

LEARNING THROUGH PERFORMANCE

Variation and Heredity

GRADE 6



How do the environment and genetics affect who we are and how we are similar or different?

Teacher Edition

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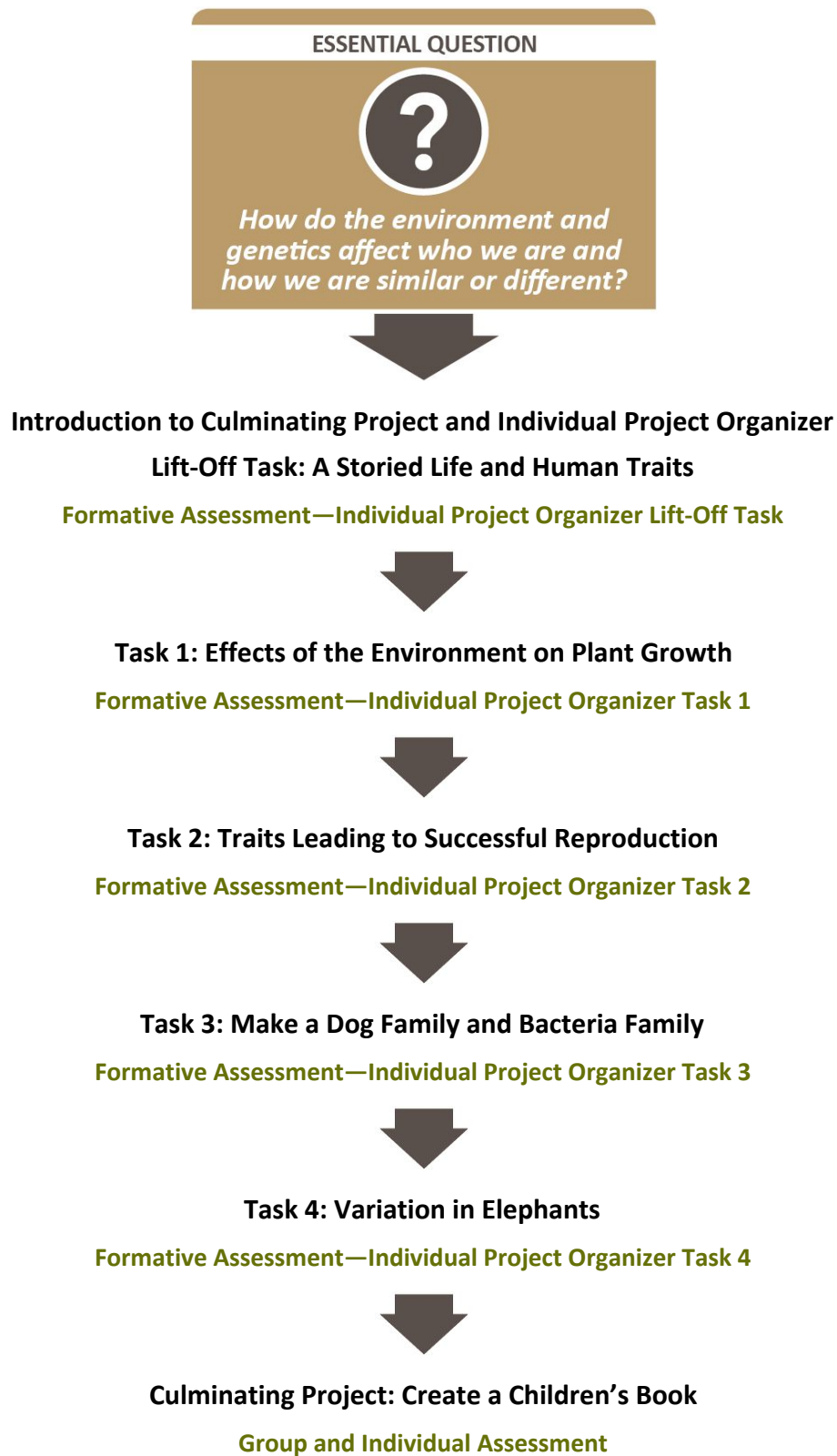
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How do the environment and genetics affect who we are and how we are similar or different?





Variation and Heredity Objectives

Unit	Content	Science and Engineering Practices	Equity and Groupwork	Language
Lift-Off A Storied Life and Human Traits	<ul style="list-style-type: none"> Identify human traits. 	<ul style="list-style-type: none"> Make an argument from evidence about whether humans are more similar to each other or more different from each other. 	<ul style="list-style-type: none"> Collaborate with teammates to identify human traits. 	<ul style="list-style-type: none"> Identify the theme and plot of a story.
Task 1 Effects of the Environment on Plant Growth	<ul style="list-style-type: none"> Determine how different environmental conditions affect plant growth rate. 	<ul style="list-style-type: none"> Plan and conduct an experiment about environmental effects on plant growth. Use data to construct an explanation about how the environment and genetics influence plant growth. 	<ul style="list-style-type: none"> Discuss and plan procedures. 	<ul style="list-style-type: none"> Write a lab report.
Task 2 Traits Leading to Successful Reproduction	<ul style="list-style-type: none"> Identify animal behaviors and plant structures that are associated with reproduction. 	<ul style="list-style-type: none"> Analyze evidence of inherited behavior and characteristics of both plants and animals that increase their ability to survive and reproduce. Make an argument based on evidence and scientific reasoning that agrees with one of the competing ideas for guppy mating. 	<ul style="list-style-type: none"> Summarize key points in video clips. Debate competing ideas with peers. 	<ul style="list-style-type: none"> Construct an argument based on evidence.
Task 3 Make a Dog Family and Bacteria Family	<ul style="list-style-type: none"> Distinguish between sexual and asexual reproduction. 	<ul style="list-style-type: none"> Develop a model to show how sexual reproduction results in variation of traits and asexual reproduction results in identical traits. 	<ul style="list-style-type: none"> Collaborate to identify patterns. 	<ul style="list-style-type: none"> Use language to describe diagrams.
Task 4 Variation in Elephants	<ul style="list-style-type: none"> Determine whether variations of living organisms are due to genetics or the environment. 	<ul style="list-style-type: none"> Construct a scientific explanation about how environmental and genetic factors influence the growth of organisms. 	<ul style="list-style-type: none"> Share observations with their group. 	<ul style="list-style-type: none"> Communicate ideas and listen actively.

Unit	Content	Science and Engineering Practices	Equity and Groupwork	Language
Culminating Projects <ul style="list-style-type: none"> Group: Create a Children's Book Individual: Heredity and Variation (genetics simulation with pigeons) 	<ul style="list-style-type: none"> Genetics and environment affect who we are and how we are different. Our traits increase the probability that we will survive and reproduce. 	<ul style="list-style-type: none"> Construct explanations. Develop and use models. 	<ul style="list-style-type: none"> Write a children's book together as a group. 	<ul style="list-style-type: none"> Write a book. Present a book. Explain their pigeon offspring.

Connect the Sixth Grade Variation and Heredity Unit with Prior Knowledge

This summary is based on information found in the NGSS Framework.

Disciplinary Core Ideas

LS1 From Molecules to Organisms: Structures and Processes

LS3 Heredity: Inheritance and Variation of Traits

This unit spans two different Disciplinary Core Ideas: LS1, From Molecules to Organisms: Structures and Processes, and LS3, Heredity: Inheritance and Variation of Traits.

In the Cells and Body Systems unit, students began studying LS1, From Molecules to Organisms: Structures and Processes, by formulating an answer to the question “How can we explain the ways cells contribute to the function of living organisms?” Students continue their work on Disciplinary Core Idea LS1 in this Variation and Heredity unit by focusing on the sub-idea LS1B, Growth and Development of Organisms. In the context of this Disciplinary Core Idea, students will achieve the following goals by the end of this unit:

- Construct an explanation about how environmental and genetic factors affect growth of organisms.
- Connect their explanation to the role of animal behaviors in reproduction of animals, as well as the dependence of some plants on animal behaviors for their reproduction.

Meanwhile, the performance expectations in LS3, Heredity: Inheritance and Variation of Traits, help students formulate an answer to the question “How do living organisms pass traits from one generation to the next?” The LS3 Disciplinary Core Idea from the NRC Framework includes two sub-ideas—LS3A, Inheritance of Traits; and LS3B, Variation of Traits—both of which are covered in this unit. By the end of this unit, students will be able to use models to describe the ways gene mutations and sexual reproduction contribute to genetic variation. The crosscutting concept of cause and effect is of paramount importance in this unit.

In this unit, students plan and carry out an investigation to provide evidence of environmental effects on plant growth. They combine their results with other evidence gathered throughout the unit to construct sound explanations about the environmental and genetic influences on the growth of organisms. Students also identify characteristic animal behaviors and plant structures that increase the probability of successful reproduction, and then model the variation that results as a consequence of reproduction.

Note that students have not previously been introduced to much of the basic vocabulary related to genetics, such as *trait*, *heredity*, *gene*, and *reproduction*. Students may have an experiential understanding of the effects of the environment and genetics on organisms, but they have not yet learned the internal processes and evidence-based thinking in the context of genetics.

The following are the sixth grade Variation and Heredity performance expectations.

- MS-LS1-4** Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. [Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.]
- MS-LS1-5** Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.] [Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.]
- 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. [Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.]

Prior Knowledge from Prior Grades

In first grade, students begin to think about why certain behaviors in plants and animals exist—for survival. At this stage, students recognize simple patterns between behavior of parents and offspring that aid survival. This understanding sets the foundation for discussions in this Variation and Heredity unit about behaviors that aid not just in survival, but in successful reproduction. This first grade performance expectation does not access the mechanism of heredity, but begins exposing students to concepts that they will later use to form their understanding of heredity. In the first grade, students also make observations of how offspring are similar, but not exactly like, their parents. This understanding introduces students to the concept of variation, but is limited to noticing patterns. It sets the stage for this Variation and Heredity unit, in which students will take these observations and attempt to explain why such variations occur.

The following are the first grade performance expectations.

- 1-LS1-2** Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive. [Clarification Statement: Examples of patterns of behaviors could include the signals that offspring make (such as crying, cheeping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring).]
- 1-LS3-1** Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents. [Clarification Statement: Examples of patterns could include features plants or animals share. Examples of observations could include leaves from the same kind of plant are the same shape but can differ in size; and, a particular breed of dog looks like its parents but is not exactly the same.]

In third grade, students move to more specific references to reproduction and the effects of genetics and environment on the growth of organisms. Students consider the life cycles of living organisms, including birth, growth, reproduction,

and death. Identifying these important events allows students to comfortably explore the events in different contexts in this Variation and Heredity unit, specifically focusing on variation due to reproduction and the effects of genetics and environment on growth. In third grade, students also begin to take an evidence-based approach to variation and inheritance and environmental influence, which sets the stage for students to use the same cognitive skills in combining these two ideas (genetics and environment) in this Variation and Heredity unit.

The following are the third grade performance expectations.

- 3-LS1-1** **Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.** [Clarification Statement: Changes organisms go through during their life form a pattern.]
- 3-LS3-1** **Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.** [Clarification Statement: Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans.]
- 3-LS3-2** **Use evidence to support the explanation that traits can be influenced by the environment.** [Clarification Statement: Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted; and, a pet dog that is given too much food and little exercise may become overweight.]

Connect Core Ideas, Scientific Practices, and Crosscutting Concepts from K–6

	First Grade	Third Grade	Sixth Grade
Core Idea LS1.B Growth and Development of Organisms	<ul style="list-style-type: none"> Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive. (1-LS1-2) 	<ul style="list-style-type: none"> Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (3-LS1-1) 	<ul style="list-style-type: none"> Animals engage in characteristic behaviors that increase the odds of reproduction. (MS-LS1-4) Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. (MS-LS1-4) Genetic factors as well as local conditions affect the growth of the adult plant. (MS-LS1-5) Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary to MS-LS3-2)
Core Idea LS3.A Inheritance of Traits	<ul style="list-style-type: none"> Young animals are very much, but not exactly, like their parents. Plants also are very much, but not exactly, like their parents. (1-LS3-1) 	<ul style="list-style-type: none"> Many characteristics of organisms are inherited from their parents. (3-LS3-1) Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (3-LS3-2) 	<ul style="list-style-type: none"> Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2)
Core Idea LS3.B Variation of Traits	<ul style="list-style-type: none"> Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways. (1-LS3-1) 	<ul style="list-style-type: none"> Different organisms vary in how they look and function because they have different inherited information. (3-LS3-1) The environment also affects the traits that an organism develops. (3-LS3-2) 	<ul style="list-style-type: none"> 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. (MS-LS3-2)
Science and Engineering Practices	<ul style="list-style-type: none"> Obtaining, Evaluating, and Communicating Information Constructing Explanations and Designing Solutions 	<ul style="list-style-type: none"> Developing and Using Models Analyzing and Interpreting Data Constructing Explanations and Designing Solutions 	<ul style="list-style-type: none"> Constructing Explanations and Designing Solutions Engaging in Arguments from Evidence
Crosscutting Concepts	<ul style="list-style-type: none"> Patterns 	<ul style="list-style-type: none"> Patterns Cause and Effect 	<ul style="list-style-type: none"> Cause and Effect

Standards and Objectives

Variation and Heredity Standards

NGSS Performance Expectations

- MS-LS1-4** Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. [Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.]
- MS-LS1-5** Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.] [Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.]
- 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. [Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.]

Disciplinary Core Ideas

LS1.B: Growth and Development of Organisms

- Animals engage in characteristic behaviors that increase the odds of reproduction. (MS-LS1-4)
- Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. (MS-LS1-4)
- Genetic factors as well as local conditions affect the growth of the adult plant. (MS-LS1-5)
- Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary to MS-LS3-2)

LS3.A: Inheritance of Traits

- Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2)

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. (MS-LS3-2)

Science and Engineering Practices**Engaging in Arguments from Evidence**

Engaging in arguments from evidence in grades 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

- Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS1-4)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in grades 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) 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. (MS-LS1-5)

Developing and Using Models

Modeling in grades 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena. (MS-LS3-2)

Crosscutting Concepts**Cause and Effect**

- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS1-4, MS-LS1-5)
- Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS3-2)

Standards by Task

Tasks	Descriptions of Tasks	Performance Expectations	Disciplinary Core Ideas and Crosscutting Concepts	Science and Engineering Practices
Lift-Off Task: A Storied Life and Human Traits	<ul style="list-style-type: none"> Students listen to you read a children's book to help them reflect on parts of a book that make it interesting and how a theme runs through a book. Students are introduced to genetic traits. 			
Task 1: Effects of the Environment on Plant Growth	<ul style="list-style-type: none"> Students examine variation in plant seeds to see phenotypic variation. Students design an experiment to identify the effect of environment on plant growth. Based on their data, students construct an explanation for how the environment and genetics influence plant growth. 	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. (MS-LS1-5)	LS1.B: Growth and Development of Organisms <ul style="list-style-type: none"> Genetic factors as well as local conditions affect the growth of the adult plant. (MS-LS1-5) LS3.A: Inheritance of Traits <ul style="list-style-type: none"> Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2) 	<ul style="list-style-type: none"> Planning Investigations Carrying Out Investigations Analyzing and Interpreting Data Constructing Explanations and Designing Solutions
Task 2: Traits Leading to Successful Reproduction	<ul style="list-style-type: none"> Students are provided with pictorial and empirical evidence that demonstrates how inherited behaviors and characteristics of both plants and animals can increase their ability to survive and reproduce. Students analyze competing ideas for guppy mating and make their argument based on evidence and scientific reasoning. 	Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. (MS-LS1-4)	LS1.B: Growth and Development of Organisms <ul style="list-style-type: none"> Animals engage in characteristic behaviors that increase the odds of reproduction. (MS-LS1-4) Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. (MS-LS1-4) 	<ul style="list-style-type: none"> Engaging in Arguments from Evidence

Tasks	Descriptions of Tasks	Performance Expectations	Disciplinary Core Ideas and Crosscutting Concepts	Science and Engineering Practices
Task 3: Make a Dog Family and Bacteria Family	<ul style="list-style-type: none"> Students model sexual reproduction (in dogs) and asexual reproduction (in bacteria) to see the resulting differences in variation. Students examine how genes from both parents contribute to the genes (and hence appearance) of their offspring. 	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-LS3-2)	<p>LS3.B: Variation of Traits</p> <ul style="list-style-type: none"> 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. (MS-LS3-2) <p>LS3.A: Inheritance of Traits</p> <ul style="list-style-type: none"> Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2) Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary to MS-LS3-2) <p>LS1.B: Growth and Development of Organisms</p> <ul style="list-style-type: none"> Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary to MS-LS3-2) 	<ul style="list-style-type: none"> Developing and Using Models
Task 4: Variation in Elephants	<ul style="list-style-type: none"> Students analyze the size of existing species of elephants to determine how they differ based on genetics and environment. 	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. (MS-LS1-5)	<p>LS3.A: Inheritance of Traits</p> <ul style="list-style-type: none"> Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2) <p>LS1.B: Growth and Development of Organisms</p> <ul style="list-style-type: none"> Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary to MS-LS3-2) 	<ul style="list-style-type: none"> Constructing Explanations and Designing Solutions

Tasks	Group Culminating Project	Individual Culminating Project	Science and Engineering Practices
Culminating Project	<p>Group Task:</p> <ul style="list-style-type: none"> Students write a children's story based on the theme of how genetics and the environment affect who we are, how we are different, and how our traits increase the probability that we reproduce to make offspring. 	<p>Individual Task:</p> <ul style="list-style-type: none"> Students learn about pigeon traits and pigeon breeding. They pick two parents with different traits to make their own pigeon. They explain to a friend how pigeon breeding works. They design a Q&A Fact Sheet for others who are interested in pigeon breeding. 	<ul style="list-style-type: none"> Constructing Explanations and Designing Solutions Developing and Using Models

Misconceptions

Knowing what is wrong is as important as knowing what is right.

Lift-Off Task: A Storied Life and Human Traits

Misconception	Accurate Concept
Traits are only things you can physically see.	Traits not only refer to physical characteristics, but behaviors as well.
Inheritance means that entire traits are passed down from either your mother or your father.	Your traits are a combination of your mother's and father's genes. Thus, each of your traits comes from both mother and father, not just one or the other.

Task 1: Effects of the Environment on Plant Growth

Misconception	Accurate Concept
Genes determine all of your characteristics, and cloned organisms are exact copies of the original. In other words, "living things are different because they are just born that way."	While genes play a very important role in development, environmental factors also play a role. As stated in the background section, epigenetics shows that gene expression can change from factors such as diet and exposure to toxins, without actually changing the genome itself.
Environmental conditions can change an organism's traits; thus, environment changes the genes of an organism.	The environment does not change the actual genetic makeup, just actual growth of the organism. As stated above, environment can affect gene expression, but not the genes themselves.
If the experimenter changes a variable, any result is definitely caused by that change.	It is also necessary to control all other variables to ensure that logical cause and effect can be attributed to the changed variable.

