# The Effect of Discovery Learning through Biotechnology on the Knowledge and Perception of Sickle Cell Anemia and It's Genetics on Lower Income Students

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**Abstract**
The purpose of this action research is to study how discovery learning through the use of biotechnology will affect the knowledge and perception of Sickle Cell disease and the genetics of that disease in lower income students. Many students that have the trait for Sickle Cell do not understand how or why this disease came to be nor do they understand the genetic behind it. In this study, students will use techniques learned from the Bench to Bedside program along with other curriculum materials in order to learn important concepts associated with the genetic dispositions of Sickle Cell disease and how this disease became so prevalent in the African-American population. Each student will be given a pre-test and a post-test to assess the learning gains of the unit. The pre- and post-test will include a survey to determine their overall experiences, including what they like and do not like. Students will be able to use the knowledge gain from this experience and apply it to questions that they might find on the Biology End-of-Course Exam.

**Rationale**
Seagull Alternative High School is one of many high schools in Broward County. However, it is the only high school to have both "Teen Parent" and "Credit Recovery" programs. To add to that, the Florida Department of Education has reported that more than 80% of these students are considered to be economically disadvantaged. Due to this, most students have to seek out jobs and financially contribute to their family. There are also some students that are a part of the foster care system in Florida. Homework is not considered an option for these students as their jobs and children take precedent over their education at this point in their lives. These factors, among others, contribute to the negative perception of science and difficulties in the classroom.

In order to make an impact on these students, a justification has to be made by the instructor as to why the information or skill being learned is pertinent to their success. Sickle Cell disease was chosen as the overall theme for this study because this population of students is very familiar with the high occurrence of this disease in their community (King, 2005). Many students at this school know an individual with the disease or with the trait of the disease. However, there is no student understanding as to how and why the disease developed, what having the Sickle Cell trait means and how having an understanding of genetics can not only have an impact on their knowledge of Sickle Cell disease but other genetic diseases as well.

The use of biotechnology in the classroom has become a benchmark that needs to be met in order for biology students to be successful when they take the End-of-Course Exam at the end of the school year. Studies have shown that this standard allows students to conceptualize how the specialists of different areas of science work to together to solve the problems of society (France, 2008). The goal of this study is to see whether implementing biotechnology techniques in the unit on genetics will change their overall perception about learning science and increase their scores on the post-test that will be given at the end of the unit.

**Action Research Intervention**
There will be two main topics addressed in this study, Sickle Cell disease and the genetics behind this disease. The students that are participating in this study have had some sort connection to Sickle Cell, either a friend, family member, or themselves have the disease or traits. The main objective of instruction in this action research is by the end of study Sickle Cell

disease, students will have enough knowledge to apply concepts of genetics to answer questions about other genetically linked diseases. Benchmarks that relate to biological science and health education will be addressed throughout the time that action research is being conducted. Math benchmarks will also be met through the use of probability in Punnett squares. It is also the hope that through the use of the biotechnology techniques I learned in the Bench to Bedside program, students will change their negative perception of science to a more positive one. These activities/labs include NCBI "BLAST", Pipetting by design, Modes of inheritance and Punnet square supplemental activities.

**Connections to Bench to Beachside Summer Institute**

The following listed identifies the activities that will be used from the Bench to Bedside Program

- Pipetting by design
    - A lab designed to get students acquainted with using a micropipette.
- Modes of Inheritance
    - A lab designed to allow students to complete a genetic screening for Sickle Cell on a family using gel electrophoresis
- NCBI website
    - Students will be grouped and given a nucleotide sequence which is correlated to a genetic disease. They will answer questions about the disease and create a

**Data Collection and Analysis**

- Assignments
    - Punnett squares
    - Blast Activity
    - Lab
- Pre/Post-test with a survey component
- Notebooks
    - Bell-ringers, note-taking and non-collected assignments

Students will create an identifier that will be used to maintain anonymity for the pre/post-tests and survey. By using the pre-test and the survey, I will be able to gather the initial data that I need for this study. Microsoft Excel will be used as the means by which data will be recorded and stored.

