Biology Instructional Segment on Inheritance (Part 2 of 2)

Student Science Performance	
Grade Level: Biology	**Title:** Not the Weakest Link
Topic: Patterns of Heredity in Sickle Cell	

Performance Expectations for GSE:

SB6. Obtain, evaluate, and communicate information to assess the theory of evolution.

b. Analyze and interpret data to explain patterns in biodiversity that result from speciation.

d. Develop and use mathematical models to support explanations of how undirected genetic changes in natural selection and genetic drift have led to changes in populations of organisms. (*Clarification statement:* Element is intended to focus on basic statistical and graphic analysis. Hardy Weinberg would be an optional application to address this element.)

SB3. Obtain, evaluate, and communicate information to analyze how biological traits are passed on to successive generations.

b. Use mathematical models to predict and explain patterns of inheritance. (*Clarification statement:* Students should be able to use Punnett squares (monohybrid and dihybrid crosses) and/or rules of probability, to analyze the following inheritance patterns: dominance, codominance, incomplete dominance.)

Lesson Performance Expectations:

Group Performance:

1. Obtain, evaluate, and communicate information to analyze how biological traits are passed on to successive generations
2. Obtain, evaluate, and communicate information to assess the theory of evolution.
3. Students carry out an investigation using different colors of beads to collect evidence to show change in frequency of the sickle cell allele in a population.
4. Students, in groups, use data from the bead activity to develop a mathematical model correlating the frequency of sickle cell alleles in a population
5. Students plan and carry out an investigation that would demonstrate the effect of random change in the population on an allele and resulting genotype frequencies.
6. Students research the heterozygote advantage online in order to construct an explanation for the persistence of sickle cell in the human population.

Individual Performance:

1. Students make a claim, collect, and analyze evidence from their investigation to support or refute their claim regarding change in allele frequency in the population.
2. Students construct written explanations for causes and effects of changes in traits in populations over time.
3. Students write lab report of findings.

Group Discussion:

1. Students engage in discussion to share models with the class.
2. Class participates in culminating group discussion regarding the implications their data has for persistence of traits in populations in a changing environment.

Additional notes on student supports

Materials:

Per group: *2 bags with a mix of 50 of one color and 50 of another color beads.*

Engaging Learners	**Phenomenon** Some individuals do not contract malaria if bitten by an Anopheles mosquito whereas others do. *Obtaining* On the board write, *"The anopheles mosquito's bite can give a person malaria but some people get bitten and do not get malaria." Now write 4-5 questions you have about that sentence. What do you want to know?* Once they have their four or five questions, have them share their questions and find common ones. Post them somewhere in the classroom. Students then watch 2 short video clips on how the Anopheles mosquito transmits malaria. ● HHMI BioInteractive: Malaria Life Cycle ● HHMI BioInteractive: Malaria and Sickle Cell Anemia ○ HHMI offers an in-depth teacher guide for this video, including suggested pause/discussion points and a student quiz. ● Bozeman Science: Cellular Variation; Video of some individuals contracting malaria while others do not (Play from 4 minutes 18 seconds through 6 minutes 38 seconds). After the videos, ask: ● *Were any of the questions were answered. Which ones?* ● *How can we find the other answers to our questions?* Post the unanswered questions in an accessible part of the room and when anyone finds an answer, they write it on a sticky note and post it. Carry out an investigation: Students carry out an investigation using different colors of beads to collect evidence to show change in frequency of the sickle cell allele in a population. A student data collection handout can be used to guide the start of the activity. *Teacher Notes: You will need 2 bags with a mix of 20 of one color and 20 of another color beads. The first color represents normal blood and the second color sickled blood cells. Students will randomly pull two beads out of the bag and record its color and then return the bead to the bag. The simulation will have 3 rounds. In the first round, all individuals (beads) pulled from the bag survive. In the second round if two sickle cell colored beads are pulled together, the individual dies. The 3rd round represents a malarial environment. Every other two normal beads that are pulled together die and every two sickle cell beads that are pulled together die. Those where one of each type of bead is pulled together live. Students calculate percent of traits surviving.* *Students should ultimately find that* ***the sickle cell trait is recessive, allowing individuals to be carriers who are not affected by the disease but may pass the trait to offspring.*** *Note the distinction between trait and allele. The sickle cell "trait" is recessive in the population; however, the sickle cell allele is Codominant. This is an opportunity to demonstrate Hardy-Weinberg principles.* *Students can also count the number of each allele left in their bags at the end of each round. This will show selection for the sickle cell allele in a malarial environment.*