Task 2: Traits Leading to Successful Reproduction

Misconception	Accurate Concept
Genes and traits are the same thing.	A <i>gene</i> is a portion of your DNA that codes for a specific trait. A <i>trait</i> is the physical expression of that gene. For example, if you have a gene that codes for blue eyes, blue eyes are the trait.
Genes and alleles are the same thing.	Genes are units of heredity. Alleles are variants of a gene.
Organisms, like guppies, try to adapt over their lifetime.	Natural selection is a process, not a guiding hand. Individuals cannot try to adapt over their lifetime. Rather, in the case of guppies, they select traits in a mate that will make it more likely for their offspring to survive and reproduce. This results in a more common trait over generations in the population.
Genes only affect physical traits, not behaviors and personality.	Behaviors and personality are traits just like eye color and skin color. These are influenced by genes and the environment.

Organisms only have traits that help them survive.	Variation in traits arises all the time due to mutation and recombination, which do not always benefit the organism's survival. Furthermore, some traits do not help an organism survive, but rather help it reproduce. The case example of this is male guppies with their colorful scales.
Plants do not have reproductive structures or behaviors because they cannot move or think.	Plants have bright flowers to attract pollinators. Plants have different size stamens, pistils, and petals to encourage pollination by way of wind, water, birds, bats, and bees. Plants protect their young in the seed and have evolved seed structures that help disperse seeds to places where there is enough sun, water, and minerals for new plants to grow and survive.
Plants cannot reproduce because there is no male and female.	The pollen is the male reproductive part of the plant and the ovary/egg is the female part of the plant. Together they make a seed, which is equivalent to offspring.

Task 3: Make a Dog Family and Bacteria Family

Misconception	Accurate Concept
There is only one gene for every trait.	Most traits are controlled by many genes.
There are only two different alleles (dominant and recessive) for each gene.	Most traits are controlled by more than two alleles. For example, there are at least six genes that control cat coat color and three different alleles in each gene.
Environmental changes can be inherited (Lamarck view).	Environmental changes, unless they impact actual gene expression (epigenetics), cannot be inherited. For example, an amputated arm is not a trait that is passed on to the offspring.
Breeds and species are the same thing.	Different breeds can mate and produce fertile offspring. Different species cannot.
Offspring inherit alleles from mom or from dad.	Offspring inherit half their alleles from mom and half their alleles from dad when the sperm and egg combine.
Dominant traits are always seen more often.	Dominant traits are not always seen more often. For example, having five digits on your hand is a recessive trait, but is more common.
In dominant traits, there are only dominant alleles. In recessive traits, there are only recessive alleles.	With dominant traits, the genotype can be Tt or TT. In the first genotype example, the dominant allele masks the recessive allele, which is still present.
There are always two parents involved in reproduction.	In asexual reproduction, there is only one parent, which divides into two cells. As a result, the offspring is identical to the parent.

Task 4: Variation in Elephants

Misconception	Accurate Concept
Traits are influenced exclusively by either genetics or environment.	Traits are influenced by a combination of genetics and environment. In fact, these two factors often influence each other as well.
Identical twins are exactly the same; that is why they are called “identical.”	“Identical” in this context refers to their genes, but if exposed to different environmental factors, twins will most likely not be exactly the same.
Variation in the size of elephants only occurs because of different ages.	Variation in the size of elephants could also arise from genetics, diet, exposure to toxins, stress, exercise, etc.
All types of elephants are similar and can reproduce together.	There are different species of elephants, which means they cannot reproduce together and produce fertile offspring. Different species of elephants are genetically different.
If organisms can mate, then they belong to the same species.	For organisms to be considered the same species they must be able to mate and produce fertile offspring. Donkeys and horses, for example, can mate, but their offspring is not fertile, so they are classified as different species.

Culminating Projects

Essential Question: *How do the environment and genetics affect who we are and how we are similar or different?*

Introduction

There is extreme diversity in the life that surrounds us. We see all different types of living organisms—for example, plants, animals, mushrooms, seaweed, and bacteria (which we really can't see without a microscope). We see similarities in organisms. Most trees have roots, trunks, branches, leaves, and possibly flowers. If you look closely, there are also differences between the trees—for example, bark color and texture; leaf color, shape, and density; flower color and shape; and tree height. What we don't think about on a regular basis is why are there so many similarities and differences. The similarities are often thought of as being due to similar genes that have been passed down from the parents. But differences are also genetically driven, resulting in differences between parents and offspring, between different individuals in a population, and between different species. There is another factor that may cause similarities and differences between organisms, and that is environmental conditions surrounding the organisms. The amount of food and water an organism has available may determine the final height of an elephant, the number of leaves on a tree, or the color of a bird. In the end, diversity of life is due to both genetic and environmental factors.

In the group Culminating Project, students will write and illustrate a children's storybook to teach the reader about heredity and the interaction between traits and the environment.

In the individual Culminating Project, students will work with a pigeon genetics simulation to learn about pigeon traits and pigeon breeding. Students will pick two pigeon parents with different traits to make their own unique pigeon breed. They will design a model and write a scientific explanation for how traits get passed down and why there are variations between parents and offspring.

Materials

Group Culminating Project

Student Materials

- Blank paper
- Storyboard
- Colored pencils/pens or computer graphics

Individual Culminating Project

Student Materials

- Computer for each student

Group Culminating Project

Instructions

1. Introduce the Culminating Project at the start of the Lift-Off Task.
 - Read over the introduction and instructions found in the Student Edition.
 - The theme of the student's book will be to help a reader understand how genetics and the environment affect who we are, how we are different, and how we increase the probability that we will reproduce to produce offspring.
 - Note that the digital slide presentation for the Lift-Off Task provides information about parts of a story.
2. The plot of the book revolves around writing a story about a character, it's mate, and their offspring. The story should describe the character's adventures as it goes through life, overcomes a problem, has offspring, and is influenced by its environment. The actual plot and characters are up to the imagination of the students.
3. If possible, have some children's story books available for students to look at throughout the unit.
4. Tell students that as they work through the Individual Project Organizer, they may decide to change their story or character(s). This is acceptable and to be expected. Students don't actually do the final writing and illustrating until the end of the unit, so making changes along the way isn't problematic.
5. Make sure students fill out the Individual Project Organizer after each task. The Individual Project Organizer will help students think about different parts of their story along the way and help them apply scientific concepts into their story.
6. The table below summarizes how the Individual Project Organizer guides students through developing different components of their children's book.

Task	Individual Project Organizer	Culminating Project (Children's Book)
Lift-Off Task Read a children's story and identify human traits	<ul style="list-style-type: none"> • Draw one character for the book. • Identify traits for the character. • Describe the character. 	<ul style="list-style-type: none"> • Main character development • Traits
Task 1 Environmental effects on plants	<ul style="list-style-type: none"> • Draw a scene in the book. • Draw the character in the environment. • Show and explain in a short narrative how physical traits are affected by the environment. 	<ul style="list-style-type: none"> • Scene • Variation of traits due to environment
Task 2 Behaviors increasing chances of mating and producing offspring	<ul style="list-style-type: none"> • Decide on and draw traits that will attract a mate. • Draw a mate for the main character. • Decide on and write a short narrative about how traits/behaviors increase the mating or survival of offspring. 	<ul style="list-style-type: none"> • Attracting a mate • Survival of offspring
Task 3 Make a dog family and bacteria family	<ul style="list-style-type: none"> • Create alleles for the main character and its mate. • Show the alleles in the offspring. • Explain the difference in alleles between the parent and the offspring. 	<ul style="list-style-type: none"> • Inheritance of alleles/traits • Variation in offspring
Task 4 Genetic and environmental effects on elephants	<ul style="list-style-type: none"> • Create a storyboard of the plot showing how the character goes through life, attracts a mate, has offspring, and is influenced by his/her environment. 	<ul style="list-style-type: none"> • Plot • Option: Recommend that students continue with their storyboard in their science notebook or on a separate sheet of paper.

7. After students have gone through all the learning tasks and filled in all the Individual Project Organizers, students should finish their storyboard and then write and illustrate their children's book. The Individual Project Organizers should be used as reference for students to remind them of all components of their story.
 - Recommend that each group assign individual students to be in charge of parts of the story, like the writing or the illustrating or the coloring of the illustrations.
8. Have students engage in a peer review of other groups' children's books.
 - Ask students to fill out a Peer Feedback for Children's Book form for each book they review. (The form is in the Student Edition.)
 - Have groups trade their children's book with that of another group.
 - Ask that each group designate a reader to read the story out loud to their group. Groups should rotate the reader job for each new book they read.
 - Advise each group to give one positive comment and one constructive comment for each section of the form.

Individual Culminating Project

Time Needed

- 1.5 days for the pigeon breeding simulation
- 1.5 days for creating a unique pigeon

Instructions

1. Refer students to the Introduction of the Individual Culminating Project instructions in their Student Edition. Review the first page with students to introduce the project.
2. Refer students to the Day 1 section of the project in their Student Edition. It is recommended that you go through the task before students attempt the simulations so that questions about process can be addressed quickly. The simulation is easy once it has been played for a short amount of time. Students will play games 1–7 as shown below.
 - Games 1–2: Students will do a breeding simulation focusing on one trait (two alleles), the male and female alleles. Note that bird alleles for gender are different and backward as compared to human or dog alleles. Bird females are ZW and human females are XX. Bird males are ZZ and human males are XY. (This may not be an issue for students who have not internalized information about human sex alleles.)
 - Games 3–6: Students will do a breeding simulation focusing on two traits: crest and gender or slippers and gender.
 - The slippers simulation introduces the situation in which two alleles can equal an in-between trait. This situation is called *incomplete dominance*, but you do not need to introduce this term.
 - Game 7: Students will do a breeding simulation focusing on three traits: slippers, crest, and gender.
 - There are actually 26 simulation games that focus on multiple genetic situations (incomplete dominance, sex linked, multiple genes). Interested students can do other simulations.
3. Review the chart of game controls in the Student Edition before students use the simulation so that they are comfortable with the controls and can move on at their own pace.
4. Help students to access the Pigeonetics simulation.
5. Have students move through Games 1–7. After each game they should either diagram (model) what they did or check off a box to indicate that they played the game.
6. After the simulation, refer students to Day 2 of the project in their Student Edition. Have them follow the instructions to make their own pigeon breed.
7. Students can move through Day 2 at their own pace. Students will be assessed on their work in Day 2.

Assess the Individual Culminating Project

The Individual Culminating Project will be assessed using:

- The Science and Engineering Practices Rubric
 - “Constructing Explanations and Designing Solutions” row
 - “Developing and Using Models” row
- The Science Content Rubric

Science Content Rubric

Assess Using Individual Culminating Project Script

SCIENCE CONTENT RUBRIC				
THE STUDENT DEMONSTRATES THEIR SCIENTIFIC KNOWLEDGE OF THE FOLLOWING CONTENT STANDARD	EMERGING	DEVELOPING	PROFICIENT	ADVANCED
In sexually reproducing organisms, each parent contributes (at random) half of the genes acquired 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. (LS3.B)	The concept of how one allele moves from each parent to the pigeon offspring is modeled and/or explained inappropriately and/or incorrectly .	The concept of how one allele moves from each parent to the pigeon offspring is modeled and/or explained correctly but incompletely .	The concept of how one allele moves from each parent to the pigeon offspring is modeled and/or explained correctly and completely .	The concept of how one allele moves from each parent to the pigeon offspring is modeled and/or explained in detail, correctly and completely .
Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (LS3.A)	The concept that variation between the parent and pigeon offspring is a result of different genes on chromosomes is modeled and/or explained inappropriately and/or incorrectly .	The concept that variation between the parent and pigeon offspring is a result of different genes on chromosomes is modeled and/or explained correctly but incompletely .	The concept that variation between the parent and pigeon offspring is a result of different genes on chromosomes is modeled and/or explained correctly and completely .	The concept that variation between the parent and pigeon offspring is a result of different genes on chromosomes is modeled and/or explained in detail, correctly and completely .
Genetic factors as well as local conditions affect the growth of an adult organism. (LS1.B) *DCI has been expanded from plant to organism to align with PE	The concept that the environment as well as genetics affects the growth of pigeons is explained inappropriately and/or incorrectly .	The concept that the environment as well as genetics affects the growth of pigeons is explained correctly but incompletely .	The concept that the environment as well as genetics affects the growth of pigeons is explained correctly and completely .	The concept that the environment as well as genetics affects the growth of pigeons is explained in detail, correctly and completely .

Science and Engineering Practices Rubric

The Variation and Heredity Unit will be assessed using the highlighted rows.

SCIENCE AND ENGINEERING PRACTICES RUBRIC				
SCORING DOMAIN	EMERGING	DEVELOPING	PROFICIENT	ADVANCED
ASKING QUESTIONS AND DEFINING PROBLEMS <input type="checkbox"/> No Evidence*	<p>Asks general questions that cannot be investigated.</p> <p>Writes a problem or design statement but it does not match the intent of the problem or the need of the client.</p>	<p>Asks specific questions that can be investigated but do not require empirical evidence.</p> <p>Writes a problem or design statement that matches the intent of the problem or the need of the client with minor errors.</p>	<p>Asks questions that require empirical evidence to answer.</p> <p>Writes a problem or design statement that accurately matches the intent of the problem or the needs of the client.</p>	<p>Asks questions that require empirical evidence to answer and evaluates the testability of the questions.</p> <p>Writes a problem or design statement that accurately and completely matches the intent of the problem or the need of the client.</p>
DEVELOPING AND USING MODELS <input type="checkbox"/> No Evidence*	<p>Makes models (drawings, diagrams, or other) with major errors.</p> <p>Explains the limitations of the model with major errors.</p>	<p>Makes models (drawings, diagrams, or other) to represent the process or system to be investigated with minor errors.</p> <p>Explains the limitations of the model with minor errors.</p>	<p>Makes accurate and labeled models (drawings, diagrams, or other) to represent the process or system to be investigated.</p> <p>Explains the limitations of the model as a representation of the system or process.</p>	<p>Makes accurate and labeled models (drawings, diagrams, or other) to represent the process or system to be investigated and explains the model.</p> <p>Explains the limitations of the model as a representation of the system or process and discusses how the model might be improved.</p>
PLANNING INVESTIGATIONS <input type="checkbox"/> No Evidence*	<p>Plans an investigation that will not produce relevant data to answer the empirical question(s).</p> <p>Plans a design that does not match the criteria, constraints, and intent of the problem.</p>	<p>Plans an investigation that will produce some relevant data to answer the empirical question(s).</p> <p>Plans a design and writes an explanation that partially matches the criteria, constraints, and intent of the problem.</p>	<p>Plans an investigation that will produce relevant data to answer the empirical question(s) and identifies the dependent and independent variables when applicable.</p> <p>Plans a design and writes an explanation that accurately and adequately matches the criteria, constraints, and intent of the problem.</p>	<p>Plans an investigation that will completely produce relevant and adequate amounts of data to answer the empirical question(s) and identifies the dependent and independent variables when applicable.</p> <p>Plans a design and writes a detailed explanation that accurately and completely matches the criteria, constraints, and intent of the problem.</p>
CARRYING OUT INVESTIGATIONS <input type="checkbox"/> No Evidence*	<p>Writes procedures that lack detail so the procedures cannot be duplicated by another person.</p>	<p>Writes procedures with enough detail that another person can duplicate (replicable) but does not conduct a sufficient number of trials.</p>	<p>Writes detailed replicable procedures with descriptions of the measurements, tools, or instruments and conducts adequate number of trials.</p>	<p>Writes detailed replicable procedures with descriptions of the measurements, tools, or instruments and conducts adequate number of trials with an explanation for the proposed data collection.</p>

* If there is no student response then check the "No Evidence" box.

The Variation and Heredity Unit will be assessed using the highlighted rows.

SCIENCE AND ENGINEERING PRACTICES RUBRIC				
SCORING DOMAIN	EMERGING	DEVELOPING	PROFICIENT	ADVANCED
ANALYZING AND INTERPRETING DATA <i>"Accurately labeled" means inclusion of title, column titles, description of units, proper intervals.</i> <input type="checkbox"/> No Evidence*	<p>Makes spreadsheets, data tables, charts, or graphs that are not accurately labeled or do not display all the data.</p> <p>Uses inappropriate methods or makes major errors analyzing the data.</p>	<p>Makes accurate and labeled spreadsheets, data tables, charts, or graphs to summarize and display data but does not arrange the data to examine the relationships between variables.</p> <p>Uses appropriate methods but makes minor errors analyzing the data.</p>	<p>Makes accurate and labeled spreadsheets, data tables, charts, and/or graphs to summarize and display data and arranges the data to examine relationships between variables.</p> <p>Uses appropriate methods to accurately and carefully identify patterns or explains possible error or limitations of analyzing the data.</p>	<p>Makes accurate and labeled spreadsheets, data tables, charts, and/or graphs and uses more than one of these methods to summarize and display data; arranges the data to examine relationships between variables.</p> <p>Uses appropriate methods to accurately and carefully identify patterns and explains possible error or limitations of analyzing the data.</p>
CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS <input type="checkbox"/> No Evidence*	<p>Constructs an explanation that includes an inappropriate claim, inaccurate evidence, and/or unclear reasoning.</p> <p>Uses no data to evaluate how well the design answers the problem and the redesign of the original model or prototype is inappropriate or incomplete.</p>	<p>Constructs or evaluates an explanation consisting of minimal claim(s), limited sources of accurate evidence, and/or minimal reasoning.</p> <p>Uses minimal data to evaluate how well the design answers the problem and describes an appropriate redesign of the original model or prototype with minor errors.</p>	<p>Constructs or evaluates an explanation that includes a claim, multiple sources of accurate evidence, and reasoning using accurate and adequate scientific ideas or principles.</p> <p>Uses adequate data to evaluate how well the design answers the problem and accurately explains an appropriate redesign of the original model or prototype.</p>	<p>Constructs, evaluates, or revises an explanation that includes a claim, multiple sources of accurate evidence, and reasoning using accurate and adequate scientific ideas or principles.</p> <p>Uses adequate data to evaluate how well the design answers the problem and accurately provides a detailed rationale for the appropriate redesign of the original model or prototype.</p>
ENGAGING IN ARGUMENTS FROM EVIDENCE <input type="checkbox"/> No Evidence*	<p>Constructs an argument that includes an inappropriate claim, inaccurate evidence, and/or unclear reasoning.</p>	<p>Constructs or evaluates an argument consisting of minimal claim(s), limited sources of evidence, or minimal reasoning.</p>	<p>Constructs and/or evaluates an argument consisting of appropriate claim(s), multiple sources of evidence, and reasoning using accurate and adequate scientific ideas or principles.</p>	<p>Constructs, evaluates, or revises an argument consisting of appropriate claim(s), multiple sources of evidence, and reasoning using accurate and adequate scientific ideas or principles.</p>
OBTAINING, EVALUATING, AND COMMUNICATING INFORMATION <input type="checkbox"/> No Evidence*	<p>Communicates information that is inaccurate and/or inconsistent with the evidence.</p>	<p>Communicates accurate but minimal information consistent with the evidence but does not explain the implications or limitations of the investigation or design.</p>	<p>Communicates accurate, clear, and adequate information consistent with the evidence and explains the implications and/or limitations of the investigation or design.</p>	<p>Communicates accurate, clear, and complete information consistent with the evidence and provides a rationale for the implications and limitations of the investigation or design.</p>

* If there is no student response then check the "No Evidence" box.

