NGSS OVERVIEW

REPRODUCTION

Performance Expectation 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.

Performance Expectation MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

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

Performance Expectation 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.

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
1. **View and Reflect: Joe's Situation** This activity introduces the fictional scenario of Joe, who has learned that he might have a genetic condition. Students engage in the practices of asking questions and obtaining, gathering, and communicating information as they attempt to understand Joe's story. As they do this, they explore both the causes and effects of a genetic condition, beginning a focus on the crosscutting concepts of cause and effect and structure and function, which run throughout the unit. Also throughout the unit, students apply what they learn to Joe's situation. In the final activity of the unit, they will make a recommendation to Joe.	MS-LS1.B	Asking Questions and Defining Problems Obtaining, Evaluating, and Communicating Information	Cause and Effect Structure and Function Connections to Nature of Science: Science Addresses Questions About the Natural and Material World	ELA/Literacy: RST.6-8.2 WHST.6-8.9 SL.8.1
2. **Modeling: Creature Features** Students begin to use the practice of developing and using models to show and revise their ideas about genes and inheritance of traits. The crosscutting concepts of patterns and cause and effect provide helpful lenses for thinking about the results of an imaginary scenario in which animals are bred to produce two generations of offspring. This activity begins a sequence in which students explore core ideas and concepts related to patterns of inheritance of traits as a result of sexual reproduction. Students also begin to engage in scientific argumentation as they evaluate possible hypotheses.	MS-LS1.B MS-LS3.B	Developing and Using Models Constructing Explanations and Designing Solutions Engaging in Argument from Evidence	Patterns Cause and Effect	ELA/Literacy RST.6-8.7 WHST.6-8.1 WHST.6-8.9 SL.8.1

REPRODUCTION (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
3. **Reading: Reproduction** Students engage in the practice of obtaining information as they read about the cellular basis of sexual and asexual reproduction. This information will help them to revise their models and explanations for the inheritance of traits and prepare them for quantitative predictions of the incidence of traits in offspring.	MS-LS1.B MS-LS3.A MS-LS3.B	Constructing Explanations and Designing Solutions Developing and Using Models Obtaining, Evaluating, and Communicating Information	Patterns Cause and Effect	ELA/Literacy: RST.6-8.1 RST.6-8.4 RST.6-8.7 WHST.6-8.2 WHST.6-8.9
4. **Investigation: Gene Combo** Students use a coin-tossing model to investigate quantitatively the outcomes of breeding a second generation of offspring from heterozygous parents. The crosscutting concepts of patterns and cause and effect continue to be emphasized. This activity helps students understand how genes determine traits, distinguish between predicted and actual outcomes of such crosses, and further elaborate their model of inheritance of traits. This will lead into activities where students will learn about Mendel's work and will use Punnett squares as another model for predicting the outcomes of genetic crosses.	MS-LS1.B MS-LS3.A MS-LS3.B	Developing and Using Models Constructing Explanations and Designing Solutions Using Mathematics and Computational Thinking Analyzing and Interpreting Data Engaging in Argument from Evidence	Patterns Cause and Effect Scale, Proportion, and Quantity	Mathematics: 6.RP.A.1 ELA/Literacy: RST.6-8.4
5. **Problem Solving: Gene Squares** This activity introduces the use of Punnett squares as a model for predicting the ratios of both genotypes and phenotypes in the offspring of genetic crosses. Students use crosscutting concepts of patterns and cause and effect as they use Punnett squares to predict outcomes of crosses of various pairs of critters.	MS-LS1.B MS-LS3.A MS-LS3.B	Constructing Explanations and Designing Solutions Developing and Using Models Using Mathematics and Computational Thinking	Patterns Cause and Effect	Mathematics: 6.RP.A.1 ELA/Literacy RST.6-8.2 RST.6-8.4 RST.6-8.7

