

## NGSS Tools Work: HSL3-3 Heredity: Inheritance and Variation of Traits for A Study of Traits

### Performance Expectation HS-LS3-2

**Make and defend a claim based on evidence that inheritable genetic variations may result from 1) new genetic combinations through meiosis, 2) viable errors occurring during replication, and/or 3) mutations caused by environmental factors.**

**Clarification Statement:** Emphasis is on using data to support arguments for the way variation occurs.

**Assessment Boundary:** Assessment does not include the phases of meiosis or the biochemical mechanisms of specific steps in the process.

### Performance Expectation HS-LS3-3

**Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.**

**Clarification Statement:** Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.

**Assessment Boundary:** Assessment does not include Hardy-Weinberg calculations.

### Performance Expectation HS-LS1-1

**Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out essential functions of life ~~through systems of specialized cells~~**

**Clarification Statement:** Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.

### Performance Expectation 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.**

**Assessment Boundary:** Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

## HS-LS3 Heredity: Inheritance and Variation of Traits

### LS3.A: Inheritance of Traits

- Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cells may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS-LS3-1)

### LS3.B: Variation of Traits

- In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. (HS-LS3-2)
- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depend on both genetic and environmental factors. (HS-LS3-2), (HS-LS3-3)

## HS-LS1 From Molecules to organisms: Structures and Processes

### LS1.A : Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life (HS-LS1-1)
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (secondary to HS-LS1-1)

*(Note: This Disciplinary Core Idea is also addressed by HS -LS3-1.)*

## HS-LS4 Biological Evolution: Unity and Diversity

### LS4.B: Natural Selection

- The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS-LS4-3)
- Natural selection occurs only if there is both (1) variation in the genetic information between organisms 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. (HS-LS4-2) (HS-LS4-3)

### LS4.C: Adaptation

- Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2)
- Natural selection leads to adaptation, that is, to a population dominated by organisms that are 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. (HS-LS4-3) (HS-LS4-4)

## Asking Questions and Defining Problems

Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

- Ask questions that arise from examining models or a theory to clarify relationships. (HS-LS3-1)

## Analyzing and Interpreting Data

Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to science and engineering questions and problems, using digital tools when feasible. (HS-LS3-3)

## Constructing Explanations and Designing Solutions

Construction explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS1-1)

## Engaging in Argument from Evidence

Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Make and defend a claim based on evidence about the natural world that reflects scientific knowledge and student-generated evidence. (HS-LS3-2)

## Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different material, the structures of different components, and the connections of components to reveal the structure's function and/or to solve a problem. (HS-LS1-1)

## Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS3-1) (HS-LS3-2)

## Scale, Proportion, and Quantity

- Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g. linear growth vs. exponential growth). (HS-LS3-3)



## A Study of Traits

**Grade:** 9-10 General Biology

**Length of unit:** Approximately 3 ½ weeks

**Nine lesson unit**

### Unit Overarching Goal

In plants and animals, similarities and differences among individuals within a species result from proteins coded for by the DNA inherited from their parents. Variations among individuals are the result of mutation, meiosis, and recombination through sexual reproduction.

### Unit Central Question

What is the best explanation for the similarities and differences we see in individuals within a species—not only for one species, but for every species of plant and animal?

Lesson	Main Learning Goal	Focus Question	Science Content Storyline
1	Individual organisms have characteristics that differ from others of the same species.	What might cause individuals to have versions of a trait that are different from others of the same species?	Individual organisms have characteristics that differ from other individuals of the same species. For example, different jaguars have different colored fur, some mosquitoes are resistant to insecticides, and some geese can fly at extreme altitudes. There are different explanations for why these variations occur. Evidence helps scientists evaluate the strengths and limitations of explanations.
2	Characteristics (different versions of a trait) that organisms exhibit are the result of proteins in their bodies. Proteins perform many jobs (functions) in cells. The function (job) of a protein depends on its specific structure. If the structure (sequence of amino acids) changes, the protein may not function in the same way.	What differences would you expect to find in two organisms of the same species that have different versions of a trait?	The characteristics (different versions of a trait) of an individual organism are the result of the proteins in that organism. In jaguars, a protein determines if an individual has spotted or black fur.
3	A protein's structure is determined by its amino acid sequence. The structure of a protein influences its function.	How can a protein determine the traits, and versions of a trait, of an individual organism?	The structure of a protein determines its function; if you change the structure, the protein may not function in the same way. Proteins are made up of amino acids. The specific sequence of amino acids determines the protein's structure and shape. If the amino acid sequence changes, the shape of the protein can change which can influence its function.
4	The structure of DNA contains information (code) for assembling amino acids into proteins. A segment of DNA	How does a cell assemble amino acids in the correct sequence to make a protein	Amino acid sequence is determined by DNA. DNA is found in the nucleus of cells and has a double helix structure composed of pairs of nucleotides with complementary nitrogenous bases. A sequence of DNA nucleotides, called a gene, contains the information

Lesson	Main Learning Goal	Focus Question	Science Content Storyline
	nucleotides that codes for a specific protein is called a gene.	that can do its job in the cell?	(code) for assembling amino acids into a specific protein.
5	An intermediate molecule, mRNA, transfers the DNA code for amino acid sequence from the nucleus to the cytoplasm where the protein is made.	How does the information in a DNA sequence found in the nucleus get to the cytoplasm where proteins are made?	DNA, and its code for the amino acid sequence of proteins, is contained in the nucleus of cells. However, proteins are made outside the nucleus in the cytoplasm of cells. RNA is an intermediate molecule that allows DNA to stay protected in the nucleus and proteins to be made in the cytoplasm.
6	The combination of genes that an organism has comes from its parents. These genes determine the version of the trait an organism displays.	Why do two parents sometimes have children that have the same version of a trait as they do and sometimes have children with a different version of the trait?	The fur color of a jaguar is determined by the combination of alleles (different forms of a gene) it receives from its parents. An offspring can be heterozygous or homozygous for a trait. Some alleles seem to be more influential for a trait because they are dominant.
7	DNA is packaged into chromosomes, which allows for new genetic combinations and variation through meiosis.	If individuals have the same version of one trait, will they also have the same version of other traits?	Alleles for a trait are passed from parents to offspring on chromosomes. Although an individual jaguar can be homozygous or heterozygous for a trait, such as fur color, it inherits different alleles in different patterns for other traits. This is possible because jaguars have multiple chromosomes that are sorted independently during meiosis.
8	An individual's traits are determined by the combination of genes they receive from their parents that code for a specific amino acid sequence to make a protein with a specific function.	How can multiple offspring of the same parents can have different versions of the same trait?	In meiosis, chromosome pairs are separated in the production of eggs and sperm. Chromosomes are then recombined through sexual reproduction. An individual's traits are the result of proteins coded for by the combination of genes they receive from their parents.
9	Using information about parental alleles, inheritance, and proteins in cells it is possible to make predictions about the traits of family members.	Is it possible for a family who all show the same version of a trait to have an individual with a different version of the trait? If so, how did that happen? If not, why not?	Pedigrees are a tool that can help analyze the traits of a family. Information from both classical and molecular genetics as well as tools such as pedigrees, provides evidence to explain how variation in a population's traits arise.