrid Cross, led to the formulation of Mendel's Laws of Inheritance, namely The Law of Dominance, The Law of Segregation and the Law of Independent Assortment. The Law of Dominance is the first of Mendel's laws of inheritance that states hybrid offspring will only inherit the dominant trait in the phenotype. The second law of inheritance, the Law of Independent Assortment, says that a pair of trait segregates independently from another during gamete formation which allows for different traits to get equal opportunity to occur together. The third law, the Law of Segregation states that during the production of gametes, two copies of each hereditary factor segregate so that the offspring will acquire one factor from each parent.

Although information carried in genes are transmitted from parent to offspring, they are not set in stone. Genes are affected also by environment in terms of how they develop. "Science tells us that the interactions between genes and environment shape human development. Despite the misconception, research shows that early experiences can determine how genes are turned on and off — and even whether some are expressed at all. The healthy development of all organs, including the brain, depends on how much and when certain genes are activated to do certain tasks."[17] However, because environment and experiences play a role in which genes develop, we often see variations.

Environment and Gene Development

Interactions between genes and the environment shape human development and can determine how some genes are turned on, off or even expressed at all. Healthy development depends on how much and when

certain genes are activated to do certain tasks. Ensuring that there are enough growth promoting early experiences at a young age plays a crucial role in development. The chromosomes located in the nucleus of every cell in our body contains the genetic codes that are passed through each generation. Children inherit about 23,000 genes from their parents but not all develop into what they were designed to do. "Experiences leave a chemical "signature" on genes that determines whether and how the genes are expressed. Collectively, those signatures are called the epigenome."[17] During early development, the brain is particularly responsive, and external experiences spark signals between neurons whose response is to produce gene regulatory proteins. Both positive and negative experiences can change the chemistry that encodes genes in brain cells known as epigenetic modification. Such experiences include exposure to or lack of rich learning opportunities, malnutrition or environmental toxins. Epigenetic modification occurs in cells that comprise the organ systems and influences how they develop and function which can powerfully impact physical and mental health.[17]

In fact, most common diseases are a result of genes and the environment which includes our personal choices in terms of what we eat, amount of exercise, access to clean water and air as well as stress. A very small number of diseases are a result of a single mutation in a gene.[18] Most times, genes do not determine our health. Small differences in genetic makeup mean that two people can respond differently to similar environmental exposure. Genes and the environment interact through mutagens, gene-gene interactions, transcription factors and Epigenetics. Mutagens are pollutants in the environment that can directly change the DNA sequence. Gene-gene interactions occur when pollutants from the environment that doesn't alter the DNA sequence but instead causes a chain reaction of the functioning of one gene to another gene. Transcription factors are when pollutants from the environment indirectly affects the DNA sequences by altering transcription factors that are responsible for initiating the process to use genes to make proteins needed for other functions of the body. An example of this includes how stress can alter the immune system. Through epigenetics, the proteins that turn genes on or off are altered by the environment. "Epigenetic factors can switch genes on or off and determine what proteins are transcribed. They are involved in many normal cellular processes and epigenetic changes are a natural part of human development. Some changes, however, can lead to disease. Some of these abnormal changes can lead to diseases such as cancer, mental retardation, neurodevelopmental disorders, cardiovascular diseases, type-2 diabetes,obesity and infertility."[18]

The impact that environment and experiences play on the development of genes may contribute to the social construct of "race" when people were categorized partly in accordance to where they lived versus examining the actual genetic make-up and the outside contributing factors that can positively or negatively impact that development. Biologically there is little difference in people genetically at the start. "No two human individuals are genetically identical unless they are monozygotic (identical) twins. Between any two people DNA differs on average, at about one in one thousand nucleotide base pairs. We each have a total of about three billion base pairs, so any two people differ by an average of about three million base pairs. This may sound like a lot, but its only .1%of our total genetic makeup. This means that two people chosen at random are likely to be 99.9 percent identical genetically no matter where in the world they came from."[19]