REPRODUCTION (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
6. **Reading: Mendel, First Geneticist** A reading on Gregor Mendel's investigations and the principles of genetics he identified through his work provides a perspective on the history and nature of science and the data analysis, recognition of patterns, and use of mathematics central to this important advancement in explaining how genes cause traits. The reading provides data from Mendel's experiments breeding pea plants and his application of ratios to his analysis and interpretation of his results. Students can compare Mendel's findings, analysis, and model to their own work with the critter model.	MS-LS1.B MS-LS3.A MS-LS3.B	Analyzing and Interpreting Data Using Mathematics and Computational Thinking Obtaining, Evaluating, and Communicating Information Constructing Explanations and Designing Solutions Connections to Nature of Science: Science Is a Way of Knowing	Cause and Effect Patterns Scale, Proportion, and Quantity	Mathematics: 6.RP.A.1 ELA/Literacy: RST.6-8.7 RST.6-8.9
7. **Laboratory: Do Genes Determine Everything?** Students are introduced to two traits for seedling color in *Nicotiana* plants. They are then introduced to experimental design before they plan and conduct an investigation to determine how selected environmental factors affect the phenotype of plant seedlings. They analyze their data to explain the interaction between genetic and environmental factors. They use this experience as the basis for a discussion of the interplay of genetic and environmental factors in determining traits in humans, as well as in plants. The activity provides an opportunity to assess student work related to Performance Expectation MS-LS1-5.	MS-LS1.B MS-LS3.B	Analyzing and Interpreting Data Planning and Conducting Investigations Constructing Explanations and Designing Solutions Connections to Nature of Science: Science Is a Way of Knowing	Cause and Effect	Mathematics: 6.RP.A.1 6.SP.B.5
8. **Reading: Show Me the Genes!** Students obtain information from a reading that introduces the location of genes on chromosomes and the number of sets of chromosomes in sex cells and the rest of the body. This information helps explain some of the phenomena related to genes that students have been learning about, and also prepares them for future activities where they will model the cause-and-effect relationships between genes (and mutations) and protein structure and function.	MS-LS1.B MS-LS3.A MS-LS3.B	Developing and Using Models Obtaining, Evaluating, and Communicating Information	Patterns Cause and Effect Structure and Function Scale, Proportion, and Quantity	ELA/Literacy: RST.6-8.2 RST.6-8.4 RST.6-8.7 WHST.6-8.2 WHST.6-8.9

REPRODUCTION (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
9. **Investigation: Breeding Critters — More Traits** Students model and explain additional patterns of inheritance as they explore cause-and-effect relationships for additional traits of the critters. These patterns help them model and explain the wide variation that can result from sexual reproduction. The activity provides an opportunity to assess student work related to Performance Expectation MS-LS3-2.	MS-LS1.B MS-LS3.A MS-LS3.B	Constructing Explanations and Designing Solutions Developing and Using Models	Patterns Cause and Effect	Mathematics: 6.SP.B.5 ELA/Literacy: RST.6-8.4
10. **Investigation: Animal Behavior** Students analyze and interpret data to create arguments that explain behavioral and other traits in animals that at first glance seem to be either neutral or perhaps even harmful. By looking for patterns in the data, students develop arguments about how these traits cause the individual to have higher reproductive success than those with different traits. The activity provides an opportunity to assess student work related to Performance Expectation MS-LS1-4, focusing on animal traits. In the next activity, students will focus on plant traits.	MS-LS1.B MS-LS4.C	Engaging in Argument from Evidence Analyzing and Interpreting Data	Patterns Cause and Effect	Mathematics: 6.SP.A.2 6.SP.B.4 ELA/Literacy: RST.6-8.1 WHST.6-8.1
11. **Investigation: Plant–Animal Interactions** Students obtain information about flower pollination and its importance to plant reproduction. They consider a number of adaptive plant structures and traits that attract animal pollinators. Students construct an argument for how these traits cause the individual plant to have higher reproductive success than plants with different traits. The activity provides an opportunity to assess student work related to Performance Expectation MS-LS1-4, focusing on plant–animal interactions.	MS-LS1.B MS-LS4.C	Engaging in Argument from Evidence Obtaining, Evaluating, and Communicating Information	Cause and Effect Patterns Structure and Function	ELA/Literacy: RST.6-8.1 RI.6.8 WHST.6-8.1