Materials

Lift-Off: A Storied Life and Human Traits

Teacher Materials

- “A Storied Life and Human Traits” digital slide presentation
- Children’s book; recommendations:
 - *Elmer the Patchwork Elephant* by David McKee (addresses the idea that being different is okay)
 - *The Day Jimmy’s Boa Ate the Wash* by Trinka Hakes Noble
 - *If You Give a Mouse a Cookie* (or any of the others in this series) by Laura Numeroff
 - *Because I Stubbed My Toe* by Shawn Byous
 - *The Lorax* by Dr. Seuss (long version)
 - *Where Once There Was a Wood* by Denise Fleming
 - *Cleaning Day* by D. H. Figueredo
 - *First Day in Grapes* by L. King Perez

Task 1: Effects of the Environment on Plant Growth

Student Materials

Part I:

- Bag of mixed beans
- Metric ruler

Part II:

- Kidney beans (approximately 6 per group—3 for the experimental group and 3 for the control group)
- Paper towels (used to make “growth chambers”)
- Plastic plates (to put growth chambers on) or plastic bags (to store growth chambers in)
- Permanent pens (to label growth chambers)
- Possible environmental factors:
 - Vinegar (This a weak acid.)
 - Detergents/soaps (These are bases.)
 - Fertilizer (This adds minerals.)
 - Heat (Use a heat lamp, but cover beans up so light is not a factor.)
 - Cold (Put beans in a refrigerator.)
 - Dark (Put beans in a paper towel.)
 - Light (Don’t cover beans in a paper towel, but make sure there is lots of water under under the bean for germination. Perhaps put beans in a container with a half inch of water.)
 - Wind (Use a fan.)
- Small cups or beakers (to measure the amount of water the beans are given every day)
- Ruler (to measure bean growth; have both metric and English standard rulers available, since students will decide what units they want to use)
- Graph paper
- Large poster paper (to draw and display each group’s graph of data)

Task 2: Traits Leading to Successful Reproduction**Student Materials**

per group

- Computer to play videos
- Video clips (These videos were selected because they specifically show how different animal behaviors and plant structures help animals and plants reproduce, which is the focus of this task's performance expectation.)
 - Pronghorn bucks battle for dominance: <https://youtu.be/qJ9s6WF68LQ>
 - Peacock mating dance display: <https://youtu.be/jTBHiZtnCsA>
 - Matriarch Elephants Protect Baby Elephant from Crocodile Attack: <https://youtu.be/BGY0BHmjEtg>
 - Amazing Animal Babies: Emperor Penguin Chicks: <https://youtu.be/lf26jtJfL30>
 - Flower Reproduction: https://youtu.be/YqM6rgB_l_o
 - Pollination Rock: <https://youtu.be/V5yya4eRLw>
 - Seed Dispersal: <https://youtu.be/j1hRxuy1ezQ>
 - Biggest flower in the world: <https://youtu.be/FHaWu2rcP94>
 - Butterfly pollination: <https://youtu.be/gUJlcKpzH5E>
 - Pine pollen blown by the wind: https://youtu.be/V_9palHvAlc
 - Guppy mating dance!: <https://youtu.be/1tKOlc0qReQ>
- Red and green markers

Task 3: Make a Dog Family and Bacteria Family**Student Materials**

per student

Part II

- Dog Family Picture Frame handout (see Handout: VARHER_Task3_Handouts)

Part V

- Bacteria Family Picture Frame (see Handout: VARHER_Task3_Handouts)

per group

Part I

- Domestic Dog Pictures Resource Card (see Handout: VARHER_Task3_Handouts)
- Animal and Plant Reproduction Resource Card (see Handout: VARHER_Task3_Handouts)

Parts II and III

- Domestic Dog Pictures Resource Card (see Handout: VARHER_Task3_Handouts)
- Dog Traits and Alleles Resource Card (see Handout: VARHER_Task3_Handouts)
- 7 pennies with alleles attached to them (using paper and tape or stickers)
 - 2 pennies with a capital letter on each side of the coin
 - 2 pennies with a capital letter on one side and a small letter on the other side of the coin
 - 2 pennies with a small letter on each side of the coin
 - 1 penny with no letters (alleles) on it for flipping to identify (TT) or (Tt)

Part IV

- Bacteria Resource Card (See Handout: VARHER_Task3_Handouts)

Parts V and IV

- Bacteria Resource Card (See Handout: VARHER_Task3_Handouts)
- Bacteria Traits Resource Card (See Handout: VARHER_Task3_Handouts)
- Optional: A few pennies with only capital letters on each side and/or lowercase letters on each side of the coin

Teacher Materials

- "Variations and Heredity Task 3" digital slide presentation

Task 4: Variations in Elephants

- none

Unit Essential Question

How do the environment and genetics affect who we are and how we are similar or different?

Introduction

Over the course of this unit, students will be designing and writing a children's book with the theme of variation and heredity. They will create their own characters, setting, and plot, and describe a character's adventures as the character goes through life, struggles to survive, has offspring, and is influenced by their environment. In this task, students will first listen to you read a children's book to help them think about how stories are written to engage the reader. Students will discuss the plot, the characters, and the illustrations through the lens of a reader and a writer. The goal of this part of this task is to encourage students to start to imagine details in their story.

The second part of this task introduces students to science concepts that are woven through this unit. More specifically, students are introduced to the concepts about what a trait is, how traits vary from individual to individual, and how traits are inherited or are a result of environmental influences. Students will identify their own traits and compare their findings with those of their classmates. Students will discuss the variation of traits as being inherited or due to environmental changes. Finally, students will use evidence from their class data to take a stand on whether humans are more similar to each other or different from each other.

Objectives

Students will be able to

Content

- Identify human traits.
- Identify the influence of genetic and environmental factors on human traits.

Science and Engineering Practices

- Make an argument from evidence about whether humans are more similar to each other or more different from each other.

Equity and Groupwork

- Collaborate with teammates to identify human traits.

Language

- Identify the plot, theme, setting, characters, and engaging characteristics of a children's book.

Academic Vocabulary

- characteristic
- dominant
- environment
- gene
- heredity
- inheritance, inherited
- plot
- recessive
- theme
- trait
- variation

Language of Instruction

- cause
- effect
- gather
- typical

Timing

This task can be completed in 3 class periods (based on 45-minute periods).

- Part I • Example of an Engaging Story with a Message (1 class period)
- Part II • Identify Human Traits (1 class period)
- Part III • Connect to the Culminating Project and Assessment (0.5–1 class period)

Teacher Materials

- “A Storied Life and Human Traits” digital slide presentation
- Children’s book; recommendations:
 - *Elmer the Patchwork Elephant* by David McKee (addresses the idea that being different is okay)
 - *The Day Jimmy’s Boa Ate the Wash* by Trinka Hakes Noble
 - *If You Give a Mouse a Cookie* (or any of the others in this series) by Laura Numeroff
 - *Because I Stubbed My Toe* by Shawn Byous
 - *The Lorax* by Dr. Seuss (long version)
 - *Where Once There Was a Wood* by Denise Fleming
 - *Cleaning Day* by D. H. Figueredo
 - *First Day in Grapes* by L. King Perez

Background Knowledge

Genetics is an interesting and intriguing subject for most students. Students typically become curious about inheritance, genetics, and traits because these concepts directly relate to students' lives. They often have interesting, thoughtful, and scientific questions that lead to engaging discussions. Included in this background are some details about the science of genetics.

Human Traits

Human traits can be defined by:

1. Dominant or recessive genes (Mendelian genetics)
2. Codominant, incomplete dominant, sex-linked, sex-influenced, and multiple-allele genetics
3. The environment

Dominant Versus Recessive Genes (Mendelian Genetics)

Some genes are dominant, while other genes are recessive. The recessive gene is most often a mutation of the dominant gene and is usually seen less often. For example, in white flowers, the recessive gene is white, which means the flower has a recessive gene that missing the red protein, resulting in a white flower. In skin color, an albino gene is a mutation in the gene that produces melanin, the protein that colors skin. If the melanin gene is mutated, the person cannot make melanin, resulting in completely white skin. Note: Skin color is actually a situation in which the color is determined by multiple genes, so it is a trait that is more complex than just dominant and recessive.

Human Traits	Dominant/Recessive Facts
Earlobes	The dominant trait is free-hanging earlobes, sometimes called detached earlobes. The recessive trait is lobes that are attached directly to the head, sometimes called attached earlobes.
Tongue Rolling	The dominant trait is the ability to roll your tongue. The recessive trait is not being able to roll your tongue. The recessive trait is a mutation in a gene coding for a muscle that helps the tongue roll.
Widow's Peak	A widow's peak is dominant. A straight hairline is recessive.
Mid-Digit Hair	Hairy mid-digits is the dominant trait. The absence of hair on the mid-digits is the recessive trait. Hairy mid-digits is when there is hair on one or more of the mid-digits between the knuckles.)
Hitchhiker's Thumb	No hitchhiker's thumb, or a straight thumb, is dominant. Hitchhiker's thumb, or a curved thumb, is recessive.
Dimples	Dimples are dominant. They are best seen when smiling. There may be a dimple only on one side, or on both sides. The recessive trait is having no dimples.
Hand Clasp	The dominant trait is placing the left thumb on top of the right thumb when the hands are clasped (without thinking about it). The recessive trait is right thumb over left.
Cleft Chin	A prominent cleft is dominant. Females appear to be less conspicuously affected than males. No cleft is recessive.
Face Freckles	Face freckles are dominant. No face freckles is the recessive trait.
Handedness	Right-handedness is the dominant trait. However, scientists think that the recessive form of the gene does not cause left-handedness, but rather results in no dominance for either; thus, the handedness becomes a 50–50 chance.

Eye Color	Eye color (as well as hair and skin color) is a complex trait. The main pigment that colors the eyes is melanin—the more melanin, the darker the color. Eye color is controlled by more than one allele, which is why there is such a variation in this trait. Essentially, blue is recessive compared to green, and brown is dominant. Hazel eyes don't really change color, they simply reflect the colors being worn that day.
Hair Color	Hair color (as well as eye and skin color) is a complex trait. The main pigment that colors hair is melanin—the more melanin, the darker the color. Hair color is controlled by more than one allele, which is why there is such a variation in this trait. Essentially, blonde hair is recessive compared to red and brown, and black is dominant.

Codominant, Incomplete Dominant, Sex-Linked, Sex-Influenced, and Multiple-Allele Genetics (Non-Mendelian Genetics)

The following are genetic situations that Gregor Mendel did not discover—they were discovered later. This information exemplifies the complexity of genetics. Most traits do not fit into the simple dominance and recessive category, and for sixth graders all these different situations can be overwhelming. Thus, this information is intended just to be background knowledge for you and to help guide you if questions are brought up and further investigation is warranted.

The following information is not meant to be taught in sixth grade.

Non-Mendelian Genetic Situation	Definition	Example
Codominance	Codominance is a genetic condition in which neither allele in the heterozygote is dominant or recessive. When an individual has both alleles in a gene pair in a heterozygote, both alleles are expressed, and the offspring has both traits.	<ul style="list-style-type: none"> When a cow has both the brown and white allele and is spotted brown and white When a human has both the A and B blood type allele and has AB blood type
Incomplete Dominance	Incomplete dominance is a genetic condition in which both alleles are expressed, but the resulting phenotype is an intermediate trait between the two allele traits.	<ul style="list-style-type: none"> When a rabbit has an allele for black and an allele for white, and the resulting phenotype is grey
Sex-Linked	Sex-linked traits are based on a genetic condition in which the gene is found on the sex chromosome.	<p>The following genes are found on the X chromosome:</p> <ul style="list-style-type: none"> Color blindness Hemophilia Duchenne muscular dystrophy
Sex-Influenced	Sex-influenced traits are based on a genetic condition in which the gene is influenced by female or male hormones.	Baldness is influenced by testosterone. As a result, baldness is a dominant trait in males and a recessive trait in females.
Multiple-Allele	Multiple-allele traits are based on a genetic condition in which there are more than two alleles for the two allele positions.	Blood type has three alleles for two allele positions. Blood type has the A, B, and O allele, but each individual only has two alleles—for example, AB, AO, BB.

Part I • Example of an Engaging Story with a Message

Introduce the Group Culminating Project

1. Introduce the group Culminating Project.
2. Read the introduction to the Culminating Project aloud, emphasizing the goal of teaching the reader about heredity and the interaction between traits and the environment.
3. See the Culminating Project section in the Unit Overview of the Teacher Edition for more details about this project.

Example of an Engaging Story with a Message

4. Introduce the children's book you are going to read to the class. (See Materials for recommended book options.)
5. Ask student volunteers to read the questions in the Student Edition.
6. Discuss and give examples of theme, plot, and cause and effect. Use Slides 2, 3, and 4 of the "A Storied Life and Human Traits" digital slide presentation.
7. Read the children's book.
8. Have students work in small groups to answer the questions in the Student Edition.
9. Discuss the questions as a class. During your discussion, start incorporating these words and ideas:
 - **Traits** of characters.
 - **Variation** of traits in characters
 - Why characters have certain traits, which leads to discussions around the crosscutting theme in this unit, **cause and effect**

Answers to Questions

- What big ideas, themes, or messages do you think the author wants you to understand?
 - *The answer depends on the book read.*
 - *Ask students to remind you what a theme is.*
 - *Remind students what the theme of their book for the Culminating Project will be. The theme is on the introduction to the culminating project page. The theme is heredity (showing that traits are passed from parents to offspring and environmental influences on traits).*
- What are the different parts of the story: setting, characters, and plot?
 - *Ask students what the setting is for this book. Have a student expand on another student's description.*
 - *Ask students to describe the characters in the book.*
 - *Create a model storyboard. Have students list the events in the story, and record their ideas on a board or chart paper. As students start voicing the events in the book, ask where they go in relation to (before/after) the other events that they mentioned. Start to place the events in order on your board or chart paper to create a sample storyboard as a model for students.*
- What are some examples of **cause and effect** in the story?
 - *Discuss the concept of cause and effect. Discuss some examples of cause and effect found in the story. Add the cause and effect examples to the model storyboard.*
 - *The answer to this question depends on the book that you read to the class.*

- What is on a typical page of the book that makes the story fun and interesting?
 - *A few words on a page*
 - *Interesting pictures that show the characters, the setting, and what is happening (e.g., events and problems)*
 - *A page number*
 - *And more...*

Part II • Identify Human Traits

1. Review Slides 5–7 to introduce the concepts of human traits (characteristics), inherited traits, and genes. These will be important throughout the unit.
2. Have students identify their own traits using the table in the Student Edition. Work through this part of the task with students using Slides 8–19 of the digital slide presentation in order to help students identify the traits correctly and answer any student questions for each trait. Encourage students to work together to help each other identify traits.
3. Students should circle the picture of their own traits as you walk them through these traits on the slides.
4. Go back through the traits and poll the class for each trait.
5. Students should fill in the class data columns with the number of students having each trait.
6. Give students a few minutes to discuss question 3 from their Student Edition and write out their answer in their science notebook.
7. Lead a class discussion addressing question 3, and any questions students bring up about the tasks and the concepts of heredity and environmental influences. The chart below gives some examples of genetic traits versus traits that are due to environmental influences. Note: This discussion might be long and may go in many directions due to student curiosity.

Human Traits	Genetic Traits (can pass on to offspring)	Traits Based on Environmental Influences (can NOT pass on to offspring)
Eyes	Two eyes, distance between eyes, size of eyes, color of eyes	Wearing contacts to change color of eye
Skin	White, brown, black, etc.	Changing from white to dark brown (getting a tan from the sun or tanning booth), getting a sunburn
Muscles	Have muscles to move	Large muscles from working out Strong muscles from working out
Hair	Has hair, straight, curly, wavy, brown, blonde, black	Straight to curly with a perm or curling iron Curly to straight with a flat iron Change color with dyes
Height	Short, medium, tall, very tall, grow at a young age, grow when you are older	If you do not get enough food (nutrition) you may become shorter
Hearing Seeing	Being able to hear with your ears and see with your eyes	Illness/cancer may damage your inner ear and cause deafness; damage to eyes can cause blindness



LANGUAGE SUPPORT STRATEGIES

- Some common pitfalls with argumentation are that only a few students contribute, students become upset when others disagree with them, students do not back up their claim with evidence, etc. In order to avoid these pitfalls, try these suggestions: conduct partner shares or small-group discussions before whole-class talk in order to garner more equitable student participation; provide sentence stems for respectful disagreement, such as “While I agree that _____, I also think _____”; provide sentence stems to encourage students to use evidence, such as “This was shown by the data because _____.”
8. Have students fill in the Claim, Evidence, Reasoning chart in order to answer the question: Are humans more similar to each other or more different from each other? Different students might answer this question differently. Both answers can be argued correctly depending on the evidence that students use. Students may reason that humans are different due to genetics or the environment, and that they are similar due to genetics or the environment. For this reason, the discussion may be lively, lead to many questions and answers, and in the end leave students with questions they must ponder throughout the unit. Some students may struggle with filling in this type of chart; if so, model both sides of the claim with one of the examples from the chart below. Use the sentence stems provided to show students how to proceed if they get stuck with the language.

Similar to Each Other	Different from Each Other
<i>Two legs</i>	<i>Length of legs, shape of legs</i>
<i>Two eyes</i>	<i>Color of eyes</i>
<i>Two ears</i>	<i>Shape of ears</i>
<i>Hair</i>	<i>Color of hair, texture of hair, thickness of hair</i>



LANGUAGE SUPPORT: SENTENCE FRAMES

Use these sentence stems for students who need help with the Claim, Evidence, and Reasoning chart.

Claim:

Humans are more _____ because _____.

Evidence:

One piece of evidence to back up this claim is _____.

For example, when the class was polled about different traits, we found that _____.

Reasoning:

These traits can be explained by _____.

In the scientific community, it is believed that _____.



9. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following question in their Student Edition: How has your idea of what a trait is changed over the course of this task? In particular, do you still have the same ideas about where traits come from?

There is no right answer, but encourage students to think about their ideas from the beginning of the class about what traits are and what they have now added to or changed about their ideas.

Part III • Connect to the Culminating Project and Assessment

1. Have students independently complete the Lift-Off Task portion of the Individual Project Organizer in class.
2. Collect the Individual Project Organizers and assess using a criterion of your choice.
3. Return the Individual Project Organizers. Give students time to make revisions based on one of these two options.
 - Have students make changes to their Individual Project Organizer according to your comments. (This could be done for homework, depending upon students' needs and/or class scheduling.)
 - Ask students to exchange their Individual Project Organizer with a partner, and give partners 5 minutes to provide written feedback. Then allow students time to make changes to their work according to the feedback.

Unit Essential Question

How do the environment and genetics affect who we are and how we are similar or different?

Introduction

There are variations in all living organisms. Some variations are a result of genetic information that the organism received from its parents. Other variations are a result of different environments that an organism lives in. In this task, students will observe and gather evidence about how genetic and environmental factors influence the growth of plants. In part I, students will examine a variety of beans to identify some of the characteristics of beans, compare and contrast the characteristics of different types of beans, and explain why they think some characteristics are the same and some are different. In part II, students will brainstorm ways the environment might cause variation in the growth of plants. Students will select a specific environmental factor and design a controlled investigation to determine what effect the environmental factor has on plant growth. Students may gather their data periodically through task 2 and reflect on their data after task 2.

