Personal Genetics Education Project

Ethical, Legal and Social Issues in Personal Genetics

Title: Genes, environment and genetic complexity: Aggression in humans

Aim: How do genetic factors impact complex human behaviors such as aggression?

Time: This lesson can be adjusted to fill 1 or 2 classes.

Guiding Questions:

- What are the key scientific concepts to understand when talking about the genetic basis of aggression?
- What roles do genes, or combinations of genes, play in how we behave?
- What are the personal and societal questions as we look to understand the genetic basis of complex behaviors?

Learning Objectives:

By the end of the lesson, students will be able to:

- Define genetic complexity.
- Discuss the benefits and concerns of seeking an understanding of the genetic underpinnings of behavior.
- Analyze the ethical dilemmas regarding how information about genes and aggression might be used in society and for individuals.

Materials: Projector or Smartboard, laptop, paper and pens.

Common Core Standards:

CCSS.ELA-Literacy.RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

CCSS.ELA-Literacy.RST.9-10.2 Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

CCSS.ELA-Literacy.RST.9-10.6 Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.

CCSS.ELA-Literacy.RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

CCSS.ELA-Literacy.RST.9-10.9 Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Background information and note to teachers:
Questions about whether genetics can, in part, explain violent, aggressive behavior in humans are not new. Recent episodes of large-scale violence, whether in schools or other public places, have renewed discussion about the intersection of crime, mental health and genetics. Where do the scientific and ethical debates stand on this issue in 2015?

Genetic analysis is becoming a much larger part of healthcare and having a great impact on varied aspects of society. New techniques are allowing us to better understand the connections between genes and human health, improve medical care, and help extend people's lives. The cost of the technology that made the Human Genome Project possible is plummeting, and genetic analysis is increasingly available to a broader population. In 2015, companies continue to compete to bring the cost of sequencing a human genome to $1,000 (US).

While it is likely that there are many useful or interesting things a person might learn from a personal genome sequence, the path to truly understanding the utility and limits of this information will be a lengthy and sometimes confusing one. This is particularly true when it comes to seeking genetic explanations not just for complex human disease and traits, but also behaviors that must be understood in the context of environment, culture and society.

Media coverage of recent episodes of extreme violence in the United States and elsewhere is also bringing a renewed focus on how genetics might impact criminal behaviors. For example, following the killings in Newtown, Connecticut, the state medical examiner's office asked for an analysis of the DNA of the gunman, Adam Lanza. This was covered by a number of news sources, including the *New York Times* that featured an article entitled "Seeking Answers in Genome of Gunman." Headlines such as this raise the question: "Why study his DNA?"

In this lesson, students are asked to examine popular but incorrect ideas related to the idea that a single gene or even set of genes can "cause"

human to behave aggressively. Because of the complicated nature of this topic, we have included additional resources to help students understand the scientific and ethical questions and assist teachers in framing an informed discussion in the classroom about genetic complexity and the many factors that influence human behavior. These resources include articles that we recommend teachers read in advance of the lesson and a handout on key concepts that will be addressed.

Here is an outline of the resources and activities in this lesson.

1. Key concepts (pages 3-4, student handout on pages 11-12)
2. Recommended reading for teachers (page 5)
3. Reading for students (page 6)
4. Video clip (page 6)
5. Classroom discussion (pages 6-9)
6. Homework assignment (page 9, handout on page 13)
7. List of additional resources (pages 9-10)
8. Short quiz (answer key on page 10, handout on page 14)

After teaching this lesson, we would appreciate your feedback via this quick survey, as well as your student's feedback via this brief survey.

Key Concepts:

Aggression: "Most social psychologists define human aggression as any behavior intended to harm another person who does not want to be harmed (Baron & Richardson, 1994; Bushman & Huesmann, 2010)." It is important to understand aggression not as a feeling or an emotion, but as an action. Another key concept is that a person taking aggressive action is doing so intentionally, with the goal of harming a victim.