	Evaluating Students, in groups, use data from the bead activity to develop a mathematical model correlating the frequency of sickle cell alleles in a population to why an individual may or may not contract malaria if bitten by an Anopheles mosquito. *Communicating* Students engage in discussion to share models with the class. *Additional notes on topic, focus, and phenomena.*
Exploring Revising Model	**Phenomenon** Changes in traits in populations can result due to only a few surviving after a disturbance. *Obtaining* Students plan and carry out an investigation that would demonstrate the effect of random change in the population on an allele and resulting genotype frequencies. This investigation can be centered around an actual scenario researched online or a created scenario modeled by students with classroom/craft objects. *Teacher Notes: Students can start with this Biology Corner Peppered Moth Simulation, or other simulation/activity. Students can then generate their own questions to begin their investigation. Some sample questions asked:* ● *How could we demonstrate selective pressures?* ● *How can we demonstrate non-random mating?* ● *What would happen to allele frequencies if a portion of the population were wiped out due to a natural disaster.* *Evaluating* Students make a claim, collect, and analyze evidence from their investigation to support or refute their claim regarding change in allele frequency in the population. *Communicating* Students revise their models regarding change in allele frequency in a population.
Explaining Finalizing Model	**Student Science Performance** *Evaluating* Students gather information online to explain how undirected changes in frequency of alleles affect patterns of inheritance. *Teacher Notes: Questions to initiate class discussion:* Q: What conditions must be present for Hardy-Weinberg Equilibrium to be in effect? Q: Why can evolution not happen if the Hardy-Weinberg Equilibrium is true in a population? Q: Many harmful genes are recessive and have been expressed in the human gene pool for hundreds of thousands and possibly even millions of years. How do you explain the persistence of these genes over such long periods of time in the face of such intense selective pressure against them? Q: What is dominance and recessive? Q: How can the Sickle Cell trait be recessive, and the sickle cell allele be codominant? Q: How can you calculate frequency of alleles in a population mathematically? Q: How do directional selection, stabilizing selection, and disruptive selection show natural selection at work in a population? Q: How can genetic drift affect prevalence of traits in a population?

	Communicating Students construct written explanations for causes and effects of changes in traits in populations over time. **Assessment of Student Learning** *Students are provided a rubric to formatively assess their written responses. Teacher provides feedback.*
Elaborating Applying Model to Solve Problems	**Phenomenon** The sickle cell trait, or heterozygote advantage, in the human population may increase fitness for the population over time. *Obtaining* Students research the heterozygote advantage online in order to construct an explanation for the persistence of sickle cell in the human population. *Teacher Notes: Students should note that whether the trait is an advantage depends on the environment considered.* *Evaluating* *How does sickle cell increase fitness for the human population in areas where malaria is present?* *Communicating* Students revise models and share in class discussion. **Assessment of Student Learning** Students peer review group models and teacher provides feedback.
Evaluation	*Evaluating* Students write lab report of findings. Students participate in giving peer feedback in addition to instructor feedback. *Communicating* Class participates in culminating group discussion regarding the implications their data has for persistence of traits in populations in a changing environment. **Assessment of Student Learning** Students write lab reports of their findings. Reports may be scored with a rubric.

SEP, CCC, DCI Featured in Lesson	**Science Essentials**
Science Practices	Obtaining, evaluating, and communicating information Analyzing and interpreting data Developing and using models
Crosscutting Concepts	Patterns Cause and Effect
Disciplinary Core Ideas	From ***A Framework for K-12 Science Education:*** LS1.B Growth and Development of Organisms LS3.A Inheritance of Traits LS3.B Variation of Traits LS4.A Evidence of Common Ancestry and Diversity

Name______________________________________Date__________________

Modeling Sickle Cell Inheritance

For this investigation, your group should have a mixed bag with 20 beads of one color and 20 beads of another color. The color _________________ will represent the normal blood allele, A, and the color ______________ will represent the sickle cell blood allele, S. You will pull two beads out of the bag at a time to represent one person's genotype (2 alleles).

Round 1:

For this round, you will randomly pull two beads from the bag and record the colors in the data table below. Record whether the person has sickle cell disease, the sickle cell trait (just one sickle cell allele), or if they have normal blood. Return the beads to the bag after each pull. *In this round, all individuals will survive.* You will repeat this 15 times.

	Bead Colors	Individual's Genotype	Individual's Phenotype	Did this individual survive?
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				

Round 2:

For this round, you will randomly pull two beads from the bag and record the colors in the data table below. Record whether the person has sickle cell disease, the sickle cell trait (just one sickle cell allele), or if they have normal blood. *In this round, those with sickle cell disease will die.* Return surviving beads to the bag after each pull and set the non-survivors aside. You will repeat this 15 times.

