Case Teaching Notes for "The Case of Desiree's Baby: The Genetics and Evolution of Human Skin Color"

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INTRODUCTION / BACKGROUND

This case about the genetics and evolution of skin color is based on Kate Chopin's short story "Desiree's Baby," which was first published in 1893. It is a story of race and gender in antebellum Louisiana. Desiree is deeply in love with her husband, Armand, and he is a loving husband and a proud father until he notices their infant's dark skin. Because Desiree was abandoned as a child, her ancestry is unknown. Armand concludes that she is not white and tells her to leave. His rejection drives Desiree to take her own life and that of the baby. A few weeks later, Armand discovers that he is of mixed ancestry.

The case was developed for urban community college students in their first semester of general biology. The course curriculum is organized around the general theme of evolution. By the time the case is introduced, students have covered evolution, biochemistry, cell biology, and Mendelian genetics. The case is also appropriate for anthropology and biology courses for non-majors.

Objectives

Students finishing this case will be able to:

- Explain polygenetic inheritance.
- Describe the inheritance of skin color.
- Discuss the "sunscreen" and "vitamin" hypotheses of skin color evolution.
- Write a short essay summarizing the key points in a popular science article.

CLASSROOM MANAGEMENT

The short story and the accompanying three parts of the case were designed to be presented using the progressive disclosure method (for more information on this method, also known as the Interrupted Case Method, see http://ublib.buffalo.edu/libraries/projects/cases/coots/coots_prologue.html). The case was tested in a class of 30 students divided into groups of three to four students following the steps described below:

Part I—"A Mendelian Approach" (20 minutes)

The short story, "Desiree's Baby," was distributed as a reading assignment in lecture. Students were told that an in-class activity based on the story was scheduled for the next session. At the start of the next lecture period, Part I of the case was distributed and the students worked in groups on the questions. This was followed by a whole-class discussion. The class quickly agreed on answers to all

the questions except for number 4. Most students felt that skin color must follow a simple dominant/recessive pattern, even though this could not explain the intermediate phenotype of biracial individuals.

Part II—"Skin Color is a Polygenetic (Multiple Gene) Trait" (20 minutes)

At this point, an overhead transparency of the AaBbCc X AaBbCc Punnett square was used to explain the inheritance of skin color. A copy of Part II was distributed and the students determined the number of offspring with each skin color. If time permits, the number of offspring with each skin shade can be used to construct a bell-shaped curve on the chalkboard. Students worked in groups on the questions. This was followed by a whole-class discussion.

Students often assume that an individual with the aabbcc genotype is an albino. If the students don't ask, the instructor should pose the question. These individuals have fair skin (Northern Europeans) due to low melanin production. Albinos have no pigmentation in their skin, hair, and eyes because they lack the enzyme tyrosinase needed for melanin production. Albinism is inherited as an autosomal recessive. Two recessive albinism alleles at the tyrosinase gene locus will prevent expression of the genes (A, B, and C) that govern the amount of melanin production. This gene interaction is called epistasis.

Students sometimes raise the issue of Michael Jackson's skin color. He is said to suffer from viteligo, an autoimmune disorder that destroys melanin producing cells.

Part III—"Evolution of Skin Color"

Students were given one week to complete the group writing assignment, described in Part III, which was graded using a holistic scale (Bean, 1996). Individual learning was assessed on the next unit exam by questions pertaining to the genetic and evolutionary principles emphasized in the short story and in the written assignment.

An effective way either to introduce the writing assignment or to provide closure to the case is to show a video that explores the science of human variation. A particularly good film is "Episode 1—The Difference Between Us" from the video series "Race—The Power of an Illusion" (California Newsreel, 2003, http://www.newsreel.org) Should you only have time to screen the segment on skin color, begin the video at 23:41 (begins with Stephen Jay Gould saying: "My favorite trivia question in baseball...") and run it through 28:03 (ends with Joseph Graves saying: "Oh, this is the place where we go from the light race to the dark race."). If you are using the DVD, go to scene 8. (To further explore how race is socially constructed, see "Episode 3—The House We Live In.")

Any class time that remains could be devoted to a discussion of other polygenetic traits such as height, body build, intelligence, and Type II diabetes.