Human variation however around this world is real. We see it in outward physical appearances from eye color to skin color to shoe size. Human variation though, does not equate to racial difference. "In the 1970s, Richard Lewontin found that the amount of genetic variation within any human 'race' is greater than the variation among races. Interestingly, because our species spent so much of its time in Africa, that's where the most genetic variation is to be found today. Researchers have shown the variation between two Africans is on average greater than the variation between an African and a European or Asian person. There are no

subgroups within Homo sapiens that have been reproductively isolated long enough to develop anything close to separate races. The concept of 'race' fails to describe human variations or explain how variations evolved. On the other hand, socially defined races do exist: Humans invented them! The variations between members of our species only take on deeper cultural and political significance when humans in power start dividing and ranking individuals based upon them."[20]

Classroom Activities

The following activities were chosen as a guide for teachers to present 'race' and human variation through a historical, cultural and biological lens. It begins with knowing yourself before you can know others in Activity 1- Uncovering Your Roots. This activity is designed for teachers alike in that we cannot adequately help others understand themselves if we don't truly understand ourselves. Its' focus is on the understanding the story of our ancestry and the process of the migration and settlement of those that came before us, more so than the exact detail of the family tree. Not all students will be able to trace their ancestry in great detail and it can be difficult. It is important to share with students that it is a learning activity to help them better be able to understand their own identity through their history and that their family stories will help guide them. Activity 2, Identity, Who You Are Matters, continues with this idea, in that connects their ancestry with their own identity and how history has played a part in it. Students will delve deeper into the complexity and intersectionality of identity. They will then learn about the role of "race" as a vital part of social identity before seeing it as a social and political construct in activities 3 and 4. Activity 3, Racism, A Social Construct, unpacks 'race' as a socio-political construct and not biologically meaningful. This is followed by our scientific understanding that the biological basis of human genetic variation proves that there are no biological features that are present in one 'race' group but not in others in Activity 4: Race is Not Biological. Activity 5, 'Races' and Phenotypes continues to drive the notion home in that students understand that 'race' is not a genetically meaningful way to group people.

Activity 1- Uncovering Your Roots (This lesson was adapted from http://www.pbs.org/latino-americans/media/docs/classroom/en-lesson-plan-roots-of-my-family-tree.pdf)

Overview: In this activity, students reflect on their own family's arrival to the United States by filling in a family tree with as many generations as possible. Students research and fill in as much information as possible on the names and birthplaces of themselves, their parents, grandparents and so on. Next, they plot the names and birthplaces on a World Map. More important than establishing the exact detail of their family tree is the process of understanding the migration/settlement story of those that came before them. Students complete reflective questions.

Objectives: • Conduct personal historical/genealogical research • Plot birthplaces of ancestors on a map • Construct and identify their own "narratives of arrival" to the United States

Materials: • Handout: Family Tree Organizer and Reflection Questions • Handout: World Map • Atlas or online maps • Web access

Procedure: • Assign students to investigate their family trees as homework by asking elders or using other genealogy resources, public records, etc. Upon completing family research: As prompted in the Family Tree

Organizer and Reflection Questions handout, students write down as much information as they can with regard to the names and birthplaces of their families: themselves, their parents, grandparents, etc. The goal is not to create a complete record of all family members; rather, it is to get a sense of the migration/settlement story behind each student below. • Next, they plot out the birthplace locations on the World Map. Or, if there is greater computer access, consider having the students complete the map work digitally using PowerPoint or Google Earth. • To conclude, have students complete the reflection questions in writing or discussion format, individually or in small groups. • Mount a large world map in the classroom, where the whole class can document their family trees and see how it intersects with their classmates.

Handout: Create a table entitled, Family Tree Organizer and write down as much information as you can about yourself and previous generations of your family. In the table, list the person, i.e., you, mother, father, maternal and paternal grandparents, maternal and paternal great grandparents and others. List their name, birth city/town, country and "story."