REPRODUCTION (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
12. **Modeling: How Do Genes Produce Traits?** This activity introduces the concept that a gene encodes for a protein, which has a specific function in the cell. These protein functions manifest as traits in the body. Students use a toober and pipe cleaners to model and generate explanations for how a gene's sequence codes for a protein sequence. They continue using this model to explore how the protein sequence determines the protein structure and function. As students model structure and function, they also examine cause-and-effect relationships between gene sequence and protein function.	MS-LS3.A	Developing and Using Models Constructing Explanations and Designing Solutions	Cause and Effect Structure and Function	ELA/Literacy: RST.6-8.7
13. **Modeling: Fault in the Genes** Students return to their three-dimensional protein models to begin investigating the cause-and-effect relationship between mutations and protein structure and function. The activity begins with a game that introduces students to different types of mutations: deletions, additions, and substitutions. Students then make predictions about how different mutations may affect their protein structure. Using the toobers and pipe cleaners, students model the mutations and the resulting changes to their protein structures. After investigating different types of mutations, students construct explanations for how a mutation in a gene leads to changes in body function, specifically how a mutation in the fibrillin-1 gene leads to Marfan syndrome symptoms. The activity provides an opportunity to assess student work related to Performance Expectation MS-LS3-1.	MS-LS3.A MS-LS3.B	Developing and Using Models Constructing Explanations and Designing Solutions Analyzing and Interpreting Data	Cause and Effect Structure and Function	ELA/Literacy: RST.6-8.7
14. **Talking it Over: Advising Joe** Students apply what they have learned to Joe's scenario and create a written communication that explains the causes and effects of Marfan syndrome and the actions Joe and his family might take.	MS-LS1.B MS-LS3.A MS-LS3.B	Obtaining, Evaluating, and Communicating Information	Cause and Effect Understandings About the Nature of Science: Science Addresses Questions About the Natural and Material World	Mathematics: 6.RP.A.1 ELA/Literacy WHST.6-8.2

NGSS CORRELATIONS

REPRODUCTION

Crosscutting Concepts		Activity number
Cause and Effect	Cause and effect relationships may be used to predict phenomena in natural or designed systems.	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14
	Phenomena may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.	7, 9, 10, 11
Patterns	Patterns can be used to identify cause and effect relationships.	2 ,3, 4, 5, 6, 8, 9, 10, 11
Structure and Function	Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.	1, 8, 11, 12, 13
Scale, Proportion, and Quantity	Phenomena that can be observed at one scale may not be observable at another scale.	8
	Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.	4, 6
Connections to the Nature of Science	Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.	1, 14
Science and Engineering Practices		**Activity number**
Analyzing and Interpreting Data	Analyze and interpret data to determine similarities and differences in findings.	6, 7
	Analyze and interpret data to provide evidence for phenomena.	4, 10, 13
Asking Questions and Defining Problems	Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.	1
	Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.	1

Science and Engineering Practices		Activity number
Constructing Explanations and Designing Solutions	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 nature operate today as they did in the past and will continue to do so in the future.	4, 5, 7
	Construct an explanation that includes qualitative or quantitative relationships between variables that predict or describe phenomena.	2, 3, 6, 7
	Apply scientific ideas to construct an explanation for real world phenomena, examples, or events.	9, 12, 13
Developing and Using Models	Develop a model to predict and/or describe phenomena.	4, 5, 8, 9, 13
	Develop a model to describe unobservable mechanisms.	2, 3, 9, 12, 13
Engaging in Argument from Evidence	Construct and present oral and written arguments 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.	2, 4, 10, 11
Obtaining, Evaluating, and Communicating Information	Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.	1, 3, 6, 8, 14
	Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.	1
Planning and Carrying Out Investigations	Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.	7
	Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.	7
Using Mathematics and Computational Thinking	Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.	4, 5, 6
Connections to the Nature of Science	Scientific knowledge is based on logical and conceptual connections between evidence and explanations.	6, 7

Performance Expectations		Activity number
From Molecules to Organisms: Structures and Processes (LS1)	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)	10, 11
	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. (MS-LS1-5)	7
Heredity: Inheritance and variation of Traits (LS3)	Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. (MS-LS3-1)	13
	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)	9
Disciplinary Core Ideas		**Activity number**
Growth and Development of Organisms (LS1.B)	Animals engage in characteristic behaviors that increase the odds of reproduction.	9, 10
	Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.	11
	Genetic factors as well as local conditions affect the growth of the adult plant (and other organisms).	1, 7, 11, 14
	Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring.	1, 2, 3, 4, 5, 6, 7, 8, 9, 14
Inheritance of Traits (LS3.A)	Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.	4, 5, 8, 12, 13, 14
	Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited.	3, 4, 5, 6, 8, 9, 14

Disciplinary Core Ideas		Activity number
Variation of Traits (LS3.B)	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.	2, 3, 4, 5, 6, 7, 8, 9, 13, 14
	In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.	3, 5, 7, 8, 13
Adaptation (LS4.C)	Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.	10, 11