This description is adapted from DeWall C.N., Anderson C.A., and Bushman B.J. (2012). Aggression. Chapter in I. Weiner (Ed.), *Handbook of Psychology, 2nd Edition*, Volume 5, 449-466. H. Tennen & J. Suls (Eds.), *Personality and Social Psychology.* New York: Wiley.

Genetic complexity: In general, there is not a simple relationship between our genes and our traits. Our physical, mental and behavioral states are the result of complex interactions between multiple genes in combination with our environment and our lifestyles. For example, height is influenced by the action of at least 180 regions in one's genome in addition to environmental factors, including diet as well as maternal and childhood health. Coming back to the example of aggression in this lesson, it is important to think about the complexity of human behavior, which is impacted by an intricate

network of genes in combination with the environment and social experiences.

To read more about research exploring the genetic basis of height, see:

- "Complex Genetic Trait Research Reaches New Heights," by Karen Hopkin, September 2010, *Scientific American*.
- "Scientists stack up new genes for height," September 2010, *University of North Carolina School of Medicine News*.

Biological determinism: This is a framework for understanding humans through a biological lens and aims to explain complex human traits as being largely, if not entirely, dictated by biology, particularly our genes. This theory downgrades, if not dismisses, the role that culture and environment might have in shaping human behaviors. There has been much criticism of this theory, and many scientists are now focusing also on interactions between genes and environment and how that relationship may impact traits and behaviors.

Population genetics: Genetics research seeks to make connections between people's genetic make-up and their traits. Often, the relationship is not a simple one, but rather a statistical correlation based on what percentage of people in the population with a shared genetic make-up exhibit a particular trait. Your DNA sequence can inform you about your predisposition for certain traits, such your likelihood for reaching a certain height or your risk for developing a disease. It is important to note, however, that predispositions are not guarantees.

For example, people who carry certain genetic variants are at increased risk for developing heart disease or type 2 diabetes, and knowing this information can be beneficial for making lifestyle choices about diet and exercise as well as healthcare decisions. However, some people who learn they have these markers for elevated risk will not develop the associated conditions. Conversely, a person who is free of these variants still has the possibility of developing heart disease or type 2 diabetes.

The same principle can be applied to the genetic underpinnings of aggression. In fact, to date, there is no genetic variant that has been perfectly correlated with aggressive behavior. Even for variants that some researchers have correlated with aggressive behavior, there is much controversy. It is important to note that correlations are statistical descriptions of populations consisting of many people and, therefore, cannot be used to determine whether or not a given individual will exhibit aggressive behavior.

Recommended Reading for Teachers:
We recommend that teachers read this set of 4 articles in advance as preparation to answer questions likely to arise during this lesson.

1. "Seeking Answers in Genome of Gunman," by Gina Kolata, December 2012, *New York Times*.
   This article examines the debate surrounding the Connecticut state medical examiner's request to analyze Adam Lanza's DNA. Of particular interest are the arguments that looking at a single individual is unlikely to yield an explanation for these crimes and that larger sample sizes are needed to draw scientifically valid conclusions.

2. "The Science of Success," by David Dobbs, December 2009, *Atlantic Monthly*.
   This article offers a framework for analyzing how we think about nature and nurture, arguing that neither genes nor the environment alone determine one's destiny. Highlighting the work of many scientists, science writer Dobbs presents a complex view, known as the "Orchid Hypothesis," centered on the idea that genes and environment interact in ways that are dynamic and often cannot be teased apart. The essence of the "Orchid Hypothesis" is captured in the following quote from the article:

   > "Most of us have genes that make us as hardy as dandelions: able to take root and survive almost anywhere. A few of us, however, are more like the orchid: fragile and fickle, but capable of blooming spectacularly if given greenhouse care. So holds a provocative new theory of genetics, which asserts that the very genes that give us the most trouble as a species, causing behaviors that are self-destructive and antisocial, also underlie humankind's phenomenal adaptability and evolutionary success."

3. "Could Genetics Help Us Understand Mass Killers?" by Nathaniel Comfort, January 2013, *Hartford Courant*.
   In this op-ed, historian Nathaniel Comfort critiques the idea that a "gene for violence" exists. He asks why this idea can be alluring and looks ahead to possible public policy questions.