Fill in what you can, even if you don't have a complete name or exact location. Use the World Map to plot the birthplaces of various people in your family. Make a dot for each person using the following colors: RED = you, BLUE = parents, GREEN = grandparents, ORANGE = great grandparents, PURPLE = great-great grandparents and beyond.

What is one new thing you learned about your family history? • What was unexpected or surprising as you traced the family story and plotted it on a map? • Do you have a clear understanding of when your family arrived to the United States? If so, explain your family's story of arrival. If not, list some of the questions you would ask to get a detailed understanding of your family's story of arrival.[21]

Activity 2: Identity: Who you are Matters (This lesson was adapted from https://www.fredhutch.org/en/about/education-outreach/science-education-partnership/sep-curriculum/race-racism-genetics.html)

Overview: This lesson is intended to address questions like, Who am I? and What is race? Students will explore concepts associated with identity, such that identity has personal, social, and cultural dimensions. It is complex, multi-faceted, and may change over time and with different contexts. Students will also explore the ways in which their family narratives learned from lesson one is woven into their individual identity.

Objective: • Students will understand that identity is complex, changing, and intersectional. • Students' identities are important and should be valued and celebrated. • Students discuss aspects of their avowed/ascribed identities with one another and share how these identities influence their experiences as students. • Students create "identity artifacts" that share important aspects of their identity.

Materials: • Cardstock (white, can cut in half if necessary) • Colored pencils/pens • Glue/tape • Rulers • Instant (polaroid) camera with film or student photos of themselves

Vocabulary: • Avowed identity - Aspects of your identity that you claim or hold for yourself, how you self-identify • Ascribed identity - Aspects of your identity that other assign to you based on assumptions about you • Identity - A complex and fluid concept encompasses the memories, experiences, relationships, and values that create one's sense of self • Intersectionality - A theory that examines how systems of power might impact individuals who are marginalized because of their socio-political identities, and how different types of discrimination combine to influence the experience of oppression.

Procedure Do Now: On a post-it have each student respond to the question, “What is identity?” • Share one definition of identity: The collective aspect of the set of characteristics by which a thing or person is definitively recognized or known. The set of behavioral or personal characteristics by which an individual is recognizable a member of a group. • Distribute the personal identity wheel handout downloaded at: https://sites.lsa.umich.edu/inclusive-teaching/social-identity-wheel/ a. Give students 5-10 minutes to fill it out. • In pairs or small groups, have students share their personal identity wheels. Ask students to brainstorm and share what kinds of factors make up one’s identity. Personal (Ex: Are you a worrier? Are you very curious? What kinds of sports/foods/hobbies interest you?) • Social (Ex: Do you belong to a club or group? Do you have a certain type of job?) Cultural (Ex: Do you identify with a particular race/culture/ethnicity? Religion?) • Identities can also be thought of in terms of social markers of ethnicity, race, religion, socio-economic class, ability and gender. Some aspects of identity may shift over time and in different contexts. • Share the identities are also Intersectional: Identities should be considered holistically; there are many factors that can combine to impact identity. Distinguish between Avowed and Ascribed Identity. • Pair up. Sit facing each other. One person starts: How do I self-identify? (avowed) How do others tend to see me? (ascribed) How have these identities impacted my experience of school, science, and/or science classes? What was one experience where I really felt “seen” or “understood” for who I am? The other person just listens - no questions/talking. • Switch after the first person is done or when you hear the signal to switch. At the end, there will be a few minutes for open discussion with your partner. • Ask them to only share specific experiences about themselves unless their partner has explicitly okayed it to talk about them. • Students then use the identity wheel to create artifacts celebrating parts of their identity that they want to highlight. Identity Artifact Guidelines - Include your full name in a visible place on the front. You can include a photo but that is optional. Decorate the paper with words and pictures that represent aspects of your identity. Think about things that really make you who you are. • Create a circle and allow students to talk through parts of their artifact/share their finished product with others. “What part of your identity are you most proud of and why?”

