# Heredity and Malaria:

## Using the relationship between malaria and sickle cell to increase student understanding of heredity.

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**Abstract**

Every year our students struggle in two areas, molecular biology and heredity. This past year's EOC score sheet, 2017-2018, was no different. Each year I seek to find activities that will help students better understand the information they have learned and put it all together. My teaching does not usually follow a storyline with context-specific examples, but is more of a traditional approach. Students take notes, then complete practice problems for understanding. For my research, I will be focusing on the ability of my Biology students to comprehend and therefore apply concepts in the area of heredity if given context specific examples that follow a storyline. Specifically I will be focusing on mendelian genetics, probability, and pedigrees. I will be using the lesson by HHMI titled Natural Selection in Humans throughout my unit to help students apply what they are learning.

**Rationale**

Every year our students struggle in two areas, molecular biology and heredity. This past year's EOC score sheet, 2017-2018, was no different. Again, students did well in the ecology strand, but scored low in the molecular and heredity strands. Each year I seek to find activities that will help students better understand the information they have learned and put it all together. Usually I try hands on activities and graphic organizers, but these have fallen short on getting students to really understand the mechanism of inheritance and the outcomes. My teaching does not usually follow a storyline with context-specific examples, but is more of a traditional approach. Students take notes, then complete practice problems for understanding. According to a similar study performed in Turkey, students generally have lower interest in science material in secondary school (Demircioğlu, H., Demircioğlu, G., & Çalik, M. 2009). A context based storyline approach helps students to give meaning to the content and helps them understand the importance of the material in "real life". For my research, I would like to see if teaching students about heredity through a context based storyline unit will help them better understand the principles of heredity. Specifically, I will be using the HHMI Biointeractive lesson The Making of the Fittest: Natural Selection in Humans which looks at the link between sickle cell disease and its relationship to malaria.

**Intervention**

For my research, I will be focusing on the ability of my Biology students to comprehend and therefore apply concepts in the area of heredity if given context specific examples that follow a storyline. Specifically I will be focusing on mendelian genetics, probability, and pedigrees. I will be using the lesson by HHMI titled Natural Selection in Humans throughout my unit to help students apply what they are learning. I will choose one class as an experimental group to intersperse the HHMI lesson sections after each corresponding lesson, and a second class as my control group. At the end of the unit both the experimental group and the control group will take a unit exam where they will have to apply the concepts learned in throughout the unit. The

control class will receive the lesson as I teach it each year with notes on each topic, and a few hands on activities. The difference between the experimental and control group is that the experimental group will have the HHMI activities that follow the sickle cell and malaria storyline, and the control group will have activities that I have created that do not follow a storyline.

**Data collection and analysis**

- Heredity Mind Map (Pre/Post)
- Pre Assessment
- HHMI Natural Selection in Humans Lesson Sections
- Heredity Post Assessment

**Connections to CATALySES summer institute**

- Emerging pathogen content connecting malaria to sickle cell disease

**Literature cited**

Brokaw, A. (n.d.). Mendelian Genetics, Probability, Pedigree, and Chi-Square Statistics | HHMI's BioInteractive. Retrieved June 23, 2018, from https://www.hhmi.org/biointeractive/mendelian-genetics-probability-pedigree-and-chi-square-statistics

Demircioğlu, H., Demircioğlu, G., & Çalik, M. (2009). Investigating the effectiveness of storylines embedded within a context-based approach: The case for the Periodic Table. *Chemistry Education Research and Practice,10*(3), 241-249. doi:10.1039/b914505m

**Permissions**

No personal student data will be collected, no permissions are needed.

# LESSON PLAN

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| Title | Malaria and sickle cell disease: Using the relationship between malaria and sickle cell to increase student understanding of inheritance. |
| Essential Questions | 1. What is sickle cell disease?<br>2. What is malaria?<br>3. How is the sickle cell allele passed from parents to offspring?<br>4. How can pedigrees be used to track genetic traits through a family? |
| Subject | Biology |
| Grade Level | 9-10th Grade Regular and Honors |
| Science Concepts | • Mendelian Genetics<br>• Probability<br>• Pedigrees |
| Overall Time Estimate | This lesson can be completed in one to two 50 minute class periods. |

