NGSS Connections

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Mystery of the Crooked Cell
Grade Level: Middle School

Performance Expectations: Students' ability to complete the following performance expectation(s) will be supported by participation in this activity.

MS-LS1-2: Develop and use a model to describe the function of a cell as a whole and ways parts of the cells contribute to the function.

MS-LS3-1: Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

MS-LS3-2: Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

MS-LS4-4: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

MS-LS4-6: Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

Dimension	NGSS Code or citation	Corresponding student task in activity
Disciplinary Core Idea	LS1.A Structure and Function • Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring.	Students explore how genes code for proteins, and that different proteins in red blood cells can affect how those cells function.
	LS3.A Inheritance of Traits • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. • Variations of inherited traits between parent and offspring arise from genetic differences that result	Students explore how a single mutation in the gene that codes for the protein hemoglobin can lead to changes in the structure and function of red blood cells. Students explore the probability of specific genes (sickle or normal hemoglobin) being passed from parent to offspring.

	from the subset of chromosomes (and therefore genes) inherited.	
	LS3.B: Variation of Traits • In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. • In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.	Students explore how offspring inherit a single allele from each parent, and the combination of the two alleles determines how genes at a particular locus function. Students explore how a random mutation in the gene that codes for hemoglobin can affect the structure and function of red blood cells, producing sickled cells. Some classes also explore heterozygote advantage, recognizing that in some areas, individuals with alleles (sickled and normal hemoglobin) may benefit by reducing risk of malaria while minimizing the negative impacts of sickle cell anemia when compared to homozygous individuals.
	LS4.B: Natural Selection • Natural selection leads to the predominance of certain traits in a population, and the suppression of others.	Some classes also explore heterozygote advantage, recognizing that in some areas, individuals with alleles (sickled and normal hemoglobin) may benefit by reducing risk of malaria while minimizing the negative impacts of sickle cell anemia when compared to homozygous individuals. This advantage has retained the sickled gene in the population.
	LS4.C: Adaptation • Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support	Students explore how having a mutated allele that codes for hemoglobin might convey a genetic advantage and therefore be selected for in specific environments (such as where the parasite that causes malaria is present).

	successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.	
Practice	Developing and Using Models • Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. • Develop and/or use a model to predict and/or describe phenomena. • Develop a model to describe unobservable mechanisms.	Students will use Punnett Squares to model the predict offspring ratios. Students will use a physical model to predict how changes in red blood cell shape (due to genetic differences in the genes that code for the hemoglobin protein) will affect blood flow in the body.
	Planning and Carrying out Investigations • Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.	Students will use protein gel electrophoresis to generate data to determine genotypes (at the genetic locus that codes for hemoglobin protein) of patients suspected of having sickle cell anemia.
	Analyzing and Interpreting Data • Analyze and interpret data to provide evidence for a phenomena.	Students will analyze the results of their protein gel electrophoresis test to determine if patients carry the mutated gene that causes sickle cell anemia.
	Using Mathematics and Computational Thinking • Use mathematical representations to describe and/or support scientific conclusions. • Apply mathematical concepts and/or processes (e.g. ratio) to scientific questions.	Students will use Punnett Squares to model the predict offspring ratios.
Crosscutting Concept	Patterns • Patterns can be used to identify cause and effect relationships. • Graphs, charts, and images can be used to identify patterns in data.	Students will look for patterns in family pedigrees related to the occurrence of sickle cell anemia, a disease that in inherited by offspring from their parents.

	Cause and Effect • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.	Students will explore the probability of offspring developing sickle cell anemia based on the genotypes of parents.
	Structure and Function • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among tis parts; therefore, complex natural systems can be analyzed to determine how they function.	Students will explore how the structure of red blood cells can affect their function.

Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Science Addresses Questions About the Natural and Material World

- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

Connections to Common Core State Standards

English Language Arts/Literacy	Mathematics
RST.6-8.3	PRACTICE.MP1
RST.6-8.4	PRACTICE.MP2
RST.6-8.7	PRACTICE.MP4
RST.6-8.9	CONTENT.6.RPA.1
	CONTENT.7.RPA.2