**Literature Cited**


1. Florida Deparment of Education No Child Left Behind School Public Accountability Reports. (n.d.). Retrieved June 25, 2015, from http://doeweb-prd.doe.state.fl.us/eds/nclbspar/year1314/nclb1314.cfm?dist_schl=6_601
2. King, A., Tang, S., Ferguson, K., & Debaun, M. (June 2005). An Education Program to Increase Teacher Knowledge About Sickle Cell Disease. *Journal of School Health J School Health*, 11-14.
3. France, B. (March 2008). Location, Location, Location: Positioning Biotechnology Education for The 21st Century. *Studies in Science Education*, 88-122.
4.


**Budget and Budget Justification**

Pipetting by design and Modes of Inheritance are the labs that will be used from the Bench to Bedside program. Both lab will be provided by the Center for Pre-collegiate Education and Training (CPET) via an equipment locker. The Modes of Inheritance lab was originally designed to be implemented as a means to study Pompe's Disease, however, I will be changing the scenario to incorporate Sickle Cell disease.

**Permissions**

Initial permission to participate in the action research was already given prior to the start of the Bench to Bedside program. Media releases will be sent home at the beginning of the school year. That will be used as the source of permission for pictures and video to be taken during the study. All activities will be done on the school's campus; therefore no permission forms are necessary.

## SINGLE LESSON PLAN

| **Teacher:** Saffiyah Manboard | **Content Area/Grade:** Biology | **Date:** |
|---|---|---|

| **Unit Name:** | Genetic and Reproduction of Life |
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| **Unit Goal**<br>What unit goal does this daily lesson address? | **Standard(s)/Benchmark(s)**<br>What standard(s)/benchmark(s) does this daily lesson address? |
|---|---|
| 1. Relate dominant-recessive patterns of inheritance in autosomal chromosomes to genetic disorders.<br>2. Assess patterns of inheritance in sex-linked traits.<br>3. Cite evidence of different types of allele interactions.<br>4. Evaluate polygenic traits and the effect of environmental factors on phenotype.<br>5. Examine patterns of inheritance in humans.<br>6. Summarize how a pedigree is used. | SC.912.L.16.2 - discuss observed inheritance patterns caused by various modes of inheritance, including dominant, recessive, codominant, sex-linked, polygenic, and multiple alleles.<br><br>SC.912.L.15.15 - describe how mutation and genetic recombination increase genetic variation. |
| **Students will understand that…**<br>What should the students understand by the end of today's lesson? | **Essential Questions**<br>What essential question(s) does this lesson address? |
| • Relate dominant-recessive patterns of inheritance in autosomal chromosomes to genetic disorders.<br>• Describe patterns of expression in sex-linked. genes. | How do chromosomes determine the traits of an organism?<br><br>How do genes produce a wide range of traits? |
| **Connecting Concepts**<br>How will you review yesterday's content and connect today's lesson to it? | **Organizing Students for Learning**<br>How will students be organized today for the lessons activities? |
| A punnett square will be projected and students must complete the monohybrid cross. It will be a heterozygous cross so that Sickle Cell disease can be discussed.<br><br>http://www.classzone.com/cz/books/bio_12_fl/resources/ht | Students will be working in groups of two which will be determined randomly |