COMMON CORE STATE STANDARDS: CONNECTIONS AND CORRELATIONS

REPRODUCTION

Making Connections in ELA

As with all SEPUP instructional materials, this unit introduces multiple opportunities for students to engage in a range of ELA practices and skills that are important grade-specific goals of the common core state standards and are also essential to the sensemaking students are doing throughout the unit. Specifically, starting with the very first activity, students read about and summarize a fictional scenario (RST.6-8.2) about a student who might have a genetic disorder, which helps initiate their sensemaking about the inheritance of traits. In activity 3, students engage with a reading to obtain information, including scientific vocabulary (RST.6-8.4) as they draw on specific textual evidence (RST.6-8.1) to reflect on their prior knowledge and revise and document (WHST.6-8.9) their developing models and explanations for the inheritance of traits. Additional readings are introduced in activities 6, 8, 10 and 11 as they continue to make sense of sexual reproduction, alleles, how traits can impact reproductive success and the impact of plant-animal interactions on reproduction. In activity 11, students evaluate the reading to construct an argument (RI.6.8) for how the structure of a plant increases its reproductive success by attracting a specific type of pollinator and students document their arguments in writing (WHST.6-8.1). In most readings, technical information is often presented in visual and numerical representations as well as text and students integrate all of this information (RST.6-8.7) as they progress their sensemaking. Moreover, in activity 6, students compare and contrast information from their reading about Mendel's experiments with information they gained from a game simulation they conducted in activity 4 (RST.6-8.9). Collaborative classroom discussion (SL.8.1) plays a key role in activity 2 as students engage in SEPUP's 4-2-1 model for collaborative work to develop and revise their own hypotheses and models to explain the results of genetic crosses in a story about breeding imaginary creatures. The unit culminates with students creating a written communication that explains the causes and effects of the genetic disorder from the fictional scenario they are introduced to in activity 1 (WHST.6-8.2). Specific literacy strategies are embedded throughout the unit to support student development of these ELA skills and practices. In addition, Appendix E: Literacy Strategies in the Student Book contains optional resources to support reading, writing and oral communication.

Common Core State Standards – English Language Arts		Activity number
Reading Informational Text (RI)	Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. (RI.6.8)	11

Common Core State Standards – English Language Arts		Activity number
Reading in Science and Technical Subjects (RST)	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (RST.6-8.1)	3, 10, 11
	Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. (RST.6-8.2)	1, 5, 8
	Determine the meaning of symbols, Key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics. (RST.6-8.4)	3, 4, 5, 8, 9
	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (RST.6-8.7)	2, 3, 5, 6, 8, 12, 13
	Compare and contrast the information gained from experiments, simulations, video, or multi-media sources with that gained from reading a text on the same topic. (RST.6-8.9)	6
Speaking and Listening (SL)	Engage effectively in a range of collaborative discussions (e.g., one-on-one, in groups, teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. (SL.8.1)	1, 2
Writing in History/ Social Studies, Science, and Technological Subjects (WHST)	Write arguments focused on discipline-specific content. (WHST.6-8.1)	2, 10, 11
	Write informative/explanatory texts to examine and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (WHST.6-8.2)	3, 8, 14
	Draw evidence from informational texts to support analysis, reflection, and research. (WHST.6-8.9)	1, 2, 3, 8

Making Connections in Mathematics

This unit introduces multiple opportunities for students to engage in math practices and skills that are important grade-specific goals of the common core state standards and are also essential to the sensemaking students are doing throughout the unit. The concept of ratios (6.RP.A.1) plays a key role in the unit as students calculate and analyze the ratio of different traits first in a coin-tossing model of possible outcomes of a genetic cross (activity 4), then as they use Punnett squares to predict ratios of genotypes and phenotypes in genetic crosses (activity 5), and as they analyze the data presented in a reading about Gregor Mendel's experiments (activity 6). Students also engage with statistics and probability as they analyze and summarize numerical data they gather (6.SP.B.5) in two investigations, one a plant experiment in activity 7 and in the coin-tossing model of offspring from two parents in activity 9. In activity 10, students analyze data from four real case studies on a behavioral or physical trait in an animal, examining and interpreting graphs of statistical data (6.SP.B.4; 6.SP.A.2) in order to develop arguments about how these traits can increase reproductive success for the animals. An optional student sheet entitled "Scatterplot and Line Graphing Checklist" is provided in Appendix C: Science Skills in the Student Book for students who need additional support.

Common Core State Standards – Mathematics		Activity number
Ratios and Proportional Reasoning (RP)	Understand the concept of a ratio, and use ratio language to describe a ratio between two quantities. (6.RP.A.1)	4, 5, 6, 7, 14
Statistics and Probability (SP)	Understand that a set of data collected to answer a statistical question has a distribution that can be described by its center, spread, and overall shape. (6.SP.A.2)	10
	Display numerical data in plots on a number line, including dot plots, histograms, and box plots. (6.SP.B.4)	10
	Summarize numerical data sets in relation to their context. (6.SP.B.5)	7, 9