There are several alternatives to the group writing assignment, including whole-class discussion and debate. The role of race in medicine is a related topic that is especially well suited to debate. The *New York Times* article, "2 Scholarly Articles Diverge on Role of Race in Medicine" by Nicholas Wade can be used to provide students with a good overview of the controversy.

BLOCKS OF ANALYSIS

Polygenetic Inheritance

One of the reasons why Mendel was so successful in working out the basic principles of heredity was that he studied simple traits. He chose traits in the garden pea, which appeared in two distinctly contrasting (either-or) forms, e.g., tall vs. short plants, yellow vs. green pods, and smooth vs. wrinkled

seeds. A single gene controls each of these traits. Few characteristics follow this simple pattern of inheritance. Most traits result from the additive effect of many genes. These polygenetic traits are characterized by small gradations in phenotype, known as continuous variation. Graphing the distribution of one of these traits produces a bell-shaped curve in which extreme values are much rarer than intermediate values. Environmental factors influence the expression of polygentic traits, e.g., poor nutrition limits height, sun exposure darkens skin color.

Inheritance of Skin Color

Skin color is largely determined by the amount of melanin. Dark skinned individuals produce more melanin than light skinned individuals. At least three genes regulate the amount of melanin produced. Each gene has two forms: dark skin allele (A, B, and C) and light skin allele (a, b, and c). Neither allele is completely dominant to the other, and heterozygotes exhibit an intermediate phenotype (incomplete dominance). Each dark skin allele in the genotype adds pigment by increasing melanin production. There are seven different shades of skin color ranging from very light (aabbcc) to very dark (AABBC); most individuals have the intermediate skin color (AaBbCc). A cross between two individuals with intermediate skin color produces offspring with a range of phenotypes (bell-shaped curve).

Evolution of Human Skin Color

Studies of mitochondrial and chromosomal DNA indicate that modern humans are descended from dark skinned humans that migrated out of southern Africa about 100,000 years ago. Many scientists believed that pigmentation evolved in Africa as a "sunscreen" to protect against skin cancer. However, this could not be the only selective pressure since most deaths from skin cancer occur after reproductive age. According to the most recent theory, skin color evolved to ensure reproductive success. Ultraviolet radiation (UV) catalyzes the synthesis of vitamin D, which is required for absorption of calcium and development of the skeleton. Over-exposure to UV radiation will break down vitamin B folate (folic acid), which is necessary for fetal development and fertility. Dark skin evolved near the equator to protect against the breakdown of folate. Because UV radiation is high, it can penetrate the dark skin and stimulate vitamin D production. Light skin evolved when early humans migrated to the northern and southern latitudes where UV radiation is much lower. The amount of melanin gradually decreased to facilitate vitamin D synthesis under low light conditions. As a result of recent migrations, many individuals do not live in the climate for which their skin is adapted.

ANSWER KEY

Answers to the questions posed in the case study are provided in a separate answer key to the case. Those answers are password-protected. To access the answers for this case, go to the key. You will be prompted for a username and password. If you have not yet registered with us, you can see whether you are eligible for an account by reviewing our password policy and then apply online.

RESOURCES

Print

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- Kirchweger, G. 2001. The Biology of... Skin Color. http://www.discover.com/issues/feb-01/departments/featbiology/
- Online Mendelian Inheritance in Man. *National Center for Biotechnolgy Information (NCBI)*. http://www.ncbi.nlm.nih.gov/omim/
- MendelWeb http://mendelweb.org/home.html

Video

- Race—The Power of an Illusion, "Episode 1—The Difference Between Us." VHS/DVD. Produced by California Newsreel, 3 x 56 minutes, 2003. http://www.newsreel.org

REFERENCES

- Bean, J.C. 1996. *Engaging Ideas: The Professor's Guide to Integrating Writing, Critical Thinking, and Active Learning in the Classroom*. San Francisco: Jossey-Bass.

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Image Credit: Edited detail of "Gertrude M. Hubbard with baby." Photographer unknown, taken between 1855 and 1859. From the Daguerreotype Collection of the Library of Congress. Digital ID: cph 3d02012.