4. "Brain Injury rate 7 times greater among U.S. prisoners," by Katherine Harmon, February 2012, *Scientific American*.
   Brain injuries are not heritable. However, are there genes that might elevate a person's risk of sustaining a brain injury and/or experiencing

particularly severe effects from a head injury? Possibly, but this article highlights biological factors that are not necessarily genetic, yet might still impact impulse control, addiction and aggression.

Reading for students:
In advance of the classroom activities, have students read the Key Concepts handout (on pages 11-12) as well as the December 2012 *New York Times* article, "Seeking Answers in Genome of Gunman," by Gina Kolata.

Activities: Video clip (15 minutes), class discussion (20 minutes).

Part 1: Video clip of NOVA's "Can Science Stop Crime?" (15 minutes)

Students will watch a PBS video clip from the October 2012 NOVA special "Can Science Stop Crime?" The link to the 15-minute clip is below: http://www.pbs.org/wgbh/nova/tech/can-science-stop-crime.html.

The second "chapter" of the program, from ~1:38 to 17:00, looks at questions about genes, brain activity and structure, neurotransmitters (molecules that neurons use to communicate), and the complex ways genes and environment interact. The overall theme suggests that, while there is growing evidence that genes play a role in aggression and impulse control, environmental factors that impact gene function add a significant layer of complexity. Family, culture, childhood experiences and socioeconomic status are central to understanding human behavior, and scientists may be on their way to quantifying how some of these factors impact our biology.

Part 2: Classroom discussion and student responses (20 minutes)

Below, we have two broad questions to encourage discussion. Along with each question, we have included information that is intended to help teachers guide the conversation with students.

Break students into small groups to explore Questions 1 and 2. These questions can be read aloud or shown on PowerPoint slides, located on the pgEd website along with this lesson. Have students work in groups for 10 minutes to consider and share their responses, and then allow for another 10 minutes for discussion with the whole class.

Question 1: A suspect, standing before a judge, is on trial for a violent assault. The judge has information on the suspect's genetic make-up, stating that the suspect has genetic variants associated with increased risk for violent behaviors. How dependable is this information? Should the judge

take this information into consideration? Do you think judges might be likely to lengthen or shorten sentences based on this kind of information?

Question 1 - Teacher notes and references

Example A: A 2012 study concluded that judges might be influenced by genetic information in determining sentences. When given a hypothetical court case that includes information indicating the defendant carries genetic factors that may increase his or her risk of violent behaviors, judges reduced the theoretical sentence by an average of about one year. The article below states:

> "Simply using the term psychopath adds an average of five years to criminal sentences, according to this study, but once the biological explanation was included, the length of the sentence dropped. 'It did create a significant reduction in sentencing,' says psychologist Lisa Aspinwall, 'from 14 years on average without the biological mechanism, to just about 13 years on average.'"

"Would judge give psychopath with genetic defect a lighter sentence?" by Alix Speigel, August 2012, *National Public Radio.*

Example B: In 2009, an Italian judge reduced the sentence of convicted murderer Abdelmalek Bayout, citing Bayout's genetic profile at the MAOA gene. Bayout carries a variant of MAOA, known as the MAOA-L variant, which functions at a reduced level and may influence behavior. While controversial, some researchers believe that, in combination with a violent or stressful childhood environment, MAOA-L may be associated with increased rates of aggressive behavior and lack of impulse control. MAOA is among one of the most well-known and controversial variants cited in discussions about genes and behavior. The following article provides an overview of the Bayout case.

"Lighter sentence for murderer with 'bad genes,'" by Emiliano Feresin, October 2009, *Nature.*

Note: MAOA is sometimes referred to as the "warrior gene" in the media. This is a good opportunity to ask students if they believe a single gene could be responsible for a complex human behavior, such as aggression, and to also ask them to consider how the term "warrior gene" might be misleading. To learn more about the MAOA gene, we recommend the Genetics Home Reference on MAOA maintained by the National Institutes of Health.