## LEARNING EXPERIENCES, INSTRUCTION AND RESOURCES

**What activities or experiences (from your Unit Plan) will students engage in today?**

**Lesson Sequence**

| | | |
|---|---|---|
| **Activating Prior Knowledge** | Discuss the different varieties of specific human physical traits. Ask: Why can siblings display such a diversity of traits, such as different eye or hair color? *(They inherited different forms of the genes that code for the development of those traits from their parents.)* | ☐ ABC Brainstorming<br>☐ KWL<br>☐ Anticipation Guide<br>☐ Card Sort<br>☒ Think-Pair-Share |
| **Explicit Instruction** | **Figure 7.2** Have students work through the Punnett square. Review the definitions of *homozygous* and *heterozygous*. Ask:<br>Is a carrier homozygous or heterozygous? *(heterozygous)*<br>What percentage of the offspring is expected to be a carrier? *(50 percent)*<br>Is it possible for a SS individual to have offspring with Sickle Cell disease? *(No, offpring must inherit two recessive alleles, one from each parent. A SS parent has no recessive allele.)* | ☐ Motivational Hook<br>☒ Lecture<br>☐ Demonstration<br>☒ Note-taking Guide |

| Lesson Sequence | | | | Resources and Materials |
|---|---|---|---|---|
| **Group Processing of New Information** | Students will complete the "Identifying Disease Genes" activity with their partner. They will be given a nucleotide sequence found in real human DNA that is associated with a genetic disease when mutated. Their task is to compare the sequence they are given using the BLAST tool on the NCBI website. They will answer questions and create a poster that contains the essential information about their disease. | ☐ Jigsaw<br>☒ Reciprocal Teaching<br>☐ Concept Attainment<br>☐ Think-Pair-Share | ☒ Lab / Inquiry Activity | ☒ Computer<br>☒ LCD Projector<br>☒ Paper<br>☒ Pencils<br>☒ Whiteboards<br>☒ Markers<br>☐ Butcher Paper<br>☒ Response Cards<br>☐ Post-it Notes<br>☒ Video Clip(s):<br><br>☐ Website(s):<br><br>☐ Lab Materials: |
| **Elaborative Questioning** | Is it possible for a SS individual to have offspring with Sickle Cell disease? *(No, offpring must inherit two recessive alleles, one from each parent. A SS parent has no recessive allele.)* | ☐ Inferential Questions<br>☐ Analytic Questions<br>☐ Philosophical Chairs | | |
| **Demonstrating Understanding** | Lab: "Modes of Inheritence (Natures Dice): A Genetic Screening" | ☐ Graphic Organizers<br>☐ Picture Notes<br>☐ Flow Charts<br>☐ Concept Maps<br>☐ Mnemonics<br>☐ Graffiti | | |
| **Reflection** | 3-2-1 Ticket out the door<br><br>Name 3 diseases that you learned about<br><br>Name 2 types of DNA mutation<br><br>What is 1 symptom of Sickle Cell Disease. | ☐ Reflective Journals<br>☐ Think Logs<br>☐ Exit Ticket (Student Learning) | | |
| **Daily Progress Monitoring Assessment** | Post-quiz on heredity and genetics. | ☐ Quiz<br>☐ Journal<br>☒ Exit Ticket (for Content)<br>☐ Response Cards | | |

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|---|---|
| Based in the results from your Daily Progress Monitoring Assessment, what concepts need to be revisited in the next lesson? | **Homework**<br><br>NONE |