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| Vocabulary | • Codominance<br>• Dominant<br>• Genotype<br>• Hemoglobin<br>• Heterozygous<br>• Homozygous<br>• Incomplete<br>• Dominance<br>• Independent assortment<br>• Malaria<br>• Mendelian genetics<br>• Pedigree<br>• Phenotype<br>• Probability<br>• Recessive<br>• Red blood cells<br>• Sickle cell anemia<br>• Sickle cell disease | |
| Lesson Summary | Learning Objectives | Standards |
| This lesson will cover mendelian genetics, probability and pedigrees. Students will complete scenario-based questions from the HHMI lesson, interspersed in the unit at the appropriate areas as it relates to the teaching of the content. Students should have prior knowledge of the basics of Mendelian genetics (genotype, | By the end of this lesson, students will be able to:<br>• use Punnett squares to predict the frequencies of genotypes in the next generation based on the genotypes of the parents;<br>• understand the rules of probability as they relate to genetics problems;<br>• analyze pedigrees to deduce genotypes, phenotypes, and probabilities | • SC.912.L.15.15 Describe how mutation and genetic recombination increase genetic variation.<br>• 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, codominant, sex-linked, polygenic, and multiple alleles. |

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| phenotype, homozygous, heterozygous, incomplete dominance, and codominance) and the rules of probability. They should also be familiar with how to draw and interpret pedigrees (including standard symbols used therein), use pedigrees to show family relationships, and analyze the pattern of inheritance of a particular trait. | | |
| Materials | • HHMI Making of the Fittest: Natural Selection in Humans Film Quiz Questions 1-5 only (1 per student)<br>• HHMI Lesson Plan Mendelian Genetics, Probability, Pedigrees, and Chi-Square Statistics Handout (1 per student)<br>• Sickle Cell Video sheet (1 per student)<br>• Malaria reading and note taking guide (1 per student)<br>• Allele frequency activity sheet (1 per student)<br>• Pre and Post test (1 per student)<br>• Small plastic cups (4 per group)<br>• 75 red beans and 25 white beans (1 set per group) | |
| Background | **Hemoglobin** is a protein found in red blood cells; it transports oxygen to body tissues, where the oxygen is released from the hemoglobin molecule. The hemoglobin protein consists of four polypeptide chains: two alpha chains and two beta chains. The sickle cell mutation results in an amino acid substitution in the beta chain, replacing glutamic acid with valine. In individuals **homozygous** for the sickle cell allele, the hemoglobin tends to | |

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| | precipitate (or clump together) within the red blood cells when it is not bound to oxygen. This clumping causes **red blood cells** to assume an abnormal "sickled" shape. The sickle-shaped red blood cells block blood flow in blood vessels. Blocked blood flow can cause pain, serious infections, and organ damage.<br>Individuals **heterozygous** for the sickle cell allele produce both normal and mutant hemoglobin proteins. These individuals do not show symptoms of the disease and have mostly normal red blood cells. However, as these individuals have a mutation in one copy of the gene for the beta chain of hemoglobin, they do manifest some sickling of their red blood cells when in low-oxygen environments.<br>**Sickle cell disease** was almost always lethal, but now there are many therapeutic strategies to help individuals with the disease. Most people with sickle cell disease take medication for pain management. In addition, some patients receive blood transfusions to help them maintain a population of red blood cells that can carry oxygen throughout the body. Because infections are also common in those with sickle cell disease, some people take a daily regimen of antibiotics. Unlike sickle cell disease, which is inherited, **malaria** is a mosquito-transmitted disease caused by a parasite. A person who contracts malaria usually has flu-like symptoms at first, such as fever, muscle pains, and nausea. If the disease becomes severe, patients can experience confusion, severe anemia, and difficulty breathing, and they may even become comatose. The mosquitoes that can carry the malaria |

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| | parasite belong to the genus Anopheles. Four species in the genus Plasmodium, which are single-celled protists, can cause malaria. Malaria-causing parasites need both mammals and mosquitoes to complete their life cycles. When an Anopheles mosquito carrying a malaria parasite bites a human, the parasite is transmitted from the salivary glands of the mosquito to the human bloodstream. The parasites travel through the bloodstream to the liver, where they reproduce asexually in liver and red blood cells. Some of the parasites in the red blood cells enter sexual reproduction to produce gametocytes, which can be picked up by the mosquitoes that happen to feed on a malaria-infected human. In the gut of the mosquito, male and female gametocytes fuse developing an oocyst. After one to two weeks, the oocyst bursts and releases thousands of Plasmodium parasites, which can be transmitted to another human being when the mosquito feeds again. Contemporary strategies for dealing with malaria focus on both prevention and treatment. Highly effective prevention strategies include both avoiding mosquito bites—by sleeping under mosquito netting, keeping skin covered, and using insect repellent—and taking antimalarial drugs, such as mefloquine , which prevent the malaria parasite from establishing an infection in its human host. If a person does become infected with malaria, several drugs can effectively treat the person. However, as drug-resistant strains of malaria become more common, there is a need for novel treatments. |