Objectives

Students will be able to

Content

- Determine how different environmental conditions affect plant growth rate.

Science and Engineering Practices

- Plan and conduct an experiment about environmental effects on plant growth.
- Use data to construct an explanation about how the environment and genetics influence plant growth.

Equity and Groupwork

- Discuss and plan procedures.

Language

- Write a lab report.

Academic Vocabulary

- control group
- environmental conditions
- experiment
- experimental group
- organism
- prediction
- standard factor (fair test)
- variable

Language of Instruction

- justify
- initially

Timing

This task can be completed in 14–16 class periods (based on 45-minute periods).

- Part I • Variation of Beans (1 class period)
- Part II • Design an Experiment to Analyze How the Environment Affects Physical Traits of a Plant (12–14 class periods)
 - 1 day: Brainstorm the experiment.
 - 1 day: Set up the experiment. (If short on time, this can be done at the end of the previous day.)
 - 1 day: Discuss and set up the data table.
 - 1 day: Write the experiment in science notebook. (If short on time, this can be done on the previous day.)
 - 5–7 days: Conduct experiment and gather data. (The timing depends on whether a weekend is included and whether writing in the science notebook and discussing the data table are part of these days. This part of the task will not take the whole period, but rather a few minutes at the beginning or end of class.)
 - 1 day: Make a graph.
 - 1 day: Analyze and make conclusions. (If short on time, add this to the previous day and have students complete the remainder for homework.)
 - 1 day: Share data, analysis, and conclusions.
- Part III • Connect to the Culminating Project and Assessment (1 class period)

Student Materials

per group

Part I:

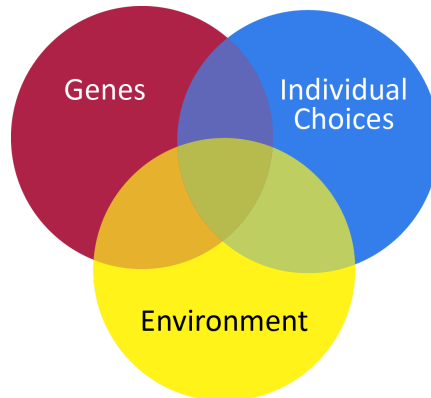
- Bag of mixed beans
- Metric ruler

Part II:

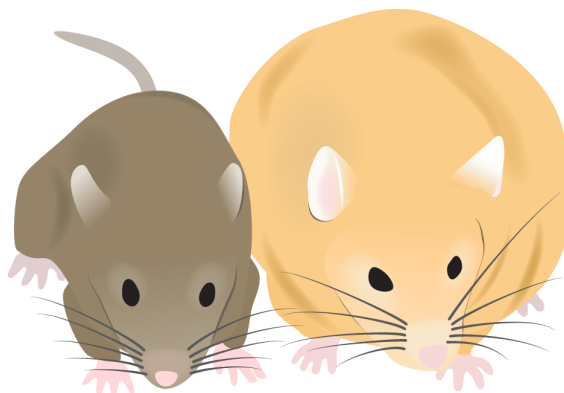
- Kidney beans (approximately 6 per group—3 for the experimental group and 3 for the control group)
- Paper towels (used to make “growth chambers”)
- Plastic plates (to put growth chambers on) or plastic bags (to store growth chambers in)
- Permanent pens (to label growth chambers)
- Possible environmental factors:
 - Vinegar (This is a weak acid.)
 - Detergents/soaps (These are bases.)
 - Fertilizer (This adds minerals.)
 - Heat (Use a heat lamp, but cover beans up so light is not a factor.)
 - Cold (Put beans in a refrigerator.)
 - Dark (Put beans in a paper towel.)
 - Light (Don’t cover beans in a paper towel, but make sure there is lots of water under the beans for germination. Perhaps put beans in a container with a half inch of water.)
 - Wind (Use a fan.)
- Small cups or beakers (to measure the amount of water the beans are given every day)
- Ruler (to measure bean growth; have both metric and English standard rulers available, since students will decide what units they want to use)
- Graph paper
- Large poster paper (to draw and display each group’s graph of data)

Background Knowledge

The nature versus nurture issue has been debated since DNA was discovered as the blueprint of all proteins, and thus the blueprint for the structure of life. Nature is the DNA component, or the inherited traits, and nurture is the environmental impact on traits, or the acquired traits. At some points in history, the predominant theory was that DNA is the dominant force that determines the looks and personality of an individual. At other times, the predominant theory was that the environment is the dominant force that determines the looks and personality of an individual. Today, most scientists believe that living organisms are not completely predisposed at birth by DNA. Although DNA determines the general characteristics of an organism, the organism's structures and personality may be influenced by life experiences and the environment they live in. Most scientists now agree that there is no fine line between nature and nurture. Instead, nature and nurture both influence the traits of an organism.



One new field of study that has contributed to the fuzzy line between nature and nurture's impact on living organisms is epigenetics. Epigenetics is the study of how cellular and structural trait variations may be caused by external or environmental factors that can "switch" genes on and off. In the case of epigenetics, there is not a genetic change or mutation in the DNA. Instead, genes are blocked by a methyl group (a process called *methylation*), or undergo a histone modification. What this means is that our environment can alter the expression of our genes, causing altered phenotypes, and these alterations can be passed on to future generations. For example, the two mice below are genetically identical, but the color and obesity genes for the mouse on the right have been methylated, and thus these genes are not being expressed. In the mouse on the left, the methyl group on the color and obesity genes has been removed, and now the mouse is an agouti color and is not obese. The mouse example shows that even if the genes are all the same, the physical structures or phenotypes can be different due to blocked gene expression.



For the purpose of this task, students only need to know that in addition to genetics, the environment can cause changes in the phenotype, or the look or growth patterns of an organism.

Introduction

1. Read the introduction in the Student Edition together as a class, allowing students to reflect back on the previous task and connect it to the task that lies ahead.
2. Have students answer the prior knowledge question as a warm-up using a think-pair-share format so every student is able to access their own prior knowledge about plant and animal growth. Students should build off their basic experience with gardening, owning pets, taking care of younger siblings, etc. Ask facilitating questions to help students access these experiences.

Possible responses could include discussions of how plants with more water or sunlight grow taller than others; babies with less nutritious food may not grow as big or strong; dogs that are not bathed regularly could get dandruff or start losing hair.

Part I • Variation of Beans

1. Place students in their project groups. Designate student roles and review the norms.
2. Set up a bowl of mixed beans at each table.
3. Ask students to examine the bowl of beans at their table and generate a list of various bean characteristics that could be compared from bean to bean. Possible comparable bean characteristics are:
 - Length
 - Width
 - Number of stripes
 - Pattern of stripes
 - Color
 - Fat or skinny in depth
 - Texture
4. Discuss with the whole class the characteristics, or **traits**, that the beans have.
5. Have each group identify several characteristics that they want to compare. Then have them compare four different beans and fill in the table in the Student Edition. When they have finished, tell them to return the beans to the bowl.
6. Now ask students to find the four beans they compared by analyzing the traits of all the beans and matching four beans to the traits they recorded.
7. Have students use evidence and reasoning to support the following claim: Beans have many different traits.
 - Students may struggle with determining a scientific concept to use in their reasoning. Ask students to think back to the slides they viewed in the previous task, and the terms they learned. Possible facilitating question: You learned that many traits are inherited. What does that mean and how does it work?



LANGUAGE SUPPORT: CLAIM, EVIDENCE, REASONING SENTENCE FRAMES

Provide the following sentence stems as needed.

- Evidence: "Some beans have _____, but other beans have _____."
- Reasoning: "The beans could look different because _____."

8. Have students share their bean comparisons and claim, evidence, reasoning statements. Use a share-pair, or hold a full-class discussion by calling on students to contribute examples of evidence and reasoning from their own claim, evidence, and reasoning responses.

Sample Explanation

Claim

Beans have many different traits.

Evidence

Use evidence from your observations to support the claim.

Students should use the different traits (characteristics) they identified in their bean comparison chart. For example: Some beans have stripes, but other beans are a solid brown color. Some beans are 15 mm long, but other beans are only about 4mm long.

Reasoning

Use a scientific concept to explain why your evidence supports the claim.

Due to the different genes in a bean, the beans look different.

The beans are different because they came from different seeds and from different "parent" beans.

The beans are different because they don't all inherit the same genes.

It depends on their "parent's" genes.

Part II • Design an Experiment to Analyze How the Environment Affects Physical Traits of a Plant

When you look at variation between types of beans, you are looking at **genetic** variation. For this task, students will investigate ways that the environment might cause variation in bean growth. Note that this task exemplifies the crosscutting concept highlighted in this unit: **cause and effect**.

A. Experimental Question

1. Place students in their project groups. Designate student roles and review the norms.



LANGUAGE SUPPORT STRATEGIES

Ensure that ELLs are in groups with students of higher proficiency, and encourage the group to engage all group members in their roles.

2. Review the experimental question provided in Part A of the Student Edition.

B. Brainstorm Your Experimental Design

3. Begin the brainstorming process in Part B. Ask students to brainstorm in teams ways that the environment might be responsible for variations in beans. In this exercise, students should be activating their own prior knowledge and experiences as they did for the question in the introduction. Refer any students who are “stuck” back to the introductory question.
4. Discuss all groups’ ideas with the class. Display the list of ideas for the class to see.

Some possible ideas are:

- Amount of water
- Amount of wind
- Type of soil
- Amount of nutrients in the soil
- Amount of sunlight
- Temperature
- Watered with acid (acid rain) or base (soap) solution
- Presence of toxins

5. **Model** the process that students will follow in designing their experiment. Then let them work in small groups to design their experiment. As students work, move from group to group to monitor progress and ask questions to guide groups who need direction or need more specifics in their thoughts and ideas.

Design Step	Helpful Hints
Variable	Group decision: Student groups can choose one of the environmental conditions they brainstormed previously, or decide on a different environmental condition (with teacher permission). This condition should be general—for example, “amount of water” or “with or without toxins.” Review each group’s choice and initial when approved.
Control	Group decision: The control setup will not use the environmental condition (variable). For example, if the variable is water, the experimental group will have water and the control will not.

Design Step	Helpful Hints
Measurements	<p>Class decisions: Have the class decide on and use the same units so that all the data can be compared. It is recommended that all students use metrics, millimeters or centimeters. Review the meaning of each mark on the ruler. Average the bean data each day. As beans start to grow, add the measurement of the root and the stem together for the final measurement. See sample data tables at the end of these instructions.</p> <p>Ask students to draw their beans and take some observation notes each day too.</p>
Experiment	<p>Students will use the same basic setup design, as follows.</p> <ol style="list-style-type: none"> 1. Students' beans will go into a "growth chamber." This growth chamber will be a paper towel that has been folded into fourths with the beans in between the folds. Demonstrate the growth chamber for students—for example, use a 12" x 12" paper towel and fold it into a 3" x 3" square. Emphasize that students should not fold the paper towel too many times or fold it too tightly because the beans need oxygen to grow. Students will have one growth chamber for their experiment beans and one for their control beans. 2. Students will store the growth chambers either on a plastic plate or in a plastic bag (they should not seal the bag because plants need oxygen). 3. Students should label their two growth chambers with their names, with either "experimental" or "control," and, for the experimental setup, with the variable the beans are exposed to. 4. After they have placed the beans in the growth chamber, students will expose the paper towel in the experimental setup to their chosen variable. 5. Students will create a data table based on their experiment and record the table in their science notebook. 6. Important point for success: Students should make sure the paper towels are very wet every day. The beans need to get completely wet to germinate. The beans will need approximately 10 ml of water every day to stay wet. However, the beans should not sit in a pool of water, because they will drown and rot without oxygen present. 7. Each day, students will take the beans out of the paper towel and measure them—both the root and the stem. They will record their data in their data table. 8. When they have finished recording data, students will return beans to the growth chamber. They will water the beans every day, or enough to keep the beans damp. (Give same amount of fluid to each bean group.)
Draw the Experiment and Control Design	<p>Students will draw both the experimental setup and the control setup. Remind students to label their drawing and include amounts of materials. For example, they should include the water (or experimental substance) they will add to the beans every day. Review and initial students' drawing to make sure their setup is viable.</p>
Standard Factors	<p>The standard factors will be a list of everything that will be the same in the experimental setup and the control setup. For example, if students are testing whether acid affects bean growth, they would put the same amount of acid solution on the experimental beans as the amount of water on the control beans. Another example is that the beans in both setups will be given the same amount of time to grow.</p>
Prediction	<p>Students should not only give a prediction for what they think will happen, but also why they think it will happen. This emphasizes the crosscutting concept of cause and effect.</p>

6. When the small groups have designed their experiments, review each experiment, and then let students get started setting up their experiment and control.
 - It is important that students plant their beans as soon as they have designed their experiment, since it takes seven days to see the effects of different variables. Students can work on their formal experiment write-up in their science notebook after they have set up their experiment.
 - Remind students to label each growth chamber with their names and the variable the beans are exposed to.

C. Record Your Experimental Design

7. Have students write a formal description in their science notebook of their experiment, following the guidelines in the Student Edition.

Students will need to determine a structure for the data table that they will use to record their results. Below is a sample data table. Discuss data table options with the class and then give small groups time to design a data table that will work for their experiment. Have students draw their data table in their science notebook with their complete experimental design write-up.

- Step 7 can be done the day after students set up their experiment and on the first day of growth measurement (although on the first day of measurement, students should expect that their bean will have grown in size, but that no roots or stems can be seen yet).

Sample data table:

<i>Plant Growth (mm) and Observations</i>		
<i>DAY</i>	<i>Experimental Condition</i>	<i>Control Condition</i>
<i>1</i>		
<i>2</i>		
<i>3</i>		
<i>4</i>		
<i>5</i>		
<i>6</i>		
<i>7</i>		

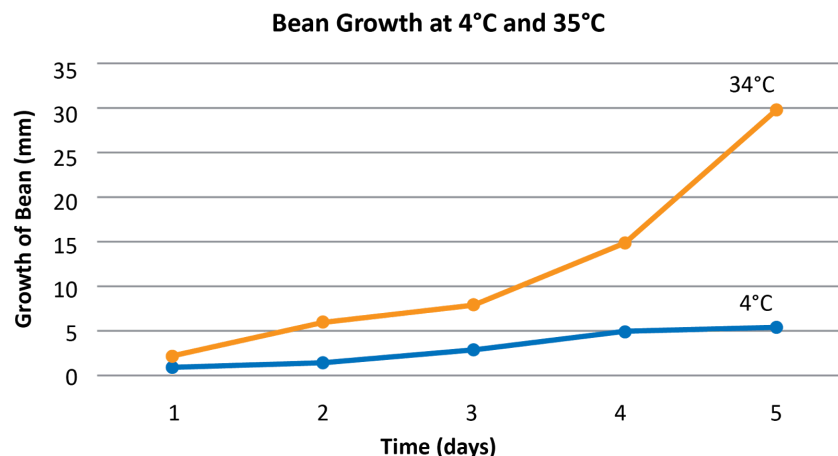
D. Conduct Your Experiment

8. Have students measure beans, draw beans, and make observation notes every day for seven days, using the following guidelines.
 - a. Take the bean plants out of the paper towels.
 - b. Measure each bean plant.
 - c. Average the measurements in the experimental group and average the measurements in the control group.
 - d. Record these averages in your data table, along with other observations and drawings.
 - e. Return the beans to the growth chamber.
9. Students should water the (or use other appropriate fluid) every day. Tell them to use enough fluid to keep the beans damp, and give the same amount of fluid to each bean plant.

Important point for success: Students should make sure the paper towels are very wet every day. The beans need to get completely wet to germinate. The beans will need approximately 10 ml of water every day to stay wet. However, the beans should not sit in a pool of water, because they will drown and rot without oxygen present.

E. Graph Your Data

10. After the beans have grown for seven days, the data is ready to graph. Review graphing procedures with students. If you have access to large poster paper, have each group make a large graph to post around the room for the review discussion about their data analysis and conclusion. A sample graph is provided below.



- Another option is to have students use an online graphing tool to graph and print their data, such as <https://nces.ed.gov/nceskids/createagraph/>. These graphs can then be pasted in students' science notebooks.

F. Analyze Your Data and Make Conclusions

11. Give time for students to discuss the two questions in the Student Edition.
12. Have students fill in the Claim, Evidence, Reasoning table in the Student Edition. Discuss students' claim, evidence, and reasoning ideas as a class. A sample table is provided below.
 - Students may have trouble coming up with scientific concepts to use for their reasoning. One option is to brainstorm some general ideas together, using facilitating questions such as: "How were your kidney beans similar before you started your experiment? Why were they similar? How were they different after your experiment? Why do you think that happened?"


LANGUAGE SUPPORT: SENTENCE FRAMES

Provide sentence stems for each part of the Claim, Evidence, and Reasoning table.

- Claim: “When plants are grown with _____, the result is _____.” OR “Plants grow better with _____ than with _____.”
- Evidence: “Plants with _____ grew to _____ mm, while plants with _____ grew to _____ mm.” OR “Plants with _____ grew every day, while plants with _____ took many days to start growing.”
- Reasoning: “These results were because _____.” OR “All kidney beans _____.” OR “The differences we saw were because _____.”

Claim

- When plants are grown with periodic watering, the results are better.
- Plants grow better when watered every other day than when watered weekly.

Evidence

- Plants with water every other day grew to 15 cm over seven days, while plants with water once a week grew only 1 cm over seven days.
- Plants with water every other day grew on average 2.1 cm per day, while plants with water once a week grew only .1 cm per day.
- Plants with water grew every day, while plants with water once a week took five days to start growing.

Reasoning

The environment affected the growth of plants. Both plants we tried to grow are kidney beans, so all the beans have similar DNA. What caused the kidney beans to grow at different rates was the environmental situation, or the type of liquid they were grown with. The frequent water environment was best for bean growth.

G. Communicate Your Findings

13. Let students share out their data, analysis, and conclusions. Remind students to:

- Describe their experiment.
- Describe their data.
- Share patterns they saw.
- Share their prediction and how their prediction compared to the actual results. For metacognition purposes, emphasize that this is a time for students to reconsider and revise their ideas based on data.

14. Summarize the purpose of this task: The environment does have an effect on the traits of plants of the same species.

15. Have students discuss this question:

Do you think the different traits that the plants have due to the environmental differences will be seen in the offspring (beans) of the plants? For example, if plants did not grow very much in the cold, will the baby plants from those plants be smaller too? (In essence, will the DNA change due to environmental differences?)

Typically, the DNA does not change due to the environment.

Following is additional information that sixth grade students do not need to know, but that may come up during the discussion. There are two ways that the environment can change the DNA of organisms. First, genetic mutations (change in nucleotide sequences) can be caused by some environmental conditions, such as toxins, UV light, and radiation. Genetic mutations actually change the DNA and cause different traits to be expressed, many times causing tumors, cancers, and death. Second, it has recently been discovered that the environment can cause genes to be turned on and off (by adding and taking away methyl groups on the DNA), and those “on and off” genes will be passed down to future generations. This is a new field of study called epigenetics.