Example C: In the 2006 murder trial of Bradley Waldroup, jurors did not recommend the death penalty, contrary to expectations. The jury explained that, after taking into consideration his MAOA variant status and his childhood environment, a lesser sentence was warranted.

"Can your genes make you murder?" by Barbara Bradley Hagerty, July 2010, *National Public Radio*.

As of 2015, pgEd is unable to locate any cases in which a specific genetic variant has been a factor in lengthening a criminal sentence.

Question 2: Imagine you are a scientist and you want to explore whether there may be genetic factors influencing complex human behaviors, such as impulse control and aggression. Would you hunt for a single gene or a group of genes? Would you want to study individuals or groups of individuals? What other factors would you consider? How should you organize your experiment?

Question 2 - Teacher notes and references

Example A: It is highly unlikely that a single gene, or a discrete cluster of genes, alone, can function to "cause" criminal behavior.

"Gene interaction and disease," by Amy Ralston, 2008, *Nature Education*, *Scitable*.

Example B: Height is a heritable trait. Nevertheless, the genetic basis behind a person's height is quite complicated. In fact, scientists have discovered hundreds of genetic variants that impact how tall a person might be. Other factors, such as childhood nutrition and access to health care, may also contribute to height. There is no simple explanation as to how genes and environment interact to contribute to complex characteristics.

"Genetics Tells Tall Tales," by Alla Katsnelson, June 2010, *Nature*.

"Complex Genetic Trait Research Reaches New Heights," by Karen Hopkin, September 2010, *Scientific American*.

Example C: Another concern about scientific studies that focus on a single individual is that the information gleaned from just one individual is not necessarily applicable to a wider population. Therefore, experiments are often designed to look at a group of people who share one or more traits (phenotypes), with the goal of discovering whether the group also shares genetic variants (genotypes).

"What is a Genome Wide Association Study (GWAS)?" *National Human Genome Research Institute*

The concepts in Examples A, B and C are summarized in an interview with Heidi Rehm, a geneticist at Harvard Medical School, in the December 2012 article "DNA of Newtown Gunman Unlikely to Yield Clues of Violence," by John Lauerman in *Bloomberg News*. According to the article:

> "Tests for the mutations are far from conclusive, geneticists said. Many people who have the DNA mutations that are associated with the disease don't have autism. And if the mutations don't appear, this wouldn't rule out autism, because less than 10 percent of the genetic causes of autism have been discovered, said Heidi Rehm, a geneticist at Harvard Medical School and Brigham & Women's Hospital in Boston. However, the presence of certain mutations might give more information about the type of mental illness Lanza suffered from, if any, she said.
>
> 'If they found a specific abnormality that's been published and associated with patients, you might be able to look at those patients to get some insight into the issues you're dealing with, rather than the entire gamut of mental illness,' she said in a telephone interview."

Homework assignment:

Teachers may wish to extend this lesson with a homework assignment. We have formatted the classroom discussion questions into an assignment sheet (page 13 of this document). The articles listed in the "Teacher notes and references" sections (pages 7-9) can also be sent home as background reading for the homework questions.

Additional resources for teachers:

pgEd also explores the concept of gene-environment interactions in our lessons "Athletics and Genetics" and "Scientific Themes in Personal Genetics."

"Neuroprediction and Crime," by Joshua Buckholtz, October 2012, *NOVA ScienceNOW*.

"Vulnerability genes or plasticity genes?" by Jay Belsky et al., August 2009, *Molecular Psychiatry*.

"Research Review: genetic vulnerability or differential susceptibility in child development: the case of attachment," by Marian J. Bakermans-Kranenburg and Marinus H. Van IJzendoorn, December 2007, *Journal of Child Psychology and Psychiatry*. (Note: this article is behind a paywall.)