| **UNIT PLAN** | |
|---|---|
| Unit Title: Mendelian Genetics | Content Area/Grade: Biology/9-12 |
| Teacher: Saffiyah Y Manboard | Implementation Time Frame: 4 weeks |
| **STAGE 1: THE DESIRED RESULTS**<br>**What are my learning goals?** | |
| **Unit Goal**<br>Students will understand that… | **Standard(s)/Benchmark(s)**<br>What standard(s)/benchmark(s) does this daily lesson address? |
| Through inquiry and exploration, students will understand the basic principles of inheritance and the role genes play in development. | **SC.912.L.16.1** Use Mendel's laws of segregation and independent assortment to analyze patterns of inheritance.<br>**SC.912.L.16.2** Discuss observed inheritance patterns caused by various modes of inheritance, including dominant, recessive, co-dominant, sex-linked, polygenic, and multiple alleles (assessed as SC.912.L.16.1).<br>**HE.912.C.1.7** Analyze how heredity and family history can impact personal health<br>**SC.912.N.2.4** Explain that scientific knowledge is both durable and robust and open to change. Scientific knowledge can change because it is often examined and re-examined by new investigations and scientific argumentation. Because of these frequent examinations, scientific knowledge becomes stronger, leading to its durability (not assessed).<br>**SC.912.N.3.1** Engage in scientific questioning to extend thinking or to guide investigations within the context of genetics |
| **Related Misconceptions**<br>What misconceptions are predictable? | **Students will know…**<br>Vocabulary, terminology, definitions |
| • Punnett squares outcomes are all going to occur and are not probabilities.<br>• Every time there is a genetic cross each subsequent cross will not have the same probability of outcomes as the first (because the first pairing produced offspring with blue eyes, no other pairing can produce blue eyes).<br>• If the parent generation has a genetic disease, all offspring will have the same disease.<br>• Recessive traits are not passed from parent to offspring. | **Vocabulary**<br>• Allele<br>• Asexual Reproduction<br>• Characteristic<br>• Chromosome<br>• Clone<br>• Co-dominant<br>• Diversity<br>• DNA<br>• Dominance<br>• F1 Generation<br>• Gamete<br>• Genetic<br>• Genotype<br>• Haploid<br>• Heredity<br>• Heterozygous<br>• Homozygous<br>• Inherited trait |

**Essential Questions**
What questions will foster inquiry, understanding and transfer of learning?

- How are gametes and sex chromosomes different from body cells and autosomes?
- What cellular events occur during the process of meiosis?
- How did Mendel's research demonstrate that traits are inherited individually?
- How do genes produce a wide range of traits?
- How do the rules of probability control the inheritance of genetic traits?
- How do independent assortment and crossing over during meiosis result in genetic diversity?
- How do chromosomes determine the traits of an organism?
- What factors affect phenotype?
- What methods are used to study human genetics?

- Meiosis
- Mitosis
- Mutation
- Nucleus
- Offspring
- Organism
- P generation
- Phenotype
- Polygenic
- Recessive
- Reproduction
- Sexual reproduction
- Species

**Students will know…**
Key facts, formulas, critical details, important events, important people, timelines

**Other Essential Knowledge**

- use a Punnett square and Mendel's laws of segregation and independent assortment to analyze patterns of inheritance
- complete monohybrid and dihybrid crosses in order to determine an organism's genotype and phenotype
- use a Punnett square to predict the effect of dominant and recessive genes on inheritance patterns
- explain that organisms exhibiting codominance will be fully expressed in the offspring resulting in a phenotype that is neither the dominant or recessive trait
- understand that with multiple alleles there are more than two phenotypes possible for a trait depending on the which two alleles are inherited
- identify polygenic traits as one whose phenotype is influenced by more than one gene
- explain that in sex-linked inheritance, the phenotypic expression of an allele is related to the chromosomal sex of the individual
- evaluate the impact heredity has on the health of the individual as well as society
- explain how ideas about inheritance changed as Mendel's work was published and verified by other scientists through additional study and experimentation
- recognize that Mendel's laws only describe the behavior he observed; they do not provide an explanation for the inheritance patterns he observed

**Students will be able to…**
Specific skills students will acquire as a result of this unit

- Students should be able to calculate outcomes of a Punnett square expressed as percentages, ratios, and fractions.
- When completing monohybrid and dihybrid crosses, students should be able to predict outcomes of the P and F1 generations.
- It is not necessary that students memorize specific diseases associated with sex-linked, polygenic, or multiple allele inheritance

**STAGE 2: ASSESSMENT EVIDENCE**

What evidence will show that my students have achieved the learning goals?

**Performance tasks:**

Through what specific "real-world" performance task(s) will students demonstrate their understanding of the learning goals?

**Sample FLDOE Question SC.912.L.16.2**

Hemophilia is a sex-linked, recessive trait. Which of the following describes the probability of hemophilia in the offspring of a man who does not have hemophilia and a woman who is a heterozygous carrier?

