Teaching About Genetics and Sickle Cell Disease in Fifth Grade

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Abstract: A 5-lesson, 5th-grade instructional unit, "Genetics and Sickle Cell Disease," was developed and tested as part of a 40-lesson curriculum entitled SEEK (Science Exploration, Excitement, and Knowledge): A Curriculum in Health and Biomedical Science for Diverse 4th and 5th Grade Students. The genetics lessons include hands-on activities (e.g., DNA extraction from cheek cells), a simulated plant genetics experiment, and a classroom visit by a person with sickle cell disease, as well as by a health care practitioner who works with sickle cell patients or a scientist specializing in genetics. The unit was tested with 82 5th-grade students at public elementary schools in Oakland, CA; 96% were racial and ethnic minorities. The comparison group consisted of 84 5th-grade Oakland students racially/ethnically, academically, and socio-economically matched to those in the experimental group. Both groups completed a 20-question, multiple-choice pre/posttest covering science concepts, scientific process, lifestyle choices, and careers. The experimental group showed significant improvement on 13 of 20 questions ($P<.05$, t-tests) and on the test as a whole, whereas the comparison group did not show significant improvement either on any of the questions or on the test as a whole. The experimental group improved on 10 concept questions, 2 scientific process questions, and 1 lifestyle question. Teachers rated the educational value of the unit as 9.5 on a scale from 1 (low) to 10 (high). These results show that genetics and sickle cell disease can be taught successfully in 5th grade, although they are not typically covered at this level.

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INTRODUCTION

Understanding how health and well-being can be optimized throughout life requires some knowledge of genetic science. Thus, most states have curriculum content standards that include genetics and related topics. Typically, however, most genetic concepts are not taught until secondary school. The need to improve K-12 education in genetics, because it is essential to enhancing public understanding of genetics and genomics and promoting health, is pointed out in a 2010 report prepared for the US Secretary of Health and Human Services.[1]

It has long been known that genetic counseling can be insufficient for imparting genetic information. In 1974, Hampton. Anderson, and Lavisso[2] found that in a survey of 47 families who were counseled about sickle cell anemia after their children had tested positive for the trait, 43 percent thought that the existence of the trait was a disease, and about half thought that their children's activities needed to be severely restricted.

In a study of 1,880 students, including 138 in 5th and 6th grade, Jones, Smith, and Calvert[3] showed that in-service teacher training by sickle cell education staff enhanced student learning about sickle cell disease: students whose teachers received such training did better than students whose teachers were given the same sickle cell curriculum to use in the classroom, but without instruction on how to use it.

In the present study, college-age presenters were trained to teach "Genetics and Sickle Cell Disease," a 5-lesson, 5th-grade instructional unit in *SEEK (Science Exploration, Excitement, and Knowledge): A Curriculum in Health and Biomedical Science for Diverse 4th and 5th Grade Students*.[4] In addition, teachers attended presentations by sickle cell education staff and genetics researchers, and these professionals came to some of the classrooms for the final lesson. The purpose of the study was to demonstrate that basic concepts in genetics and culturally relevant information on sickle cell disease can be effectively conveyed to racially and ethnically diverse 5th grade students in a relatively low-performing, large urban school district serving low-income neighborhoods.

The Genetics Unit

Each lesson has a worksheet on which students record their observations as drawings, in writing, or in tables. The lesson plans and worksheets are available free online at http://www.chori.org/Education/SEPA/SEPA_curriculum.html. They are also available in a book that can be purchased from Amazon.com: *SEEK (Science Exploration, Excitement, and Knowledge): A Curriculum for Diverse 4th and 5th Grade Students*. All proceeds from the book go to support community health education projects.

Lesson 1: DNA and Your Cells

Students explore and describe physical characteristics of people. They differentiate between traits that have been inherited from parents and traits acquired by accident or on purpose, such as scars and ability to play a musical instrument. Then they work in pairs to prepare and examine slides of onion skin and to examine pre-prepared slides of animal tissue using handheld microscopes. The worksheet asks them to observe and draw what they see in the microscope. They compare the plant and animal cells, and they find the nuclei, where DNA is stored. Then they are shown a molecular model of DNA and told that the traits they inherit from their parents are encoded in DNA.

Lesson 2: See Your DNA

Students extract and observe DNA from their own cheek cells using a procedure that requires careful measurements and following instructions sequentially. The worksheet asks them to describe what they observe as they follow this procedure. After discussing their results, they assemble strings of beads that represent strands of DNA, and they compare their strands with a molecular model of DNA.

Lesson 3: Plant Parenthood

In an activity first described in *SPACES: Solving Problems of Access to Careers in Engineering and Science* (Lawrence Hall of Science, 1982),[5] students simulate a plant genetics experiment using 2.54-cm x 6.35-cm cards to represent dominant and recessive traits in flowering plants. Every parent plant has three gene cards in this activity: one for height, one for flower color, and one for seed shape. Each characteristic has two types of genes or traits: TALL and short; RED and white; ROUND and wrinkled. Dominant genes are in ALL CAPITAL letters and recessive genes are all lowercase letters. Figure 1 shows how to make cards for two parent plants. Each card has one gene on the front and one gene on the back. The students make the cards themselves, shake them in a bag, and dump them onto a desk or table. The genes that land face up determine the traits of an offspring. Students record and count the number of offspring with given traits and determine the probability of the various possible genotypes and phenotypes.

Lesson 4: Trait Inheritance

The students use Mr. Potato Head toys to reinforce their understanding of dominant and recessive genes. They observe a Mr. Potato Head and decide if an offspring could inherit various traits. "Dominant" and "recessive" are assigned arbitrarily to traits such as ear shape and nose color. Flipping two coins for each trait, with heads representing dominant genes and tails representing recessive genes, students create and draw an offspring. Then they complete a survey of some of their own dominant and recessive traits (freckles, widow's peak, length of second toe compared to first toe, handedness, tongue-rolling, and cleft chin). Finally, the class discusses how genetic problems might affect health.

Lesson 5: Sickle Cell Disease

The students reassemble the DNA models they made in Lesson 2 to better understand how genetic inheritance can produce variations in DNA. They receive a booklet entitled *Sickle Cell Trait and Sickle Cell Disease: An Activity Book* (available on request from UCSF Benioff Children's Hospital Oakland),[6] in which they draw a family tree and practice several Punnett squares showing how different types of sickle cell disease, sickle cell or other hemoglobin traits, or ordinary hemoglobin, can be inherited. A researcher or health care practitioner talks about current and future treatments for sickle disease, and a young adult affected by the disease speaks about living with it, showing how what the students have learned in class is reflected in real life. Students are encouraged to ask questions of the practitioner and young adult to help their understanding and break possible misconceptions.

The SEEK Curriculum

"Genetics and Sickle Cell Disease" is part of the 40-lesson SEEK curriculum, which was developed by UCSF Benioff Children's Hospital Oakland and includes eight instructional units, each of which teaches human biology and scientific investigation in the context of examining a disease or medical condition, such as sickle cell disease, which disproportionately affects racial and ethnic minorities. Other instructional units

Figure 1. Gene cards for "Plant Parenthood."

PLANT 1:	Front of card	Back of card
Flower color:	RED FLOWER	white flower
Seed shape:	ROUND SEED	ROUND SEED
Plant height:	TALL PLANT	short plant

PLANT 2:	Front of card	Back of card
Flower color:	RED FLOWER	white flower
Seed shape:	wrinkled seed	wrinkled seed
Plant height:	short plant	short plant