NGSS Connections

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Mystery of the Crooked Cell
Grade Level: High School

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

HS-LS1-1: Construct an explanation based on evidence for how the structure of DNA determines that structure of proteins, which carry out the essential functions of life through systems of specialized cells.
HS-LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
HS-LS3-2: Make and defend a claim based on evidence that inheritable genetic variations may results from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
HS-LS3-3: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
HS-LS4-2: Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organism that are better able to survive and reproduce in an environment.
HS-LS4-4: Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

Dimension	NGSS Code or citation	Corresponding student task in activity
Disciplinary Core Idea	LS1.A Structure and Function • Systems of specialized cells within organisms help them perform the essential functions of life. • All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that cod for the formation of proteins.	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 • Each chromosome consists of a single very long DNA molecule, and each gene on a chromosome is	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.

	particular segment of that DNA. The instructions for forming species' characteristic are carried in DNA.	
	LS3.B: Variation of Traits • Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations. Environmental factors can also cause mutations in genes and viable mutations are inherited. • Environmental factors also affect expression of traits and hence affect the probability of occurrence of traits in a population. Thus, the variation and distribution of traits observed depend on both genetic and environmental factors.	Students explore the probability of specific genes being passed from parent to offspring 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. In some classes, students explore how specific environmental conditions can cause cells to sickle when a preserved smear is made (old method of smear production).
	LS4.B: Natural Selection • Natural selection occurs only if there is both 1) variation in the genetic information between organism in a population and 2) variation in the expression of that genetic information that is, trait variation-that leads to differences in performance among individuals. • The traits that positively affect survival are more likely to be reproduced and thus are more common in the population.	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 some populations.
	LS4.C: Adaptation • Natural selection leads to adaptation, that is, to a population dominated by organisms that are	Students explore how having a mutated allele that codes for hemoglobin might convey a genetic advantage and therefore be selected for in specific environments

	anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.	(such as where the parasite that causes malaria is present).
Practice	Developing and Using Models • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.	In some classes, students use Punnett Squares to model the predict offspring ratios. Students explore the inheritance pattern of sickle cell anemia using family pedigrees.
	Planning and Carrying out Investigations • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	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 data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.	Students will analyze the results of their protein gel electrophoresis test to determine of patients carry the mutated gene that causes sickle cell anemia.
	Using Mathematics and Computational Thinking • Use mathematical, computational, and/or other algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.	In some classes, students use Punnett Squares to model the predict offspring ratios. Students explore the inheritance pattern of sickle cell anemia using family pedigrees.

Crosscutting Concept	Patterns • Students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena.	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 • Students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. The also propose causal relationships by examining what is known about smaller-scale mechanisms with the system.	Students will explore the probability of offspring developing sickle cell anemia based on the genotypes of parents. Students will use evidence from gel electrophoresis to support their claims about if the patient has sickle cell anemia.
	Structure and Function • Students infer the functions and properties of natural and designed objects and system from their overall structure, the way their components are sharped and used, and the molecular substructures of their various materials.	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

- Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and will continue to do so in the future.

Science Addresses Questions About the Natural and Material World

- Scientific knowledge indicates what can happen in natural systems-hot what should happen. The latter involves ethics, values, and human decisions about the use of knowledge.

Connections to Common Core State Standards

English Language Arts/Literacy	Mathematics
RST.9-10.4	PRACTICE.MP1
RST.9-10.7	PRACTICE.MP2
RST.11-12.4	PRACTICE.MP4
RST.11-12.9	