A. There is a 25% chance that their sons will have hemophilia.

B. There is a 100% chance that their sons will have hemophilia.

**C. There is a 0% chance that their daughters will have hemophilia.**

D. There is a 50% chance that their daughters will have hemophilia.

**Sample Question SC.912.N.1.1**

The improvement of microscopy techniques in the late 1800a set the stage for the emergence of modern genetics because

A. it revealed new and unanticipated features of Mendel's pea plant varieties

**B. it allowed biologists to study meiosis and mitosis, revealing the parallels between the behaviors of genes and chromosomes**

C. it allowed scientists to see the DNA present within chromosomes

D. it led to the discovery of the mitochondria

**Rubric**

By what criteria will "performance of understanding" be judged?

Refer to the attached learning goal scale

| **Other Evidence:**<br>What other evidence needs to be collected in order to monitor student progress on these concepts and skills along the way? | **Self-Assessment/Reflection**<br>How will students reflect and self-assess their learning? |
|---|---|
| Pre and post-test<br>Response cards | Exit tickets<br>Journaling |

**STAGE 3: LEARNING EXPERIENCES, INSTRUCTION, AND RESOURCES**
What activities will help my students achieve the learning goals?

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|---|---|
| **W** hat **W** here | **What** is expected? How will you ensure that students are aware of the learning goals?<br>**Where** are your students? How will you establish your students' prior knowledge? |
| | |
| **H** ook **H** old | How will you **hook** students at the beginning of the unit?<br>How will you **hold** their attention throughout the units? |
| | |
| **E** xperience **E** xplore . | What critical input **experience** will help students **explore** the key ideas and essential questions? How will you **equip** your students with needed skills and knowledge? |
| | |
| **R** eflect **R** ethink **R** ehearsing **R** evising | How will you encourage students to **reflect** and **rethink**?<br>How will you guide students in the process of **rehearsing**, **revising**, and **refining** their work? |
| | |
| **E** xhibit **E** valuate | How will you help students to **exhibit** and **self-evaluate** their developing skills, knowledge and understanding throughout the unit? |
| | |
| **T** ailor | How will you **tailor** your instruction to meet the different needs, interests and abilities of all learners in your classroom? |
| | |
| **O** rganize | How will you **organize** and sequence the learning activities to maximize the engagement and achievement of all students? |
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|---|---|---|
| **Big Idea: Genetics and the Reproduction of Life** | | **Standard(s)/Benchmark(s): SC.912.N.3.1** Engage in scientific questioning to extend thinking or to guide investigations within the context of genetics |
| **Unit: Mendelian Genetics**<br><br>**Grade: 9-12** | | **Sample Activities** |
| **Score 4.0** | **In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**<br><br>**The student can:**<br>Use Mendel's laws of inheritance and various modes of inheritance to trace patterns of inheritance within my family or other families (contemporary or historical) | |
| **Score 3.0** | **The student can:**<br>a. Use Mendel's laws of segregation and independent assortment to analyze patterns of inheritance.<br>b. Discuss observed inheritance patterns caused by various modes of inheritance, including dominant, recessive, co-dominance, incomplete dominance, sex-linked, polygenic, and multiple alleles.<br><br>**The student exhibits no major errors or omissions** | |
| **Score 2.0** | **There are no major errors or omissions regarding the simpler details and processes as the student can:**<br>a. Identify and describe the difference between recessive and dominant traits.<br>b. Distinguish codominance patterns from incomplete dominance.<br>c. Explain the process of sex-linkage pattern of inheritance.<br>d. Describe multiple allele patterns of inheritance (Blood types)<br>e. Describe polygenic inheritance<br>f. Create Punnett square based on types of inheritance patterns<br>g. Use Punnett square to predict inheritance patterns<br><br>**However, the student exhibits major errors or omissions regarding the more complex ideas and processes** | |
| **Score 1.0** | **With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.** | |
| **Score 0.0** | **Even with help, no understanding or skills demonstrated.** | |