16. At the end of the task, ask students to reflect on what they learned over the course of this task by answering the following question from their Student Edition: At the beginning of this task, you were asked if you thought environment could have an effect on organisms’ similarities and differences. Look back at your response. Do you still agree with what you initially wrote? How could you add to or change your answer after what you have learned from this task?

There is no right answer. Encourage students to look back at the prior knowledge question from the start of the task. They should not change their initial answer, but rather use this reflection to modify their original idea and add evidence they have collected over the course of this task.

Part III • Connect to the Culminating Project and Assessment

1. Have students independently complete the task 1 section of the Individual Project Organizer in class.
2. Collect the Individual Project Organizers and assess using these criteria:
 - The “Carrying Out Investigations,” “Analyzing and Interpreting Data,” and “Constructing Explanations and Designing Solutions” rows of the Science and Engineering Practices Rubric
 - A criterion of your choice
3. Return the Individual Project Organizers. Give students time to make revisions based on one of these two options.
 - Have students make changes to their Individual Project Organizer according to your comments. (This could be done for homework, depending upon students’ needs and/or class scheduling.)
 - Ask students to exchange their Individual Project Organizer with a partner, and give partners 5 minutes to provide written feedback. Then allow students time to make changes to their work according to the feedback.

Unit Essential Question

How do the environment and genetics affect who we are and how we are similar or different?

Introduction

In nature, plants and animals have evolved to ensure successful reproduction in a variety of ways—for example, attracting a mate, having fit offspring, and protecting the offspring so that they have a chance to grow and reproduce. Animals attract mates with bright colors, fancy dances, and special songs. Male animals battle to show the female they are the biggest, strongest, and most fit to be the mate of choice. Animals surround their young to protect them from predators and make complex nests to keep their offspring warm and safe from environmental elements. Plants have bright flowers to attract pollinators. Plants have different size stamens, pistils, and petals to encourage pollination by wind, water, birds, bats, and bees. Plants protect their young in the seed and have evolved many types of seed structures that disperse seeds to environments where there is enough sun, water, and minerals for plants to survive. In this activity, students will watch video clips to help them understand the behaviors and structures in plants and animals that ensure successful reproduction. Students will use empirical data about guppy mating to engage in an argument about how guppy physical traits and behaviors may result in different mate choices when predators are absent or present.

Objectives

Students will be able to

Content

- Identify animal behaviors and plant structures that are associated with reproduction.

Science and Engineering Practices

- Construct an argument identifying the correct explanation for how an animal behavior results in successful reproduction.

Equity and Groupwork

- Summarize key points in video clips.
- Debate competing ideas with peers.

Language

- Listen to other's ideas.
- Construct an argument based on evidence.

Academic Vocabulary

- attract
- life cycle
- mate
- mating
- offspring
- ovaries
- plant structure
- pollen
- pollination
- predator
- seed dispersal
- successful reproduction

Language of Instruction

- displaying
- guppy
- prefer

Timing

This task can be completed in 4–5 class periods (based on 45-minute periods).

- Part I • Explore How Animal Behavior Helps Animals Successfully Reproduce (1 class period)
- Part II • Explore How Specialized Plant Structures Help Plants Successfully Reproduce (2 class periods)
(This part can be condensed into 1 day if short on time by choosing parts of each video clip to show instead of showing the whole videos.)
- Part III • Analyzing Guppy Mating Data (1 class period)
- Part IV • Connect to the Culminating Project and Assessment (1 class period)

Student Materials

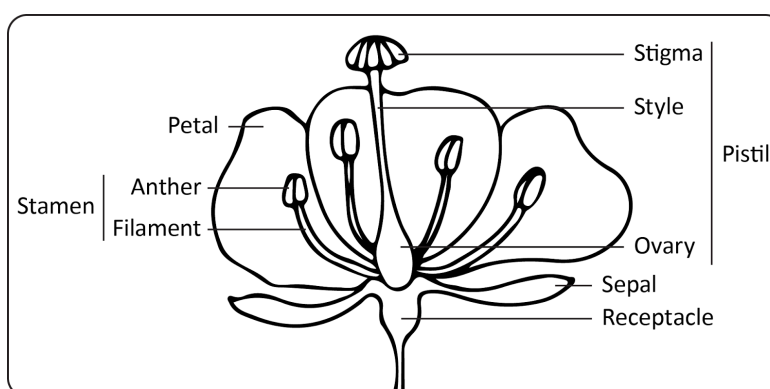
per group

- Computer to play videos
- Video clips (These videos were selected because they specifically show how different animal behaviors and plant structures help animals and plants reproduce, which is the focus of this task's performance expectation.)
 - Pronghorn bucks battle for dominance: <https://youtu.be/qJ9s6WF68LQ>
 - Peacock mating dance display: <https://youtu.be/jTBHiZtnCsA>
 - Matriarch Elephants Protect Baby Elephant from Crocodile Attack: <https://youtu.be/BGY0BHmjEtg>
 - Amazing Animal Babies: Emperor Penguin Chicks: <https://youtu.be/lf26jtJfL30>
 - Flower Reproduction: https://youtu.be/YqM6rgB_l_o
 - Pollination Rock: <https://youtu.be/V5yya4eIRLw>
 - Seed Dispersal: <https://youtu.be/j1hRxuy1ezQ>
 - Biggest flower in the world: <https://youtu.be/FHaWu2rcP94>
 - Butterfly pollination: <https://youtu.be/gLIcKpzH5E>
 - Pine pollen blown by the wind: https://youtu.be/V_9palHvAlc
 - Guppy mating dance!: <https://youtu.be/1tKOlc0qReQ>
- Red and green markers

Background Knowledge

Animals and animal behaviors are typically interesting and familiar to most students. On the other hand, the structure and function of plant parts and the reproductive cycle of plants are not as familiar to most students. This task thus introduces students to plant structures and how a plant reproduces in order to provide the basic information they need in order to analyze specialized plant structures that encourage successful reproduction. The main focus of the task is not for students to learn the scientific terms of all of the plant structures, but rather to understand the relationship between plant structures themselves (pollen, egg, and seed) for pollination and fertilization, and between plants and animals for pollination.

The diagram and chart below describe plant reproduction processes and define parts and functions. Although the terms are mentioned in the video clips, students are not expected to memorize them. Instead, the terms should be used in class to refer to the different parts of a flower (the reproductive part of a plant) so that students can start learning plant academic language.



Plant Reproduction Processes and Structures	How the Process/Structure Relates to Plant Reproduction
Pollination	The transfer of pollen usually from one flower to another
Fertilization	The meeting of the sperm (part of the pollen) and the egg (in the ovary)
Stamen	The male structure of the flower; made up of the anther and the filament
Anther (part of the stamen)	The part of the male structure (stamen) where the pollen is made
Filament (part of the stamen)	The part of the male structure (stamen) below the anther that keeps the anther raised up so that pollen on the anther can be dispersed (swept away by the wind, picked up by bees, etc.)
Pistil	The female structure of the flower; made up of the stigma, style, and ovary
Stigma (part of the pistil)	The part of the female structure (pistil) that pollen from the wind, bees, etc. sticks to (stigma = sticky)
Style (part of the pistil)	The part of the female structure (pistil) that holds up the stigma so that pollen can find the sticky stigma
Ovary (part of the pistil)	The part of the female structure (pistil) that holds and protects the eggs
Petal	Flower part that attract insects, birds, and bats

In the third part of the task, students analyze the mating patterns of guppies. There have been many studies about guppy courtships and mating preferences. Female guppies choose the male mate; scientists have found that environmental factors (biotic and abiotic) contribute factors to the female's choice. Male guppies are typically smaller and brighter in color than females. The males use their bright colors and courtship dances to entice females of the same species. However, the bright colors can also attract predators, thereby increasing the male's risk of predation. In multiple studies, evidence suggests that females are aware of the risk of predators and change their mating decisions with different levels of risk. Evidence also shows that guppies with more orange spots are more physically fit than other guppies.

Introduction

1. Read the introduction from the Student Edition aloud as a class. The purpose of this introduction is to connect students' learning from the previous task to the upcoming task.
2. Have students answer the prior knowledge question on their own and then share with a partner in a think-pair-share format.
 - The purpose of this question is to elicit students' prior knowledge of reproductive behaviors and traits.
 - If students are stuck, you can encourage them to think about animals they have seen at the zoo, or even human beings themselves. Note: If discussing human traits for attracting mates, make sure the discussion is culturally sensitive, and that it focuses on the fact that social norms for attractive features vary widely among cultures and across time periods and are heavily influenced by media.

Possible responses include: a peacock's feathers, bird mating dances, kindness and attention in human courtship, shows of strength between some male animals, etc.



LANGUAGE SUPPORT: PAIRING SCAFFOLD

Pair ELLs with lower levels of proficiency with another student who shares the same home language, and invite them to discuss the question in their native language first and then share in English. Also, ensure expanding level ELLs are paired with students who have higher English proficiency.

Part I • Explore How Animal Behavior Helps Animals Successfully Reproduce

1. Place students in their project groups with a computer or tablet. Designate student roles and review the norms.
2. Review the questions that students need to answer for each video.
 - Encourage students to take notes during each video to help them remember facts. Consider having students make a grid in their science notebook that they can use to take notes.

Pronghorn bucks video notes: 1. 2.	Peacocks video notes: 1. 2.
Elephants video notes: 1. 2.	Penguins video notes: 1. 2.

- Encourage students to discuss each question before they write answers into their science notebook.
 - Remind students that they may revise their answers as the discussion progresses.
3. Have students watch each video, discuss the questions, and then write their answers in their science notebook.

4. Hold a class discussion about the videos. The focus of the discussion should be on how animal behavior attracts a mate or helps offspring survive. The chart below gives a few ideas for discussion.

Video	Animal Behavior That Attracts a Mate or Helps the Babies Survive
Pronghorn Bucks	Male fighting: The male that wins the battle becomes the main male for the herd of females. He is considered the strongest by the females. Females will mate with this stronger buck so that their offspring might also be strong, enabling them to survive and pass on their genes.
Peacocks	Male beauty: The male presents his beautiful feathers to encourage the female to mate with him. Females often consider the males with the most brightly-colored feathers as being the most fit (healthy), and thus prefer the colorful males for their healthy genes that they can pass on to their offspring.
Elephants	Herd protection: The elephants surround their babies to protect them from predators. Since elephants only have one baby every four to five years, it is important that they protect their young in order to perpetuate their species.
Penguins	Parental protection: The male penguins keep their babies warm in the extreme cold. The babies grow fast, have dense feathers, and huddle in groups to survive to breed again.

Part II • Explore How Specialized Plant Structures Help Plants Successfully Reproduce

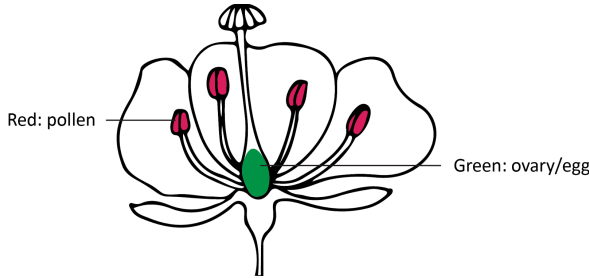
A. Introduction to Plant Reproduction

1. Place students in their project groups with a computer or tablet. Designate student roles and review the norms.
2. Review the questions that students need to answer for each video.
 - Encourage students to take notes during each video to help them remember facts. Consider having students make a grid in their science notebook that they can use to take notes.

Flower reproduction video notes: 1. 2.	Pollination rock video notes: 1. 2.
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- Encourage students to discuss each question before they write answers in their science notebook.
 - Remind students that they may revise their answers as the discussion progresses.
3. Have students watch each video, discuss the questions, and then write their answers in their science notebook.
 4. Hold a class discussion about the videos. The focus of the discussion should be on the structures and processes in plants that help the plants reproduce. Students don't have to know all the parts of a flower. What students should understand is:
 - The flower is the reproductive part of the plant.
 - The pollen is the male reproductive part of the plant, analogous to the sperm.
 - The ovary/egg is the female part of the plant.
 - The pollen has to get to the egg (from one flower to another flower).
 - The pollen and the egg make a seed, which will grow to be a new plant (successful reproduction).

The chart below gives a few ideas for discussion.

Video or Question	Structures and Processes in Plants That Help Them Reproduce (Reminder: Naming all the specific plant parts is not the focus.)
Flower Reproduction	<ul style="list-style-type: none"> • Pollination: Movement of pollen to the pistil (female structure in a flower) • Pollen: Male reproductive part of a flower; made in the stamen • Pistil: Female structure in a flower • Nectar: Sweet part in a flower that attracts pollinators • Pollinators: Bees, birds, wind, water • Fertilization: Pollen meets with the egg • Seed: Develops after pollen and egg meet
Pollination Rock	<ul style="list-style-type: none"> • Pollination: Must occur to get another plant; bees accidentally pick up pollen and bring it to other flowers • Pollinators: Insects, water, wind, dogs, birds, man • Nectar: Sweet part of a plant used to make honey • Pistil: Female structure in a flower • Seed: Fertilized egg
Questions 1 and 2	
Question 3	<ul style="list-style-type: none"> • Without pollination we would never have new plants. • Pollination is when the pollen from one flower moves to the flower (pistil) of another plant. • Pollination helps a plant get the pollen and egg together to produce a seed. A new plant will then grow from the seed.

B. Successful Reproduction

- Review the questions that students need to answer for the four video clips.
 - Encourage students to take notes during each video to help them remember facts. Consider having students make a grid in their science notebook that they can use to take notes.

Seed dispersal video notes: 1. 2.	Biggest flower video notes: 1. 2.
Butterfly video notes: 1. 2.	Wind video notes: 1. 2.

- Encourage students to discuss each question before they write answers into their science notebook.
 - Remind students that they may revise their answers as the discussion progresses.
- Have students watch each video, discuss the questions, and then write their answers in their science notebook.
 - Hold a class discussion about the videos. The focus of the discussion should be on plant structures and/or animal behaviors around a plant that help the plant successfully reproduce.

Video	Plant Structures and/or Animal Behaviors around a Plant That Help the Plant Successfully Reproduce
Seed Dispersal	Seeds have many shapes and structures that help move them to different places to germinate.
Biggest Flower	Since this plant only flowers once every 1,000 days, it must be pollinated; therefore, this flower has an extremely large, smelly pistil that attracts flies and insects, who bring pollen to the flower.
Butterflies	Butterflies are attracted to brightly-colored flowers; they move pollen from one flower to another.
Wind	Wind blows the pollen out of a tree.

Part III • Analyze Guppy Mating Data

1. Place students in their project groups with a computer or tablet. Designate student roles and review the norms.
2. Review the task. Students will
 - Watch a video about guppies.
 - Analyze data about traits female guppies choose in male guppies when predators are present and when predators are absent.
 - Read competing arguments from two scientists that explain guppy mating.
 - Choose the best argument and explain their choice using a claim, evidence, and reasoning format.
3. Have students watch the video about guppies. (The video clip is 3 minutes long, but students will get a sense of the interactions after about 1 minute. Students can continue to watch or stop watching any time after a minute.)
4. Have students read the information in steps 2 and 3 of the Student Edition about:
 - Data about traits female guppies choose in male guppies when predators are present and when predators are absent
 - Two competing arguments that explain guppy mating



LANGUAGE SUPPORT STRATEGIES

Support students by having them read the situation/problem three times, each time with a particular focus:

1. Students read the situation with the goal of comprehending the text.
 2. Students read the situation with the goal of analyzing the language used.
 3. Students read the situation in order to brainstorm which argument is best.
5. Have students use the scientific ideas from Part I and Part II as well as the guppy mating data provided to choose the better of the two arguments. They should revise that argument and add evidence in order to write their own scientific argument to explain **why female guppies prefer certain male traits when predators are absent or when they are present**.
 - As with the discussion questions from Parts I and II, this activity emphasizes the crosscutting concept of cause and effect.
 - Remind students to use the claim, evidence, reasoning format when writing their argument. A sample response is shown below. As with previous tasks, it may be helpful to provide sentence stems based on the sample answers provided.

Claim

Female guppies prefer certain male traits that will help their offspring survive and reproduce, but their choice can depend on whether a predator is around.

Evidence

Regardless of whether predators were present or not present, females chose orange-spotted males 32–33% of the time. When predators were not present, colorful males were chosen more often (55%); when predators were present, drab males were chosen more often (44%).

Reasoning

Orange-spotted males are physically fit and will pass the most fit genes on to their offspring regardless of whether predators are present. Passing on the likelihood to reproduce is beneficial when predators are not present, but if predators are present, survival is more important to the female. Females clearly prefer certain traits based on the likelihood that it will help offspring survival and reproduction.

6. Have each group share their argument using one of these options:
 - Each group presents their argument to the class.
 - Two groups get together and each one presents their argument to the other group. This option could lead to counterarguments.



7. At the end of the task, ask students to reflect on what they have learned over the course of the task by answering the following question from the Student Edition: At the beginning of this task, you were asked whether you could think of any traits (physical or behavioral) of plants and animals you have seen that may help them attract a mate. Look back at your response. Is there anything you can add to your answer based on what you have learned through this task? What types of examples had you never thought about before this task?

There is no right answer. Encourage students to look back at the prior knowledge question from the start of the task. They should not change their initial answer, but rather use this reflection to modify their original idea and add evidence they have collected over the course of this task.

Part IV • Connect to the Culminating Project and Assessment

1. Have students independently complete the task 2 section of the Individual Project Organizer in class.
2. Collect the Individual Project Organizers and assess using these criteria:
 - The “Engaging in Arguments from Evidence” row of the Science and Engineering Practices Rubric
 - A criterion of your choice
3. Return the Individual Project Organizers. Give students time to make revisions based on one of these two options.
 - Have students make changes to their Individual Project Organizer according to your comments. (This could be done for homework, depending upon students’ needs and/or class scheduling.)
 - Ask students to exchange their Individual Project Organizer with a partner, and give partners 5 minutes to provide written feedback. Then allow students time to make changes to their work according to the feedback.

Unit Essential Question

How do the environment and genetics affect who we are and how we are similar or different?

Introduction

Offspring commonly resemble their parents: monkey babies look like their monkey parents, dog babies look like their dog parents, and human babies look like their human parents. The offspring usually don't look exactly like their parents—they tend to have some characteristics of the mother and some characteristics of the father. The question then arises as to what controls the traits, and how do they get mixed up to create offspring with some of the mother's traits and some of the father's traits?

In this activity, students will model the **cause and effect** of the inheritance of various genes on chromosomes from mother and father to offspring. After identifying the cause of variation in living organisms, students will model a very different situation in bacteria, where one parent bacteria produces offspring that are identical to the parent.

The concept of combining the genes of the parents to produce offspring is often taught with Punnett squares. Punnett squares can be effective when students first focus on the concepts involved in passing genes from parents to offspring. Unfortunately, if the Punnett squares are used first, students often don't associate the letter (T) with the allele in the egg or sperm. The letter (T) simply becomes the letter (T), and the Punnett square becomes analogous to a multiplication table with a number (percent) for an answer.