Closure: As a class, discuss, “How has your identity influenced how you have experienced science classes?” [22] It is important to discuss how “race” impacts identity and how the idea of “race” came to be in order to understand what “race” is and what it is not. It is important to acknowledge that it is very real as a social and political idea and that racism is real, therefore impacting science and our lived experiences. This activity will then set the stage for the following lessons.

Handout

Identity factor	Instilled by larger community (religious affiliation, ethnicity, national identity, etc.)	Instilled by family and family heritage	Genetically inherited	Adopted from other individuals	Self-Instilled	Other (explain)

Activity 3- Racism – A Social Construct (This lesson was adapted from https://www.fredhutch.org/en/about/education-outreach/science-education-partnership/sep-curriculum/race-racism-genetics.html)

Overview: In this lesson students will understand that race is a socio-political construct and not biologically meaningful. However, that doesn’t mean it’s not an important aspect of someone’s identity, the way others perceive them, or the way they experience life. Students will learn that there are different levels of racism; structural/systemic, personally-mediated, and internalized. This lesson will show students cognitive shortcuts arise because of their evolutionary survival value, but they are also influenced by cultural messages shaped by history and structural racism and that those natural processes lead to bias if they are paired with messages

from the dominant culture that reinforce stereotypes.

Objectives: • Create their initial definitions of race, racism, and bias • Watch a video to learn about levels of racism • Discuss the biological origin of “automatic” thinking responses and how biases build off of that system by building off of cultural messages.

Materials: • Video found here- www.youtube.com/watch?v=GNhcY6fTyBM • Student Worksheets 1 and 2

Student Worksheet 1 - “Three Levels of Racism” Table

Fill out the first 2 columns when Dr. Jones gives the definitions/examples in the beginning. Come back and fill out the last column after she tells her story.

	Dr. Jones’ Definition	Example	Analogy in the Tale (described in terms of flower colors, soil, pots, etc.)
Institutional Racism			
Personally Mediated Racism			
Internalized Racism			

Student Worksheet 2 - First Flower Story: Institutional Racism

Initial conditions: Below, label the boxes to show different types of soil (one rocky / poor soil and one potting soil / good, rich soil). It doesn’t matter which one you label which, but keep them the same throughout the sheet. YOU (The ‘gardener’) prefer RED over PINK flowers. Where are you going to plant seeds for the red flowers? The pink ones? Label the seeds planted for each box.

	Box 1	Box 2
Soil		
Seeds Planted (red or pink)		

Reflection Questions: 1) After 10 generations, what might the plants in each look like? Draw some flowers into the box. 2) In this story, how does the gardener react when they see what has happened to the red flowers and the pink flowers after 10 generations? 3)What kind of racism is this situation a model for? 4) What represents the “historical insult”? 5)What represents the “structural factors?” 6) What represents the “perpetuation of the inequity” (the inequity continuing)?

Second Flower Story: Personally-Mediated Racism - Draw your plants as above

	Box 1	Box 2
Soil		
Seeds Planted (red or pink)		

The gardener now plucks off the petals of the pink flowers, and plucks off any pink flowers that are growing in the good soil. Draw the red flowers as healthy and pink flowers after they have been damaged by the gardener.

Third Flower Story: Internalized Racism Reflection Questions: 1) In the third story, what are some of the “red

flowers" thinking? 2)What are some of the "pink flowers" thinking? 3) If a bee tries to bring the pink flower pollen from another pink flower, how does the pink flower react? How does this story illustrate internalized racism? 4) Why is just saying "power to the pink" or having a workshop to help the gardener stop plucking the pink flowers not enough? What does Dr. Jones think needs to happen? 5)Who do you think is the "gardener" in the allegory?