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| Advanced Prep | • Copies of HHMI Lesson Sections (one per student)<br>• Copies of the sample mind map (one per group of students)<br>• Copies of pre assessment (one per student) |
| Procedure and Discussion Questions | **Day 1:**<br>1. Write the word heredity on the whiteboard, and ask the students to copy it onto a sheet of notebook paper. Ask the students to write everything that comes to mind when they think of the word Heredity around the word in the center. If necessary, you can scaffold this by asking students what it means to inherit something, and then ask them to write their thoughts. (5 mins)<br>2. After students have written their thoughts, ask them to draw lines that connect their words together, and write connecting phrases such as: type of, example of, etc. Model this for students using a sample mind map on the board. See attachments for sample. (5 mins)<br>3. Collect student mind maps, and pass out the pre assessment. Remind students that this pre assessment is just to understand what they already know about heredity before you begin the unit. (15 mins)<br>4. After students complete the pre assessment, begin a discussion about the mind maps and inheritance. On the board, construct a whole class mind may with linking lines (10 mins)<br>5. Explain to students you are going to play a video about sickle cell disease. In this unit they will be learning about heredity, and will be focusing on sickle cell disease and later malaria. As students watch the video, have them complete the video sheet. After the video, discuss the students answers. (10 mins)<br>a. What is sickle cell disease?<br>b. Sketch a diagram of a normal blood cell and a sickled blood cell side by side<br>c. How do you get sickle cell disease?<br>d. What are some symptoms of sickle cell disease?<br>e. Video link: https://www.youtube.com/watch?v=bEYqP8iZ8TE&index=111&list=WL<br>**Day 2**:<br>1. Conduct lesson on mendelian genetics and probabilities and have students take notes (25 mins)<br>2. Have students complete section 1 #1-3 of the HHMI lesson in small groups (20 mins)<br>**Day 3:**<br>1. Conduct lesson on other patterns of inheritance, including blood types, and have students take notes. (25 mins)<br>2. Have students complete section 1 questions 4 and 5 of the HHMI lesson. (20 mins) |

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| | **Day 4:**<br>1. Give students the reading on malaria to introduce the topic. Have students read the article in groups, each taking a turn and highlighting key information and filling out a note taking guide (20 mins)<br>a. What is malaria<br>b. Where is malaria most prevalent<br>c. What are the symptoms of malaria<br>2. Show students the HHMI video: Making of the Fittest: Natural Selection in Humans. Begin the video at 1:31. As students watch the video, they should record information about the relationship between sickle cell disease and malaria. (14 mins)<br>3. Have students respond to the prompt below. Students should cite evidence from the reading to support their answer. (10 mins)<br>. Dr. Allison discovered that protection against malaria is correlated with sickle cell. How does sickle cell protect people from malaria? Support your claim with evidence from your notes.<br>**Day 5:**<br>1. Students will complete a hands-on activity modeling allele frequency of sickle cell from the University of Washington Genome Sciences Outreach (50 mins)<br>**Day 6:**<br>1. Conduct a lesson on pedigrees and have students take notes (25 mins)<br>2. Have students complete section 2 questions 6-10 of the HHMI lesson. (20 mins)<br>**Day 7:**<br>1. Students will complete questions 8-10 of the HHMI Making of the Fittest: Natural Selection in Humans film guide. (15 mins)<br>2. Students will complete the post assessment (15 mins)<br>3. Students will complete their post Mind Map. (20 mins) |
| Assessment Suggestions | • Heredity Mind Map (pre/post)<br>• Pre Assessment<br>• Sickle Cell Video Sheet<br>• HHMI Natural Selection in Humans Lesson Sections<br>• Heredity Post Assessment |
| Extensions | • Malaria Reading |
| Resources/References | • Brokaw, A. (n.d.). Mendelian Genetics, Probability, Pedigree, and Chi-Square Statistics \| HHMI's BioInteractive. Retrieved June 23, 2018, from https://www.hhmi.org/biointeractive/mendelian-genetics-probability-pedigree-and-chi-square-statistics<br>• Chowning, J. T. (2007, May). *Sickle Cell Anemia: A Case Study Approach to Teaching High School Genetics*(M. Brown & M. |

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