This task is meant to help students learn the concept of passing down to offspring one allele from a pair of alleles for a trait in the egg and one allele from a pair of alleles for a trait in the sperm, resulting in variation of the offspring. After students understand the concept of alleles and gametes (eggs and sperm), Punnett squares can easily be taught as an extension task to calculate the probability of simple genetic outcomes. Having a conceptual understanding of gene inheritance also helps students understand more complex genetic situations in which there is more than one trait involved, and for which a Punnett square cannot be used to calculate probability.

Objectives

Students will be able to

Content

- Distinguish between sexual and asexual reproduction.

Science and Engineering Practices

- Develop a model to show how sexual reproduction results in variation of traits and asexual reproduction results in identical traits.

Equity and Groupwork

- Collaborate to identify patterns.

Language

- Use language to describe diagrams.

Academic Vocabulary

- allele
- asexual reproduction
- bacteria
- chromosome
- dominant
- gene
- recessive
- sexual reproduction
- trait
- variation

Language of Instruction

- aftermath
- combine
- domestic
- Venn diagram

Timing

This task can be completed in 8 class periods (based on 45-minute periods).

- Part I • Dog Traits (1 class period)
(This part can be condensed into half a day, if short on time.)
- Parts II and III • Make a Dog Family and Dog Family Analysis (3 class periods)
(If teaching Punnett squares [optional], you may need more time.)
- Part IV • Bacteria Traits (1 class period)
(This part can be condensed into half a day, if short on time.)
- Parts V and VI • Bacteria Family and Bacteria Family Analysis (2 class periods)
(This part can be condensed into 1 day, if short on time.)
- Part VII • Connect to the Culminating Project and Assessment (1 class period)

Student Materials

per student

Part II

- Dog Family Picture Frame handout (see Handout: VARHER_Task3_Handouts)

Part V

- Bacteria Family Picture Frame (see Handout: VARHER_Task3_Handouts)

per group

Part I

- Domestic Dog Pictures Resource Card (see Handout: VARHER_Task3_Handouts)
- Animal and Plant Reproduction Resource Card (see Handout: VARHER_Task3_Handouts)

Parts II and III

- Domestic Dog Pictures Resource Card (see Handout: VARHER_Task3_Handouts)
- Dog Traits and Alleles Resource Card (see Handout: VARHER_Task3_Handouts)
- 7 pennies with alleles attached to them (using paper and tape or stickers)
 - 2 pennies with a capital letter on each side of the coin
 - 2 pennies with a capital letter on one side and a small letter on the other side of the coin
 - 2 pennies with a small letter on each side of the coin
 - 1 penny with no letters (alleles) on it for flipping to identify (TT) or (Tt)

Part IV

- Bacteria Resource Card (See Handout: VARHER_Task3_Handouts)

Parts V and IV

- Bacteria Resource Card (See Handout: VARHER_Task3_Handouts)
- Bacteria Traits Resource Card (See Handout: VARHER_Task3_Handouts)
- Optional: A few pennies with only capital letters on each side and/or lowercase letters on each side of the coin

Teacher Materials

- “Variations and Heredity Task 3” digital slide presentation

Background Knowledge

In the Cells and Body Systems unit, students learned that a cell’s nucleus contains instructions, called DNA, to make cell proteins. This task addresses the effects of different DNA, resulting in different proteins, resulting in different traits. Each person’s cells contain DNA, which are the blueprints that code for specific proteins the cell will create. The DNA recipes are taken from the nucleus in the form of RNA to the ribosomes, where each three-base sequence codes for a specific amino acid. These amino acids then link together to form the correct protein. We are all made up of a multitude of proteins put together in a unique way to create the biodiversity of life on Earth. DNA is the foundation of variation of traits in living organisms.

Long ago, there was a scientist named Gregor Mendel (born in 1822) who studied pea plants. After 10 years of manipulating, analyzing, and watching pea plants grow, Gregor Mendel made some interesting conclusions. First, he determined that there must be something in the cells that control the pea plant characteristics. He called these “things” that control the plants’ characteristics *factors*. Second, Mendel determined that there must be two genes for every trait, one coming from the mother and one coming from the father. Lastly, Mendel determined that some traits must be dominant because they appear more often, and some traits must be recessive because they are often hidden by the dominant trait.

Today, scientists have come to the conclusion that the genetic information Gregor Mendel figured out was correct, although we now call the “things” that control characteristics *genes* and variations of those genes *alleles*. We identify a dominant allele with a capital letter (T) and a recessive allele with a lowercase letter (t). And since we know that we get an allele from the mother and an allele from the father, our gene combination in our cells could be TT, Tt, or tt. If T represents tall, and t represents short, then:

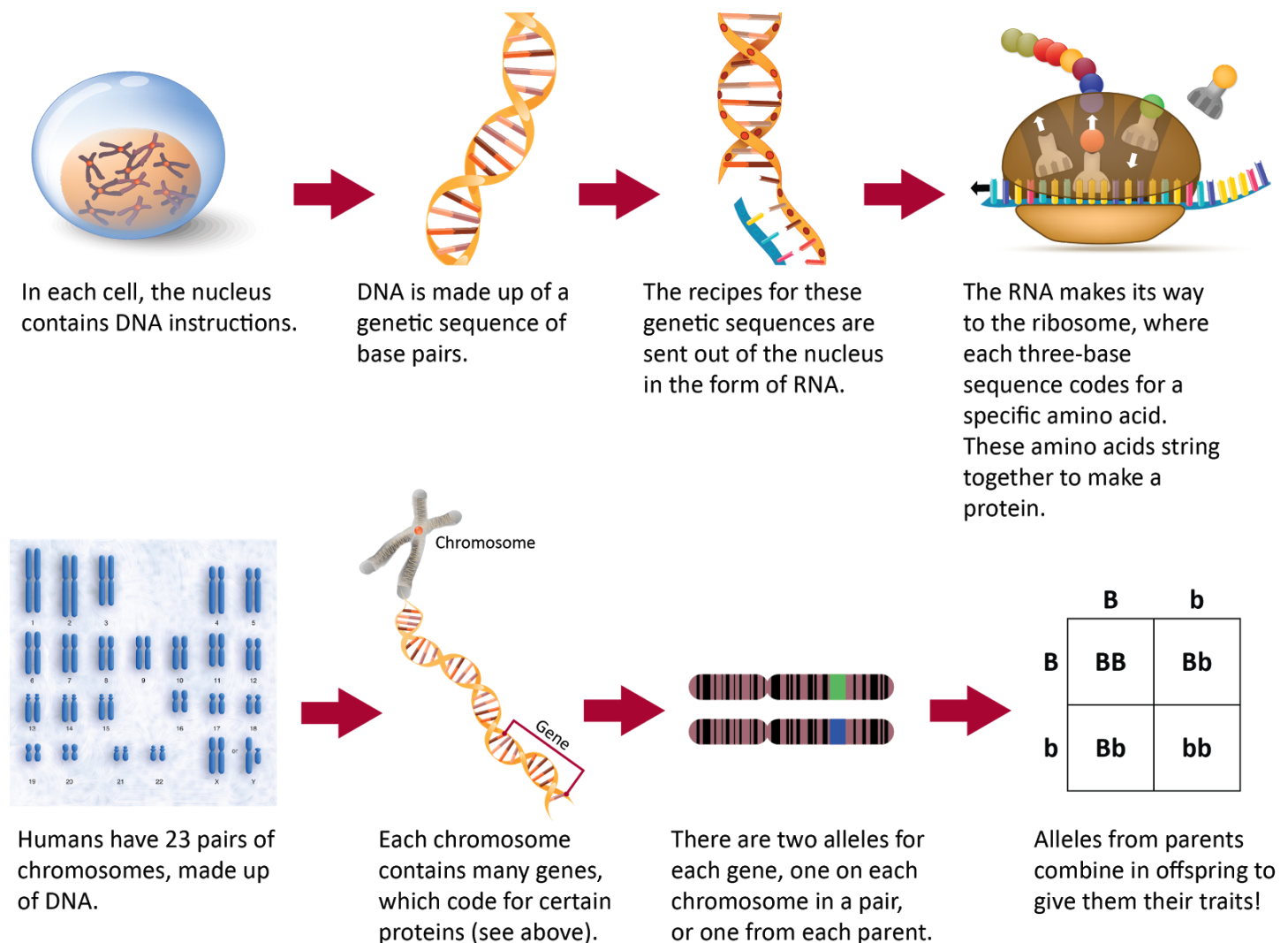
The Genes/Alleles You Have	What You Look Like
TT	Tall
Tt	Tall
tt	Short

The alleles (the Ts) are separated when making eggs and sperm through the process of meiosis and are randomly joined together to create a zygote, embryo, and eventually an offspring. Due to the random separation of genes in the process of meiosis and the random mixing of genes in the process of fertilization, there is a wide variation of phenotypes (looks) in the offspring. This variation results in the diversity of life on Earth and is important for the process of natural selection.

Genotype, meaning the genes that are found in an individual, and *phenotype*, meaning the physical traits in an individual, are typically two words that are used with genetics. This task does not use these words because the focus is on the conceptual idea of genetics without the expectation of students memorizing academic vocabulary. Using the words *genotype* and *phenotype* is optional.

A visual summary of this background information is shown below.

The Central Dogma—DNA to Proteins



For more information about Mendel and genetics, preview this video that you will show during the slide presentation:

<https://www.youtube.com/watch?v=cWt1RFnWNzk&feature=youtu.be>

Introduction

1. Read the introduction from the Student Edition aloud as a class. The purpose of this introduction is to connect what students learned in the previous task to the upcoming task.
2. Have students answer the prior knowledge question on their own and then share with a partner in a think-pair-share format.
 - In the previous task, students learned about structures that aid in successful reproduction. In this task, students will delve more into the results of successful reproduction.
 - The questions provided ask students to access their own prior knowledge about where they come from and why they think they look the way they do. Student responses should revolve around the general understanding that because they came from two parents, they have a combination of their parents' traits.

In discussions, make sure to be culturally sensitive toward students who are either adopted or do not have knowledge of the traits of one or more parents. Do not cold call on students to share aloud for this reason. Students in one of these situations can either skip this question or think about a friend and the friend's parents.

Part I • Dog Traits

1. Place students in their project groups. Designate student roles and review the norms.
2. Place on each group's table:
 - Domestic Dog Pictures Resource Card
 - Animal and Plant Reproduction Resource Card
3. Show Slide 3 of the "Variations and Heredity Task 3" digital slide presentation, which replicates the Domestic Dog Pictures Resource Card.
4. Ask students to discuss with their group the questions in their Student Edition about the Domestic Dog Pictures Resource Card.
5. Use Slides 4–5 of the digital slide presentation to lead a group discussion about the questions.
6. Have students discuss with their group the questions about the Plant and Animal Reproduction Resource Card.
7. Use Slides 6–8 to lead a group discussion about the questions.

Question	Focus of Answer
2a	<i>There are many variations of traits in the dogs. Try to elicit answers from as many students as possible. Note: It is important at this point to emphasize the difference between species and breed to avoid misconceptions in the next task. All the variations students see are breeds within a dog species. Examples of breeds are golden retriever, husky, German shepherd, etc. Because they are part of the same species, they are still able to reproduce together and produce fertile offspring. Cats and dogs, however, are different species so they cannot reproduce together to make fertile offspring. This idea will be emphasized again in Task 4.</i>
2b	<i>Variation exists because of DNA differences, genetic differences, DNA passed down from parents to offspring, sexual reproduction, and environment (food, exercise, quality of life, disease). Note: This question emphasizes the crosscutting concept of cause and effect.</i>
3	<i>The goal is to lead students to the fact that sexual reproduction is the joining of the egg and sperm. Sexual reproduction is not defined as “having sex.” Sexual reproduction is defined as “The process of producing offspring by joining the egg and sperm.” There are many organisms that do not “have sex” but still produce eggs and sperm to reproduce. With salmon, for example, the female lays her eggs and then the male swims over and releases the sperm over the eggs. Some invertebrate species in the ocean are another example. These species simply release their eggs and sperm into the ocean at a certain time of the year, stimulated by moon and sunlight patterns. These organisms can only hope that one of their sperm meets another of the same species’ eggs. Sea urchins and sea anemones exhibit this type of external fertilization (which still falls into the category of sexual reproduction).</i>

Part II • Make a Dog Family


1. Place students in their project groups. Designate student roles and review the norms.
2. Place on each group's table:
 - 7 pennies with alleles attached to them
 - 2 pennies with a capital letter (alleles) on each side of the coin
 - 2 pennies with a capital letter (allele) on one side and a small letter (allele) on the other side of the coin
 - 2 pennies with a small letter (alleles) on each side of the coin
 - 1 penny with no letters (alleles) on it for flipping to identify (TT) or (Tt)
 - Domestic Dog Pictures Resource Card
 - Dog Traits and Alleles Resource Card
3. Give to every student:
 - Dog Family Picture Frame



LANGUAGE SUPPORT: DISCUSSION SCAFFOLD

Go over the categories of domestic dogs briefly, since some students may not realize the differences depicted. Also, be mindful that some cultures and belief systems view dogs from a distance, not with familiarity.

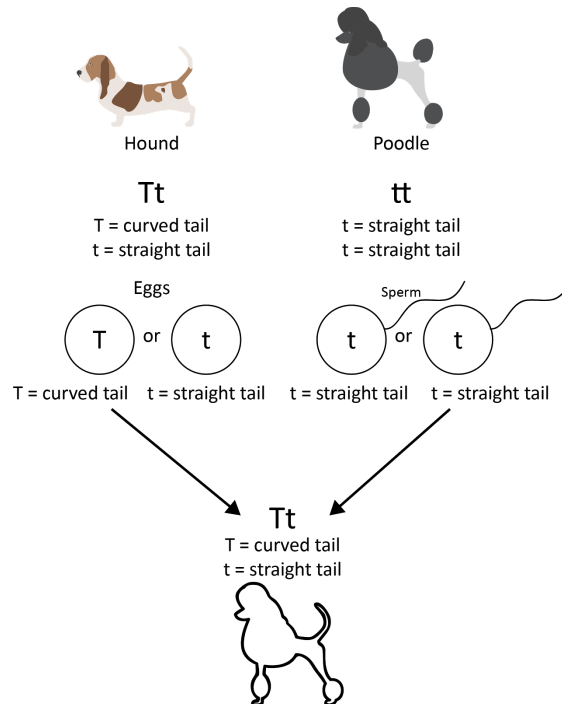
4. Show Slides 10–19 of the digital slide presentation to introduce concepts of heredity. It is recommended that students write the definitions of the vocabulary words and draw corresponding pictures in their science notebook for reference throughout the task and for use in the Independent Culminating Project. It is also recommended that students take notes in their science notebook about where genes come from as well as dominant vs. recessive traits. Try to use the vocabulary words during this task as often as possible to help the words become part of the student's natural vocabulary. The goal of the digital slide presentation is to:
 - Slide 10: Introduce Gregor Mendel.
 - Slides 11–15: Introduce (review) the words *chromosome*, *gene*, *allele*, *trait*, and *heredity*.
 - Slide 16: Give a brief history of genetics with a slide about Gregor Mendel and a short video clip: <https://www.youtube.com/watch?v=cWt1RFnWNzk&feature=youtu.be>
 - Slide 17: Introduce the idea that DNA (genes) comes from both the mom and the dad.
 - Slide 18: Review dominant and recessive traits.
 - Slide 19: Introduce the idea that in genetics, a capital letter represents the dominant allele and a small letter represents a recessive allele. TT, Tt, and tt are possible gene combinations representing allele combinations.
5. Use Slides 20–21 to model the steps of the activity with one dog trait. Further detail is provided in the table below.

Step		Example
1	Pick a mom dog and a dad dog from the Domestic Dog Pictures Resource Card.	<ul style="list-style-type: none"> Hound (mom) and poodle (dad)  <p style="text-align: center;">Hound Poodle</p>
2	Draw your mom and dad dogs in your Dog Family Picture Frame.	<ul style="list-style-type: none"> Refer students to the Dog Family Picture Frame where they will draw their dogs.
3	Identify and record mom and dad dogs' traits in the Dog Data Table.	<ul style="list-style-type: none"> Refer students to the Dog Traits and Alleles Resource Card Show students the Dog Data Table. Start with the Tail Shape trait as an example. Hound: Curved Poodle: Straight Record the trait in Dog Data Table.
4	Identify and record mom and dad dogs' alleles in the Dog Data Table.	<ul style="list-style-type: none"> Use the Dog Traits and Alleles Resource Card. Hound, curved tail: Since she has a curved tail she is either (TT) or (Tt). To determine which, flip a regular penny to see if the hound is (TT) or (Tt). For example, tails = (Tt). Record the resulting hound alleles (Tt) in the Dog Data Table. Poodle, straight tail: A straight tail is always (tt). Record the poodle alleles (tt) in the Dog Data Table.
5	Make a puppy with your penny alleles.	<p>Recommend that each group pick a person to be the mom dog to always flip the mom penny and the dad dog to always flip the dad penny.</p> <ul style="list-style-type: none"> The mom dog flips the (Tt) coin to decide which allele from the mom will be passed on to the puppy. The dad dog flips the (tt) coin to decide which allele from the dad will be passed on to the puppy. Record the resulting traits and alleles in the Dog Data Table.
6	Repeat steps 3–5 for all traits of the puppy.	
7	Repeat steps 5–6 for a second puppy.	
8	Draw your two puppies in the Dog Family Picture Frame.	
9	Name the dogs in your dog family.	

6. Have students make their dog family.
 - Rotate through the room to check on students' progress and clarify steps as needed.
7. At the end of Part II:
 - Each **student** should have completed the Dog Data Table and a Dog Family Picture.
 - Display one student's Dog Family Picture from each group. By displaying the pictures, students will be surrounded by the resulting variation and diversity in the offspring (puppies).
 - Students should move directly into Part III after finishing their dog family.

Part III • Dog Family Analysis

1. Have students use their dog family to make a model of how sexual reproduction results in variation of traits.
 - Point out that they only need to include one of their dogs' traits in their model.
 - Provide the following example to make sure students understand what they need to do.

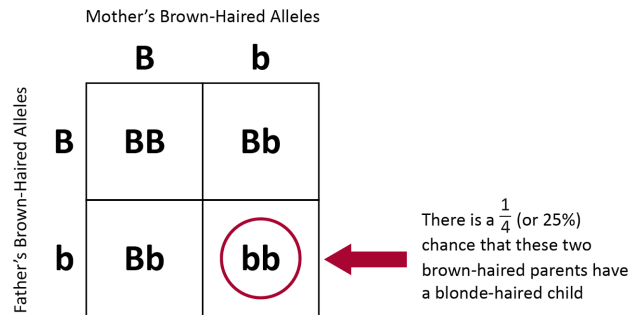


2. Have students answer question 2 in their Student Edition. This question emphasizes the crosscutting concept of **cause and effect**.