Procedure: • Levels of Racism - the Gardener's Tale- Show the Gardener's Tale Allegory by Camara Jones. Allow students to revise their definitions - again in their own words. • Debrief with students after the video. Ask students the following questions related to the video: What are the three levels of racism that Dr. Jones describes? How does Dr. Jones respond to those who say that social class, rather than race, is it more important in determining differences in housing, education, wealth, etc.? What does Dr. Jones believe we have to do if we want to set things right in the garden? Ask students to write definitions of race, racism, and bias.

Crowdsource initial definitions from students. Ask students, "What do you see in common with these definitions"? Students should note that race is socio-political in nature and not defined by biology. Students should also note that racism involves not only prejudice, but systems of power/oppression. • Explain that next, students will focus some of the science related to human bias towards others and also the connections between bias and structural racism. Students will consider how biases are created and reinforced by systems of power/oppression. Gather student definitions of bias and share this one: Bias is a prejudice in favor of or against one thing, person, or group compared with another (usually in a way that's considered to be unfair). Biases may be held by an individual, group, or institution and can have negative or positive consequences. There are several types of biases: Conscious bias (also known as explicit bias) Unconscious bias (also known as implicit bias.) Implicit Bias is the process of associating stereotypes or attitudes towards categories of people without conscious awareness. Everyone holds unconscious beliefs about various social and identity groups, and these biases stem from one's tendency to organize social worlds by categorizing. • Why are we all biased? Share the following with students: Bias is how our minds streamline thinking so we can quickly make sense of the world. Our brains are biologically designed to perform these quick judgments unconsciously.

Share the iceberg analogy: Our brain is like an iceberg with the conscious part of our brain being the smaller part of the iceberg that we can see above the water line, while the larger part of the iceberg, where our unconscious processing takes place, is below the water line. Research shows that the unconscious mind absorbs millions of bits of sensory information through the nervous system per second. Our conscious minds are processing only a small fraction of this information and doing so much more slowly and less efficiently than our unconscious minds. This means that we have a lot going on in our brains that we are not consciously aware of. • Often assumptions lead to bias. Ask students if people have ever made assumptions about them based on the way they look (race, gender, height, etc.) Associations that people make lead them to making assumptions.

Closure: Racial implicit bias rises out of, and reinforces structural racism. Our implicit biases are learned from our social and cultural world and build on a system that developed in our history.

We aren't "off the hook" for our biases just because they have been internalized. We have to take responsibility for reflecting on our own thoughts/behaviors and also for working to disrupt the cycle of connection that keeps racism alive. Why do these ideas matter? How does your understanding connect to personal, community, or societal interests?[22]

Activity 4- Race is Not Biological (This lesson is adapted from teach.genetics.utah.edu/content/heredity/files/An%20Inventory%20of%20My%20Traits_student.pdf)

Overview: What is race? Is it a social construct-- an idea created by the minds of our society? Does it have a genetic basis? Many people in our society believe that people are divided into separate, *biologically distinct* groups called "races," distinguished by phenotypes such as skin color, facial features, hair color, and hair texture. Some individuals even assume that variation in these physical traits correlates with other innate differences, including intelligence, athletic aptitude, and criminal tendencies. Human beings vary in their physical appearance and genetic composition. Traits like skin color, eye shape and hair texture are influenced by genes we inherit from our parents. But do these patterns of human variation map onto "races"? Why do we classify races the way we do, using some traits, such as skin color, while ignoring others? Is it logically reasonable to say that members of one race/ethnicity are genetically more similar to each other than to members of another race? In this exploration of race/ethnicity and genetics, we will seek to answer these questions.

Objectives: • Race is not a genetically meaningful way to group people • Humans are more alike than they are different. • There is no “race gene” that can distinguish one “race” group from another. • There is more genetic variation within a “race” group than across groups.