"Genes, environment and genetic complexity: Aggression in humans" quiz answer key (see page 14 for quiz):

1. F
2. T
3. Possibilities include:
   - MAOA (the so-called "warrior gene") affects how neurotransmitters function. Its function can be influenced by environmental factors and life experiences.
   - A single gene, such as MAOA, alone does not make a person behave aggressively. Environmental influences have a huge role in complex human behaviors.
   - There is a less active version of the MAOA gene that is linked to aggressive behavior. People may carry this version of the MAOA gene but show no evidence of being more aggressive than average.
4. Biological determinism is a framework for understanding humans through a biological lens and aims to explain complex human traits as being largely, if not entirely, dictated by biology, particularly our genes. The major criticism is that this theory downgrades, if not dismisses, the role that culture and environment might have in shaping human behaviors. Many scientists are working towards understanding the interactions between genes and environment and how that relationship may impact traits and behaviors.

Student Handout – Key concepts

"Genes, environment and genetic complexity: Aggression in humans"

Aggression: "Most social psychologists define human aggression as any behavior intended to harm another person who does not want to be harmed." It is important to understand aggression not as a feeling or an emotion, but as an action. Another key concept is that a person taking aggressive action is doing so intentionally, with the goal of harming a victim.

Adapted from:
http://www.psychology.iastate.edu/faculty/caa/abstracts/2010-2014/12DAB.pdf.

Genetic complexity: In general, there is not a simple relationship between our genes and our traits. Our physical, mental and behavioral states are the result of complex interactions between multiple genes in combination with our environment and our lifestyles. For example, height is influenced by the action of at least 180 regions in one's genome in addition to environmental factors, including diet as well as maternal and childhood health. Coming back to the example of aggression in this lesson, it is important to think about the complexity of human behavior, which is impacted by an intricate network of genes in combination with the environment and social experiences.

Biological determinism: This is a framework for understanding humans through a biological lens and aims to explain complex human traits as being largely, if not entirely, dictated by biology, particularly our genes. This theory downgrades, if not dismisses, the role that culture and environment might have in shaping human behaviors. There has been much criticism of this theory, and many scientists are now focusing also on interactions between genes and environment and how that relationship may impact traits and behaviors.

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For example, people who carry certain genetic variants are at increased risk for developing heart disease or type 2 diabetes, and knowing this

information can be beneficial for making lifestyle choices about diet and exercise as well as healthcare decisions. However, some people who learn they have these markers for elevated risk will not develop the associated conditions. Conversely, a person who is free of these variants still has the possibility of developing heart disease or type 2 diabetes.

The same principle can be applied to the genetic underpinnings of aggression. In fact, to date, there is no genetic variant that has been perfectly correlated with aggressive behavior. Even for variants that some researchers have correlated with aggressive behavior, there is much controversy. It is important to note that correlations are statistical descriptions of populations consisting of many people and, therefore, cannot be used to determine whether or not a given individual will exhibit aggressive behavior.

Name:_____ Date: _____

Homework assignment

"Genes, environment and genetic complexity: Aggression in humans"

Write a 1-2 page response to the questions you discussed in class. Use evidence from the readings and class discussions to inform your answers.

Question 1: A suspect, standing before a judge, is on trial for a violent assault. The judge has information on the suspect's genetic make-up, stating that the suspect has genetic variants associated with increased risk for violent behaviors.

- How dependable is this information?
- Should the judge take this information into consideration?
- Do you think judges might be likely to lengthen or shorten sentences based on this kind of information?

Question 2: Imagine you are a scientist and you want to explore whether there may be genetic factors influencing complex human behaviors, such as impulse control and aggression.

- Would you hunt for a single gene or a group of genes?
- Would you want to study individuals or groups of individuals?
- What other factors would you consider?
- How should you organize your experiment?

Name:_____ Date_____

Student quiz

"Genes, environment and genetic complexity: Aggression in humans"

1. Scientists have located the gene that causes humans to behave aggressively. T/F

2. Genes and environment can act together to influence complicated human traits like height. T/F

3. List two new things you learned from the PBS clip "Can Science Stop Crime?"

4. Define biological determinism and explain why this idea is highly criticized.