A sample student response could be: Sexual reproduction results in variations because in each individual there are two alleles for each trait. These alleles may not be the same. Because only one allele is in the egg and one allele in the sperm, the offspring may end up with a different combination of allele pairs when compared to the parent allele pairs.

3. Have students answer question 3 in their Student Edition. **Answer:** $b \times Bb = bb$
4. Optional: Introduce Punnett squares and have students create a Punnett square for one trait in their dog family. (Note: By introducing Punnett squares after students have made their model, you avoid the misconception of students lacking the connection between parent allele and offspring allele.) Background information on Punnett squares is below.

Punnett Squares



In a Punnett Square, the parents' alleles go on the top and left side of the 4x4 box. In order to calculate offspring genotypes, the allele from the top parent (ex: mother) is pulled down to each corresponding box and the allele from the left-side parent (ex: father) is pulled across to each corresponding box. Each inside box will thus result in a two-allele genotype for the offspring. One can find the probability of inheriting each genotype by dividing by the total number of boxes (4). In this case, there is only a $\frac{1}{4}$ chance of bb or blonde hair.

Part IV • Bacteria Traits

1. Place students in their project groups. Designate student roles and review the norms.
2. Place on each group's table:
 - Bacteria Resource Card
3. Have students discuss in their groups the questions in the Student Edition about the Bacteria Resource Card.
4. Have students discuss in their groups the questions in the Student Edition about the Bacteria Reproduction Resource Card (the bottom part of the Bacteria Resource Card.)
5. Use Slides 23–26 of the digital slide presentation to lead a class discussion about the questions in Part IV.

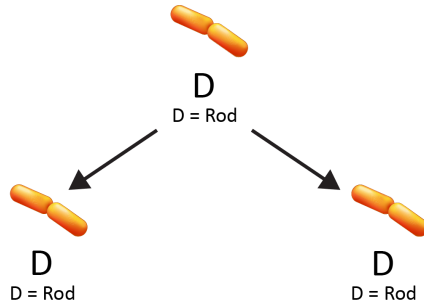
Question	Focus of Answer
2a	<i>Review the parts of the bacteria on the top of the Bacteria Resource Card. There are many variations of traits in the bacteria. Try to elicit answers from as many students as possible.</i>
2b	<i>Variation exists in bacteria because of DNA differences, genetic differences, species differences, and the environment (maybe). Differences in bacteria also exist due to mutations. (Do not expect students to know about mutations—students are not required to learn this concept. However, if students do bring up the concept, encourage discussion, since mutations and the results of mutations are introduced in the eighth grade units.) Note that this question emphasizes the crosscutting concept of cause and effect.</i>
3	<i>The goal is to lead students to the fact that asexual reproduction is the splitting of the original parent into two new and exact copies of the parent. The offspring are exact copies because there is no mixing of DNA from two different parents. Asexual reproduction does not involve the joining of an egg and sperm.</i>

Part V • Bacteria Family

1. Place students in their project groups. Designate student roles and review the norms.
2. Place on each group's table:
 - Bacteria Traits Resource Card
 - Optional: Pennies (Bacteria reproduce asexually and only have one chromosome, so they only have one allele per trait. As a result, pennies really aren't necessary. You could, however, provide students with a few pennies with only capital letters on each side and/or lower case letters on each side of the coin to show that no matter what, bacteria will create exact copies of themselves [except when mutations occur].)
 - Students should already have on their tables:
 - Bacteria Resource Card
3. Give to every student:
 - Bacteria Family Picture Frame
4. Go through the directions for creating a bacteria family. Modeling this part of the activity is not important, since the activity is similar to the dog activity. The challenge for students here is to come up with a way to show the alleles that will be passed on from "parent" to "offspring" through asexual reproduction.
 - Begin with a whole-class discussion in which students discuss how they might simulate asexual reproduction. Bacteria only have one chromosome, so they only have one allele per trait. Since there is only one parent bacteria, and the parent bacteria only has one allele for each trait, students could either flip a coin that has the same allele on both sides, or just understand that the alleles will be the same in the parent and offspring. Students may get stuck on this concept, but allow them to be stuck and think for awhile. If necessary, use guiding questions such as the following:
 - Why does the coin have the same allele on both sides?
 - How is the reproduction process different from dog reproduction?
 - What is the result of this type of reproduction on the offspring?
 Some groups may "get it" right away—you may see the fabulous "AHA" moment!
5. Have students create their bacteria family. Display Slides 27–28 as they work to guide them.
6. At the end of Part V:
 - Each **student** should have completed the Bacteria Data Table and a Bacteria Family Picture.
 - Display one student's Bacteria Family Picture from each group. By displaying the pictures, students will be surrounded by the resulting similarity in the bacteria parents and offspring.
 - Students should move directly into Part VI after finishing their bacteria family in Part V.

Part VI • Bacteria Family Analysis

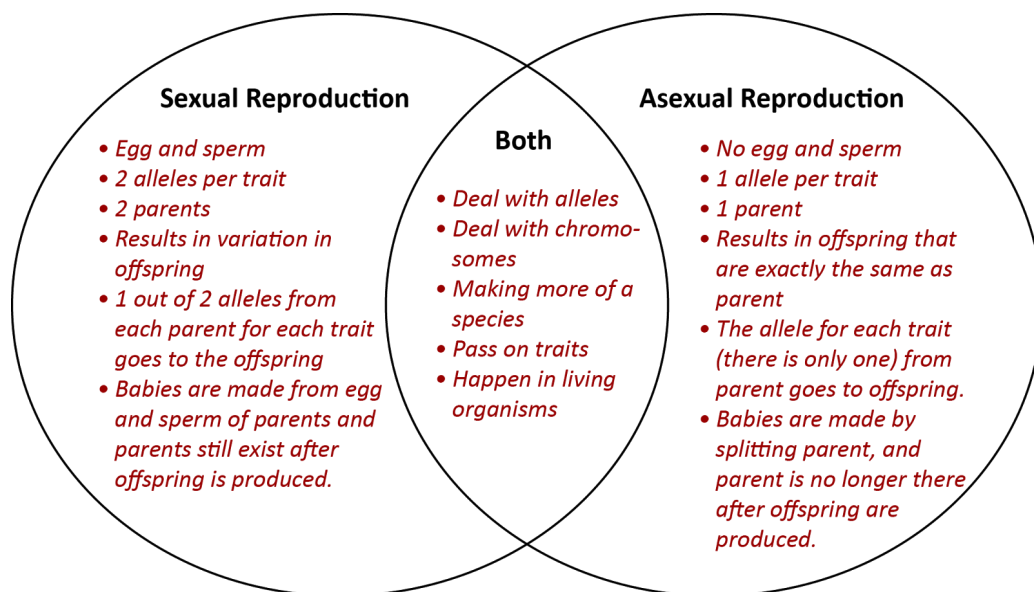
- Have students use their bacteria family to make a model of how asexual reproduction does not result in variation.
 - Point out that they only need to include one trait in their model.
 - Provide the following example to make sure students understand what they need to do



- Have students answer question 2 in their Student Edition. This question emphasizes the crosscutting concept of **cause and effect**.

A sample student response could be: Asexual reproduction does not result in variation in bacteria for two reasons. First, bacteria only have one chromosome and, therefore, only one allele for each trait. Second, because bacteria split in two to reproduce, their one chromosome doubles and then splits in two. Therefore, new baby bacteria end up with the exact same chromosome (alleles) as the parent bacteria, and thus are identical to the parent bacteria.

- Have students answer question 3 in their Student Edition. Below is an example of a Venn diagram. Students may think of more and different diagrams.



- Extension question: Have students brainstorm about ways a bacteria with a flagellum might have a baby bacteria without a flagellum. *The answer would be a genetic mutation.*

5. Display Slide 29. Have students watch the first 2:20 minutes of the following video clip for a review of sexual and asexual reproduction:

<http://study.com/academy/lesson/sexual-reproduction-inheriting-genes-from-each-parent.html>



6. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following question from their Student Guide: At the beginning of this task, you tried to explain why you look identical or different from your parents. Look back at your response. After what you have learned about sexual and asexual reproduction, how could you change or add to your ideas?

There is no right answer. Encourage students to look back at the prior knowledge question from the start of class. They should not change their initial answer, but rather use this reflection to modify their original idea or add evidence they have collected over the course of this task.

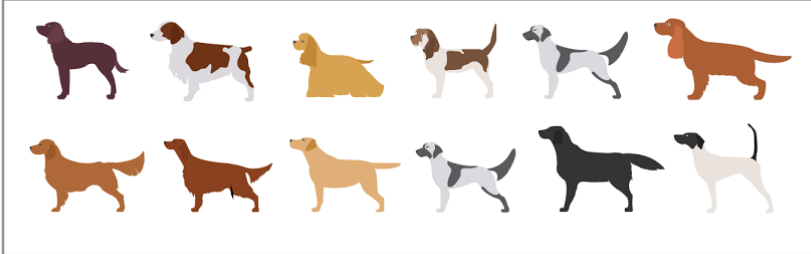
Part VII • Connect to the Culminating Project and Assessment

1. Have students independently complete the task 3 section of the Individual Project Organizer in class.
2. Collect the Individual Project Organizers and assess using these criteria:
 - The “Developing and Using Models” row of the Science and Engineering Practices Rubric
 - A criterion of your choice
3. Return the Individual Project Organizers. Give students time to make revisions based on one of these two options.
 - Have students make changes to their Individual Project Organizer according to your comments. (This could be done for homework, depending upon students’ needs and/or class scheduling.)
 - Ask students to exchange their Individual Project Organizer with a partner, and give partners 5 minutes to provide written feedback. Then allow students time to make changes to their work according to the feedback.

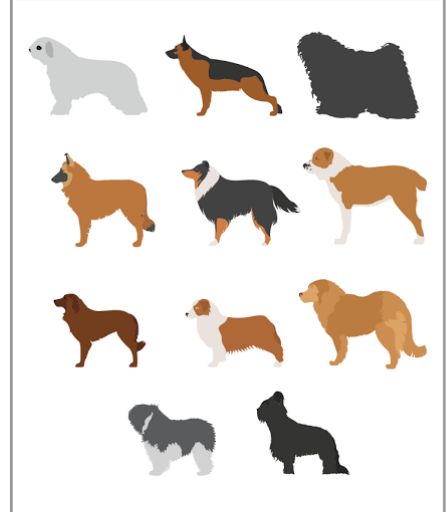
Domestic Dog Pictures Resource Card

DOG BREEDS

SPORTING GROUP



HERDING GROUP



NON-SPORTING GROUP



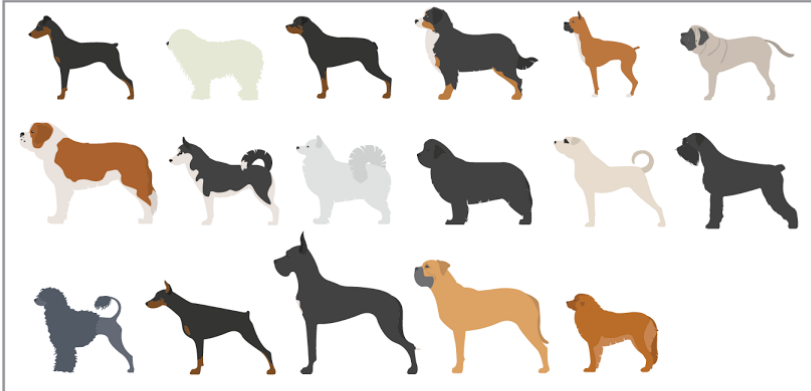
TERRIER GROUP



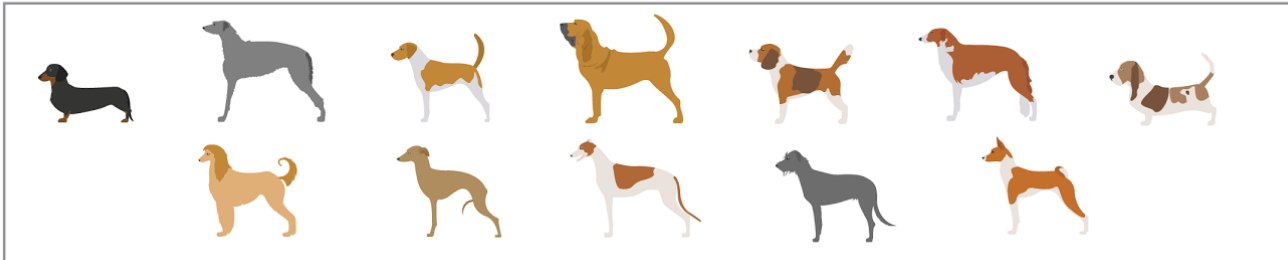
TOY GROUP



WORKING GROUP

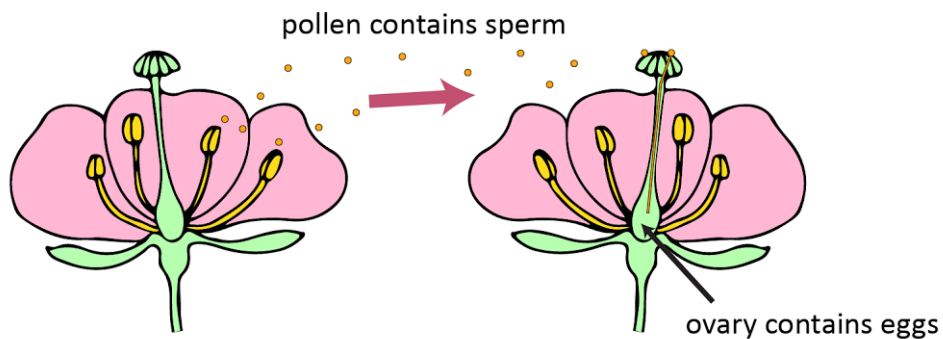
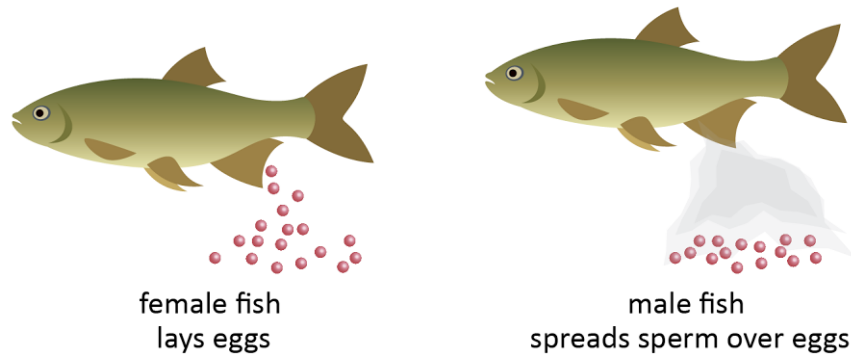
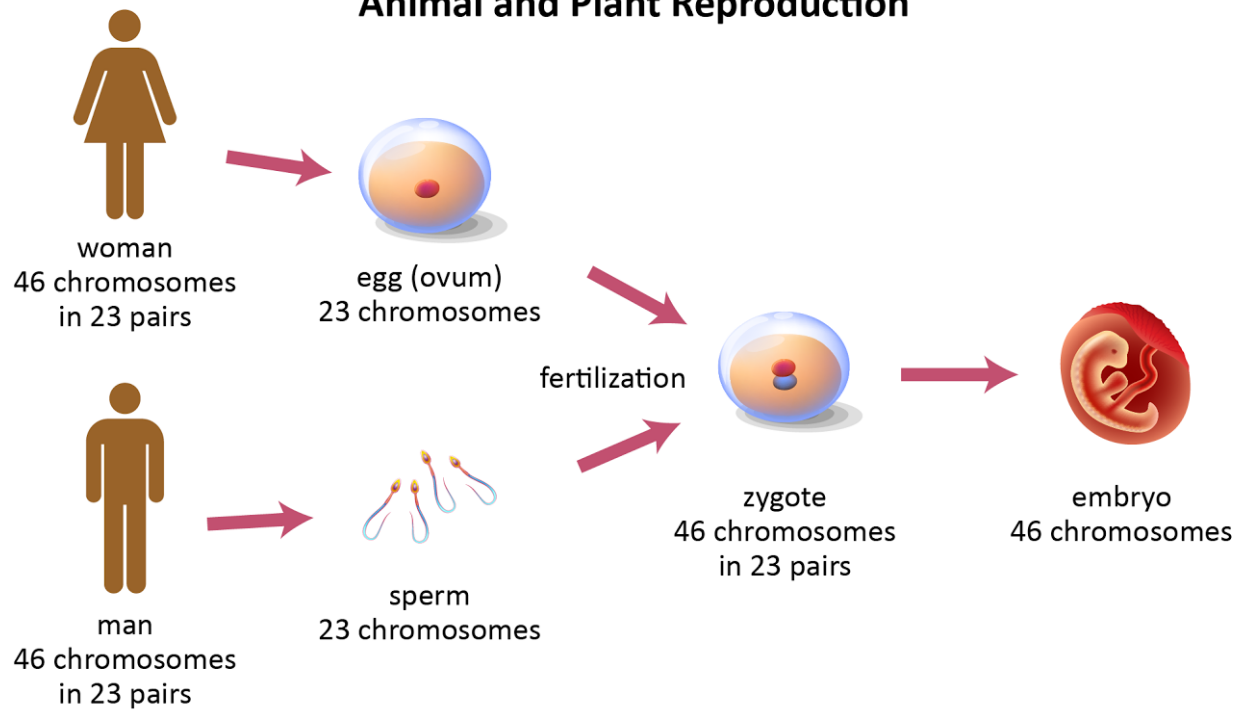


HOUND GROUP



Animal and Plant Reproduction Resource Card

Animal and Plant Reproduction



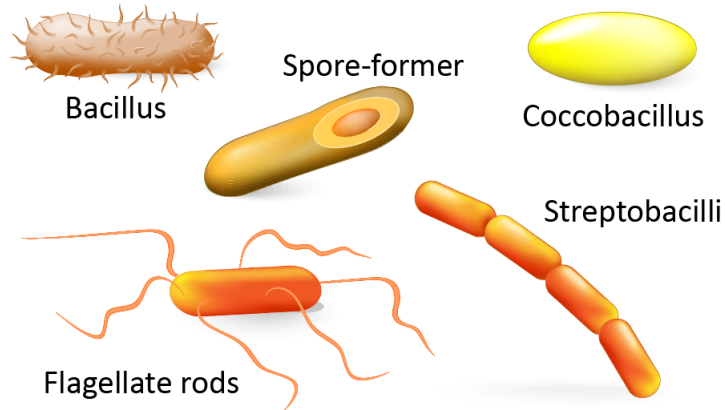
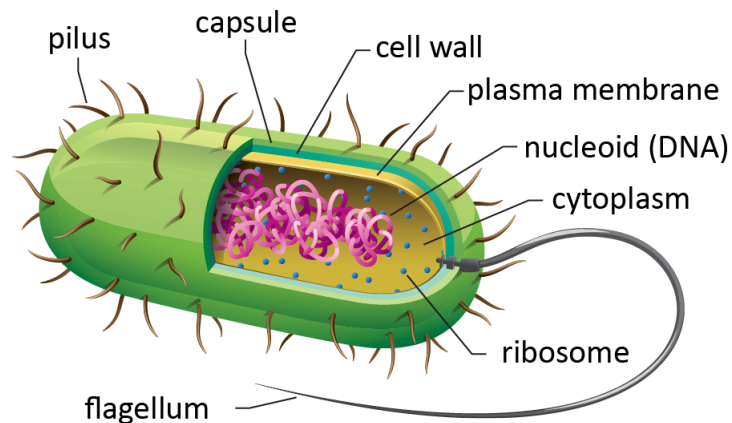
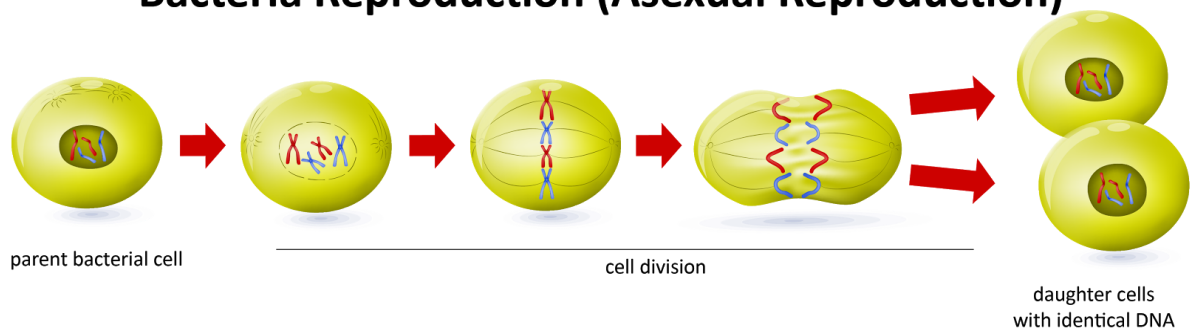
Dog Family Picture Frame**Mom Dog
Name:****Dad Dog
Name:****Puppy 1
Name:****Puppy 2
Name:**

Dog Traits and Alleles Resource Card

When designing your parent dog genotypes, use the TT or Tt alleles for the dominant traits. For dominant traits, flip a coin to determine whether your dog has two dominant alleles (TT) or one dominant and one recessive allele (Tt).