Materials: • Handouts embedded within lesson plan • Access to internet

Procedure: Do you think that we are genetically more similar to someone of the same race/ethnicity compared to someone with a different race/ethnicity? Why/Why not In this activity, you will use your inventory of traits handout and compare some of the same traits with 5 members of your race, and 5 members of a different race. Record data. • The inventory of my traits survey can be found at teachgenetics.utah.edu or you can create a table that serves as a yes or no checklist that answers the following statements: I have detached earlobes, I can roll my tongue, I have dimples, I am right-handed, I have freckles, I have naturally curly hair, I have a cleft chin, I cross my left thumb over my right when I clasp my hands together, I can see the colors red and green, I have allergies, The hairline on my forehead is straight. •Then, Calculate Percent Difference between the number of traits shared in the same race vs a different race. Use your race as the control, and the other races as an experimental. • Finally, create a table in which you list the inventory of traits, and record whether or not the same race shares the trait or not and whether or not a different race shares that trait or not.

Closure: •Create a bar graph of the totals for each category (so 4 bars total). • Was your hypothesis supported or not? Explain by citing your data your percent difference and 2 other pieces of data. •Come up with a plausible explanation for the results you got in activity 1. •Make sure you use appropriate terminology.

Activity 5 –Sorting people into races based on phenotype (This lesson is adapted from https://teach.genetics.utah.edu/content/heredity/files/An%20Inventory%20of%20My%20Traits_student.pdf)

Overview: Will you be able to identify a person’s race/ethnicity by just looking at their phenotype (physical characteristics like skin color, eye color, hair color, etc...)? Why or why not?

Objectives: • Race is not a genetically meaningful way to group people. •Humans are more alike than they are different. •There is no “race gene” that can distinguish one “race” group from another. • There is more genetic variation within a “race” group than across groups.

Materials: • Tables created within lesson plan • Access to internet

Procedure: In this this interactive activity, you will "sort" 20 people (images provided) into five federally recognized racial categories. You may click on the images to zoom. In the data table below, record the number of images you matched correctly/incorrectly. •Go to- pbs.org/race •Click on “Learn More •Click on “Sorting people” and then “Begin Sorting.” • In a table list the race images as noted, Asian, Black, Hispanic/Latino, White or American Indian as well as the correct number out of 4 that you received. • Finally, calculate your percentage correct by dividing your total correct by 20. Calculate your percentage correct by dividing your total correct by 20 Once you’ve completed the table, find one member of each “Government Race” who identifies as something else. List what they identify below.

Closure: • List at least 1 observation you made during this portion that surprised or interested you. •Create a bar graph for each table. •Come up with a plausible explanation to explain the results •Describe the relationship between phenotype and race. Can phenotype be used to identify and distinguish races?[23]

Appendix on Implementing District Standards

This unit is intended to follow the core disciplinary ideas, cross-cutting concepts and science and engineering practices as outlined through Next Generation Science Standards. The students will cycle through a series of lessons and investigations that will take them on a cross curricular journey to better enable them to understand the world around them and their place in it. Grade six students will demonstrate their understanding of basic genetics by constructing an explanation based on evidence that describes how genetic variations of traits in a population and gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits. Students will also apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. Key CT standards in Social Studies will also be addressed, allowing students to evaluate how individuals, groups, and institutions in the United States have both promoted and hindered people’s struggle for freedom, equality, and social justice, explain why individuals and groups during the same historical period differed in their perspectives, understand how culture influences the way people modify and adapt to their environments and analyze the roles and relationships of diverse groups of people contributing to the United States and early New Haven's cultural heritage.

NGSS Middle School standards for Life Sciences.

MS- LS4 - 5-Biological Evolution: Unity and Diversity states that students who demonstrate an understanding can construct an explanation based on evidence that describes how genetic variations of traits in a population and gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits.

MS-LS4-2-Biological Evolution: Unity and Diversity states that students will apply scientific ideas to construct

an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships." The performance expectations for Growth, Development and Reproduction of Organisms as well as for Natural Selection and Adaptations allows students to formulate answers to questions like, "How genetic factors determine the growth of an organism and how genetic variation among these organisms affect their growth and development?

Resources for Teachers and Students

https://www.fredhutch.org

https://www.pbs.org

www.sciencebuddies.com

teachgenetics.utah.edu

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