	Bead Colors	Individual's Genotype	Individual's Phenotype	Did this individual survive?
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				

Round 3:

For this round, you will randomly pull two beads from the bag and record the colors in the data table below. Record whether the person has sickle cell disease, the sickle cell trait (just one sickle cell allele), or if they have normal blood. *In this round, you are in an environment with malaria, and only those with the sickle cell trait will survive (heterozygotes). Homozygous normal and homozygous sickle cell people die*. Return surviving beads to the bag after each pull, and set the non-survivors aside. You will repeat this 15 times.

	Bead Colors	Individual's Genotype	Individual's Phenotype	Did this individual survive?
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				

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Patterns of Heredity and Selection

GSE: **SB3a, SB3b, SB3c, SB6d**

Anchoring Phenomenon:

Non-identical twin siblings do not look like each other or their parents.

Topic	**Focus**	**Lesson Phenomenon**	**GSE/Notes/Language**
Sexual Reproduction	Overview of sexual reproduction; include advantages and disadvantages in comparison with asexual reproduction.	DNA fingerprints of a child and parent or non-identical sibling are not identical. Offspring have the same number of chromosomes as their parents.	SB1b/SB2c/SB3c/SB6c **Biotechnology Link:** Closely related organisms have similar DNA fingerprints. Discussions on why DNA fingerprints and physical appearance of offspring are different from parents and non-identical siblings are beneficial in connecting this instructional segment with Structure and Function of Molecular Genetics and biotechnology, emphasizing that DNA fingerprints are shared between family members but will not be identical DNA sequences. Make connections between the evolutionary benefits of having variations in DNA.
Meiosis	A parent diploid cell divides into four genetically different haploid gametes; emphasize the phases of mitosis and chromosome movement.		SB1b/SB3a Compare with mitosis to note similarities and differences. Emphasize gametes divide twice including discussion of phases (prophase, metaphase, anaphase, & telophase).

Karyotypes and Chromosomal Mutations	Nondisjunction may occur during anaphase I or II; several chromosomal abnormalities may occur during crossing over.	Trisomy 21 is known as Down Syndrome.	SB2a/SB2b Connect chromosomal errors in DNA to protein synthesis and discuss implications that may arise.
Mendel's Law of Segregation and Punnett Squares	The two alleles in a diploid cell separate to form a haploid gamete that contains only one allele during meiosis. The allele separation in the gametes is displayed in the Punnett square cross as the parent alleles. Emphasize the passage of X and Y chromosomes in determining the probability of the sex of offspring Pedigrees can be introduced to help students understand carriers of recessive diseases.	Non-identical twin siblings do not look like each other or their parents Inheritance of the sickle cell allele is a random event that can increase or decrease fitness of the offspring.	SB3a/SB3b/SB6b/SB6d **Different Strokes for Different Folks** Use phenomenon examples to make a connection to evolution (genetic drift). Alternative phenomenon addressed in lesson: The Amish have a high rate of polydactyly. The Fugates of Kentucky have blue-tinted skin. Emphasize patterns in monohybrid crosses and simple dominance Clarify that the processes of meiosis, the Law of Segregation, and Punnett squares for probability occurs with each offspring that is produced (i.e. families are not guaranteed to produce two male and two female offspring although the probability of each is 50%.).

Mendel's Law of Independent Assortment and Dihybrid Crosses	The two traits tend to be assorted independently of each other in different gametes during meiosis. The allele separation in the gametes is displayed in the Punnett square cross as the parent alleles and must be duplicated for each trait.	People with sickle cell anemia do not have the same blood type.	SB3a/SB3b Use phenomenon examples to make a connection to evolution (natural selection) and advantages of sexual reproduction with increased genetic variation. Emphasize patterns seen in probability results of dihybrid crosses.
Non-Mendelian Genetics	Incomplete Dominance	Pink snapdragon may produce red, pink, and white snapdragons.	SB3a/SB3b/SB6b/SB6d Revisit random genetic variations that may cause an increase in fitness. Multiple Alleles can be mentioned as an extension with codominance of blood types. A connection using the inheritance of the skin color to the evolution of different skin color resulting from adapting to different biomes may be beneficial in connecting this instructional segment with Stability and Change in Ecosystems Polygenic Traits can be included as an extension but are not explicit in the standards. Phenomenon: Skin color, eye color, hair color, and height are traits that have a wide variation of phenotypes.
	Codominance	Children of a parent with Type AB blood and a parent with Type O blood will not have the same blood type as either parent.	