Note: For other traits you will use different letters. However, you will still use the coins with the letter “T.”

Trait	Dominant Trait (usually seen more often)	Recessive Trait (usually seen less often)
Tail Shape	(TT or Tt) curved	(tt) straight
Tail Fluffiness	(FF or Ff) fluffy	(ff) not fluffy
Tail Length	(LL or Ll) long tail	(ll) short tail
Height	(HH or Hh) long legs	(hh) short legs
Coat Color	(DD or Dd) spotted	(dd) all one color
Coat Length	(NN or Nn) naturally short hair	(nn) naturally long hair
Ear Stance	(EE or Ee) floppy ears	(ee) stand up ears
Ear Length	(GG or Gg) long ears	(gg) short ears
Your Choice of Trait:		
Sex	XX = Female (Use AA penny) XY = Male (Use Aa penny)	

Bacteria Resource Card**Types of Bacteria****Parts of a Bacteria****Bacteria Reproduction (Asexual Reproduction)**

Bacteria Traits Resource Card

Bacteria only have one chromosome, so they only have one allele per trait.

Trait	Allele
Cell Shape	Round = R Rod = D Spiral = S
Growth Pattern	Found alone (not touching each other) = A Found in pairs (touching each other) = Y Found in clumps (touching each other) = C Found in a chain (touching end to end) = H Found in no pattern = Z
Flagellum	No flagellum = G One flagellum = F Multiple flagella = M
Outer Coat (Capsule)	Outer coat (capsule) = O No outer coat (no capsule) = T
End (Spore)	Enlarged end = E No enlarged end = X

Bacteria Family Picture Frame

Parent Bacteria

Offspring Bacteria

Unit Essential Question

How do the environment and genetics affect who we are and how we are similar or different?

Introduction

Just like plants, elephants are all different. Elephants vary in many ways, including how much hair they have, the size of their tusks, their weight, and their height. Elephants vary because they have different genes and because of the different environments they live in. “Environment” includes many components, such as the place one lives, the plants and animals around, the weather and climate, the air quality, the quantity and quality of food consumed, social connections, exercise, work, play, and even the doctors and medicine available (for elephants in zoos). In this task, students will look at how an animal’s genes—specifically, elephants’ genes—and environment affect height and weight.

Objectives

Students will be able to

Content

- Determine whether variations of living organisms are due to genetics or the environment.

Science and Engineering Practices

- Construct a scientific explanation about how environmental and genetic factors influence the growth of organisms.

Equity and Groupwork

- Share observations with their group.

Language

- Communicate their ideas and listen actively.

Academic Vocabulary

- environmental differences
- genetics
- inheritance
- species
- variation

Language of Instruction

- axis

Timing

This task can be completed in 3 class periods (based on 45-minute periods).

- Part I • Variation in Elephants (0.5 class period)
- Part II • Genetic Variations Resulting in Different Elephant Sizes (0.5 class period)
- Part III • Different Environmental Conditions Resulting in Variation in Elephant Sizes (1 class period)
- Part IV • Connect to the Culminating Project and Assessment (1 class period)

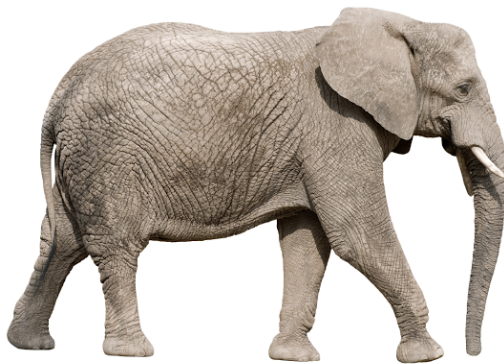
Materials

none

Background Knowledge

What is a species? There are actually over 20 different definitions of a species. For the sake of this task, you will use the definition most often associated with a species, the biological species concept. The biological species concept states that a species is a population of organisms that look similar and can breed and produce fertile offspring. Therefore, humans are all the same species because they look similar and can mate and produce fertile offspring. On the other hand, elephants and cats are not the same species because they do not look similar and cannot mate and produce fertile offspring. One interesting situation is donkeys and horses. Donkeys and horses can mate and produce offspring, mules, but mules are always sterile. Therefore, even though donkeys and horses look similar, they are not considered to be the same species.

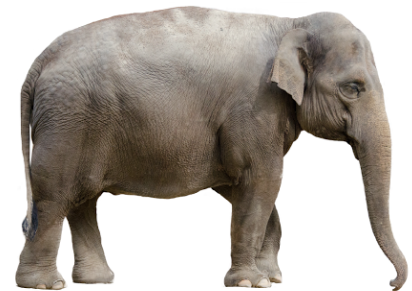
There are three main existing species of elephants: the African savanna (bush) elephant, the African forest elephant, and the Asian elephant. You might conclude that because they are all different species, they must look somewhat different and cannot mate and produce viable offspring. Actually, the DNA of the African savanna elephant and African forest elephant was analyzed in 2010, and scientists conclusively determined that the two elephants are without a doubt different species. The chart below summarizes some of the physical differences between the elephants. The maps that follow show the elephants' geographical locations.



African savanna
elephant



African forest
elephant



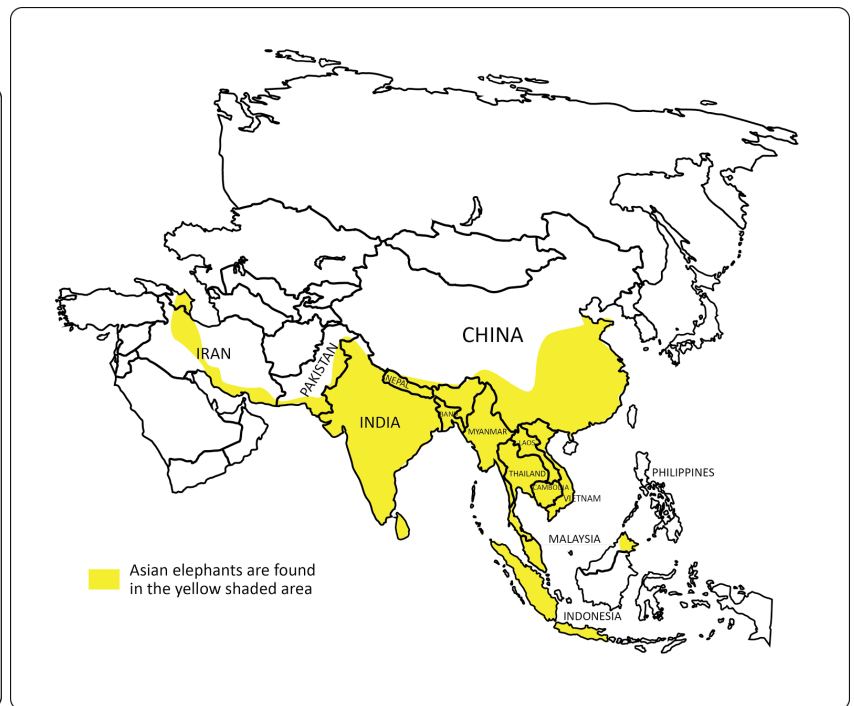
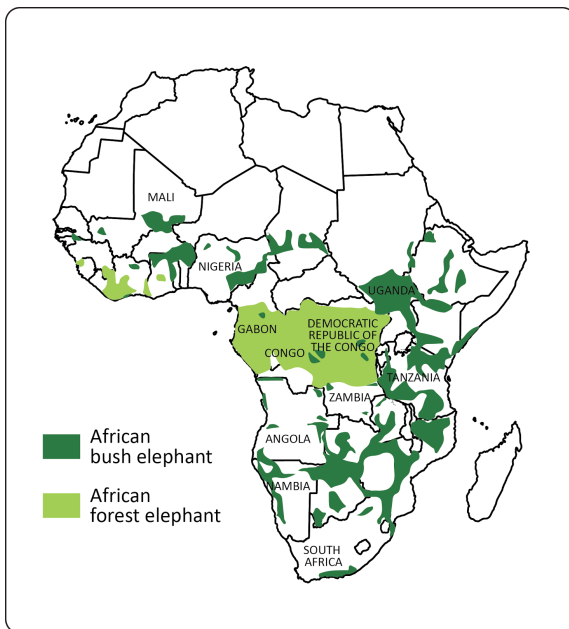
Asian elephant

Physical Differences between Elephants

Trait	African Savanna (Bush) Elephant	African Forest Elephant	Asian Elephant
Tusks	Heavier 110–175 lbs. curved	Lightest Straighter/downward	Lighter 90–110 lbs.
Trunk	2 finger like projections at the tip of the trunk	2 finger like projections at the tip of the trunk	1 finger like projection at the tip of the trunk
Trunk rings	More rings	Medium rings	Fewer rings
Back	Dipped/concave	Dipped/concave	Arched/convex
Head	No humps on forehead	No humps on forehead	2 humps on forehead
Weight	2–7 tons	2.7–6 tons	2–5 tons

Trait	African Savanna (Bush) Elephant	African Forest Elephant	Asian Elephant
Hair	Less hair	More hair	More hair
Coloration	Darker and consistent color	Dark almost black	Freckled/patches of de-coloration
Ear size	Larger	Larger but rounder	Smaller
Skin	More wrinkled	More wrinkled	Smoother
Toenails	Fore feet: 4 Hind feet: 3	Fore feet: 5 Hind feet: 4	Fore feet: 5 Hind feet: 4

Geographical Locations of Elephants



Introduction

1. Read the introduction from the Student Edition aloud as a class. The purpose of this introduction is to connect what students learned in the previous task to the upcoming task.
2. Have students answer the question in the Student Edition on their own, and then share with a partner in a think-pair-share format.
 - In the previous task, students modeled how sexual reproduction passes on a combination of genes from parents to offspring, resulting in variations in traits. They have also looked at how the environment influences traits of organisms. The question they ask in this task is: Which is it—genetics or environment?
 - The question introduces students to a twin study that asked the same question. Students need to use their own prior knowledge to make a prediction about whether identical twins who were raised apart still have identical traits after 20 years.

Part I • Variation in Elephants

1. Place students in their project groups. Designate student roles and review the norms.
2. Have the groups discuss questions 1 and 2. Ask student recorders to write down the groups' thoughts.
3. Discuss as a class the possible causes of elephant variation. Record student responses visually for all students to see.

Possible answers:

- *Age*
 - *Gender*
 - *Diet*
 - *Species (type of elephant)*
 - *Health of elephant*
4. Probe a bit further and ask students whether they think their answers involve genetic or environmental influences on the trait of elephant size.
 5. Have students discuss the word *species* in their groups. Then ask them to individually write a sentence that contains the words *cats* and *species*.
 6. Hold a whole-class discussion about species. Ask each group to give their opinion about what the word means. There may be a variety of opinions and ways that students express their thoughts about the word. In the end, the discussion should get to the idea that species are different types of organisms, and that organisms in the same species look similar and can mate to produce fertile offspring.
 - Build off of Task 3. Once again, it is important that students understand that members of the same species (like dogs of different breeds) can reproduce, while members of different species cannot.
 - Students may bring up “exceptions” to this rule, such as ligers and mules. While lions and tigers can mate and produce offspring (liger), the liger is infertile (unable to produce its own offspring), so lions and tigers are still considered different species. The same goes for donkeys and horses.
 7. After discussing the word *species* with the large group, have students work with their group to re-evaluate the sentence they wrote and revise the sentence as needed.

Possible answers:

Lions, tigers, bobcats, mountain lions, and housecats are all different species of cats because...

Dogs and cats are not the same species because...

Different species of cats are all different sizes.

Part II • Genetic Variations Resulting in Different Elephant Sizes

1. Place students in their project groups. Designate student roles and review the norms.
2. Introduce Part II by asking students what different species they see on the graph. Review the word *species*.
3. Briefly explain that in this activity, students will analyze the data in the graph about elephant sizes and then construct a claim, evidence, reasoning explanation. Remind students to use numbers from the graph when supporting their claim. Remind students to listen to each other's ideas before making a final decision as to what to write.
4. Have students work in their groups to answer the three parts of question 1 in the Student Edition.
5. Have students individually write claim, evidence, reasoning explanations. Provide sentence stems as needed based on the sample answers below.
6. Bring the class together to discuss the questions. Ask each group to share one of their comparative statements about Graph 1. Record their statements on the board. Positively reinforce the use of numbers in the statements.
7. Have students share their claim, evidence, reasoning explanations.
 - Optional: Have students exchange their explanations with a partner and get written feedback. Give students time to make edits based on the feedback they receive.

Possible answers:

Claim: After analyzing Graph 1, make a claim about elephant heights and elephant species.

- *Different elephant species have different heights.*
- *The African savanna elephant species is much taller than the African forest elephant species.*
- *All elephant species are much taller than the human species.*

Evidence: Use evidence from the graph to support your claim. Use numbers when stating your evidence.

- *On average, the African savanna elephant is 4 m tall, the Asian elephant is 3.3 m tall, and the African forest elephant is 2.7 m tall.*
- *On average, the African elephant is 0.7 m taller than the Asian elephant and 1.3 m taller than the African forest elephant.*
- *On average, the African savanna elephant is 1.3 m taller than the African forest elephant.*
- *On average, elephants are anywhere from 1 to 2.3 m taller than humans.*

Reasoning: Use a scientific concept to connect your evidence to your claim.

African savanna elephants, African forest elephants, and Asian elephants are all different species. This means that they all have different genes. Since genes determine how tall the elephants will be, the different species of elephants have different heights due to genetics or inherited traits.

Point out to students that there can still be a lot of other variables that affect height. Environmental factors, such as climate differences, food availability, etc., can also affect elephant size.

Part III • Different Environmental Conditions Resulting in Variation in Elephant Sizes

1. Place students in their project groups. Designate student roles and review the norms.
2. In a large-group setting, introduce students to Part III by asking them to look at the two pictures in their Student Edition and discuss where elephants might live. Point out that the same species of elephants usually live in similar regions, but that there are environmental differences in similar regions due to climate change, weather change, human impact, etc. In this task, students will determine what and how environmental differences might affect an elephant's growth.
3. Have students discuss questions 1 and 2 in their groups. Tell students to use their science notebook to individually take notes about the discussion (as well as write their answers) so that they can remember details for participation in the group discussion later on.
4. Have students answer questions 3 and 4 individually.
5. Bring students together to discuss the questions. Question 1 highlights the crosscutting concept of cause and effect. Ask students to elaborate on their answers by asking why and how the environmental factors may affect the elephants.

Possible answers: Amount of food, amount of rain, temperature (climate), amount of water in the rivers, type of food, amount of walking they do, stress (number of predators in the area)

6. For question 2, make sure that students understand the graph and the information that it shows.

Possible answers to question 2c: Different amounts of food, different types of food in the zoo, different amounts of vitamins and minerals in their food, different feeding times, different sizes of their cages.

7. Have students share their claim, evidence, reasoning statements.
 - Optional (encouraged for ELL students): Have students exchange their explanations with a partner and get written feedback. Give students time to make edits based on the feedback they receive.

Claim: After analyzing Graph 2, make a claim about the weights of the orphaned Asian elephants.

After 44 weeks, the two Asian elephants grew to have different weights.

Evidence: Use evidence from the graph to support your claim. Use numbers when stating your evidence.

After 44 weeks, Savannah grew to be 300 kg and Sierra grew to be 255 kg.

Reasoning: Use a scientific concept to connect your evidence to your claim.

It is likely that an environmental difference—their diet—influenced their weight gain. Elephants of the same species usually weigh about the same, so there must be another reason why they grew to different weights. Environmental influences can affect traits, and since we know the elephants were fed differently, it is a good possibility that diet affected their weights.

8. Question 4 highlights the crosscutting concept of cause and effect. The goal is for students to apply concepts they learned about elephants (the influence of genetics and the environment) to humans. This discussion can eventually lead to the concept that there is an extreme amount of diversity in life when looking at humans and all living things. One additional conversation may address why diversity in life so important to life on Earth.



9. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following question from their Student Guide: At the beginning of this task, you were asked to think about a study of identical twins raised apart and predict whether these identical twins still had identical traits after 20 years. Look back at your response. After what you have learned about genetics and environment through this task, how would you add to or change your ideas? Is there any evidence from this task that you can add?

There is no right answer, but encourage students look back at the prior knowledge question from the start of class. They should not change their initial answer, but rather use this reflection space to modify their original idea or add evidence they have collected over the course of this task.

Part IV • Connect to the Culminating Project and Assessment

1. Have students independently complete the task 4 section of the Individual Project Organizer in class.
2. Collect the Individual Project Organizers and assess using these criteria:
 - The “Constructing Explanations and Designing Solutions” row of the Science and Engineering Practices Rubric
 - A criterion of your choice.
3. Return the Individual Project Organizers. Give students time to make revisions based on one of these two options.
 - Have students make changes to their Individual Project Organizer according to your comments. (This could be done for homework, depending upon students’ needs and/or class scheduling.)
 - Ask students to exchange their Individual Project Organizer with a partner, and give partners 5 minutes to provide written feedback. Then allow students time to make changes to their work according to the feedback.