Biodiversity and Patterns of Selection	Connect these random genetic mutations in offspring to an increase in biodiversity These mutations may increase or decrease fitness; it tends to decrease fitness and leads to a stabilized population	Some individuals do not contract malaria if bitten by an *Anopheles* mosquito whereas others do. Changes in traits in populations can result due to only a few surviving after a disturbance. The sickle cell trait, or heterozygote advantage, in the human population may increase fitness for a population over time.	SB6b/SB6d Revisit that analyzing DNA sequences are beneficial in determining relatedness between organisms (ancestry of the same species or of different species). Revisit random genetic variations that may cause a change (increase or decrease) in fitness. Model stabilizing, directional, and disruptive selections noted in populations. Most speciation events occur due to reproductive isolation.

Anchoring Phenomenon:

Non-identical twin siblings do not look like each other or their parents.

Students should be able to explain the phenomenon using the following concepts:

- Parents produce haploid gametes through meiosis that join to produce an offspring through sexual reproduction.
- The gametes contain an allele for a trait that may be dominant or recessive.
- The combination of these alleles produces the genotype and phenotype of the offspring.
- Many alleles segregate and are assorted independently during the meiosis to produce variations in siblings.
- Punnett squares are useful in determining probability of inheriting traits from parents.
- Some alleles do not follow Mendelian genetics and may be codominant, or incompletely dominant.
- Errors may occur during meiosis and result in increased variation among offspring.

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Additional Supports for struggling learners:

The following supports are suggestions for this lesson and are not the only options to support students in the classroom. These supports target students that struggle with science material, this lesson or a previous lesson. These are generalized supports and do not take the place of IEP accommodations as required by each student's Individualized Education Program.

General supports for the following categories:

Reading:	Writing:	Math:
1. Provide reading support by reading aloud or doing partner reads 2. Have the teacher model what they are thinking when reading the text 3. Annotate the text with students so that they may refer to it as they work through the lab	1. The teacher can provide a sentence starter for the students. 2. The teacher can give students an audience to write to (i.e. Write a letter to your sibling explaining this topic). 3. The teacher can provide constructive feedback during the writing process to help students understand the expectations.	1. The teacher should model data collection in the activity. 2. The teacher may need to assist in calculating frequencies of alleles. 3. Some students may require a calculator.

Supports for this specific lesson if needed:

Performance expectations for instruction:

1. The teacher should provide multiple formats that the student can use to express their knowledge.
2. At the end of the lesson the teacher should reflect on the following topics:

   -The teacher should reflect on grouping of students. Was it beneficial and were all students able to contribute? Why or Why not?

   -The teacher should reflect on supports for struggling learners. Were the supports enough for the student population? Why or why not? Then make a list of other supports that the teacher can try in the classroom.

Engaging Learners: 1. The teacher should provide a graphic or an image that shows the sentence in a visual form for students that have trouble visualizing what the sentence is saying. 2. Students should write down anything that seems important as they view the videos. This will assist them in writing questions that are valuable. 3. Provide the students with the data collection handout to keep the students on task and collecting data. 4. Remind the students of the directions as needed. 5. Students may feel overwhelmed with creating a "mathematical" model. Some supports that could be offered to the students are, guiding questions, a template or intentional partner grouping. These things can be used to help this model not feel overwhelming to students. 6. Students may need additional time to construct the model.
Exploring: 1. Some students may feel that creating scenarios or finding scenarios through research to be a little open ended and stressful. The teacher should provide some scenarios for those students to research and find information that they can use for the investigation. 2. The questions provided in the teachers notes contain vocabulary that the students may not have encountered before or do not recall well. The teacher may need to assist in defining these words. 3. The teacher should provide a template for the students to make a claim, collect evidence, analyze evidence and support or refute their claim on. This will lessen time spent looking at a blank page for many students. 4. Students may need additional time to revise their model.
Explaining: 1. The teacher should provide discussion questions in advance to struggling students. Letting students that need additional processing time see the questions in advance increases the likelihood that struggling students will feel confident enough to participate. 2. The students should be given the opportunity to express their knowledge in various formats. This can include writing, drawing or explaining verbally.
Elaborating: 1. The teacher should provide a rubric so that the students can self-assess prior to peer review. This cuts down on embarrassment of the students as their peers and the class view their model.
Evaluating: 1. The teacher should provide a rubric for peer review to keep the discussion focused on what the student did well and where the student could improve the model 2. Writing can be a major struggle for some students. Some choice as to how students express their knowledge may be warranted. Students could express their knowledge in the form of a picture, cartoon, slides presentation, or verbally.

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