									Scientific and Engineering Practices (SP / EP)							
Inv	**Inv Title**	**Part**	**Part Summary**	**Sessions**	**Content**	**NGSS Standards Addressed**	**Disciplinary Core Ideas (Framework)**	**Crosscutting Concepts**	**Asking questions (SP) / Defining problems (EP)**	**Developing and using models**	**Planning and carrying out investigations**	**Analyzing and interpreting data**	**Using mathematics and comp. thinking**	**Constructing explanations (SP) / Designing solutions (EP)**	**Engaging in argument from evidence**	**Obtaining, evaluating, and communicating information**
1	**The History of Life**	1	**The Fossil Record** Students watch a slide show that suggests the diversity of life on Earth that exists today. They consider how that diversity came to exist and then start exploring fossils. They observe a collection of fossils and find out more about the organisms and when they lived. Students consider how scientists date fossils. They construct a time line of Earth's history and assign dates to the fossil samples. They add to the time line a set of events that extends their understanding of the history of life on Earth.	4	● The chronological fossil record documents the existence, diversity, extinction, and change of life-forms throughout Earth's history. ● The fossil record is incomplete because of the nature of fossilization.	• **MS-LS4-1.** Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.	**LS4.A: Evidence of Common Ancestry and Diversity §** ● The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MS-LS4-1)	**Patterns** • Patterns in rates of change and other numerical relationships can provide information about natural systems. Patterns can be used to identify cause-and-effect relationships. Graphs, charts, and images can be used to identify patterns in data. **Scale, proportion, and quantity** • The observed function of natural and designed systems may change with scale. Phenomena that can be observed at one scale may not be observable at another scale.		**SP**		**SP**				**SP**
1	**The History of Life**	2	**Transitions** Students consider the transition of vertebrates from water to land. They explore the fossil evidence that supports current theories of how this transition occurred, based on limbstructure. They predict what an organism may have looked like in the millions of years between two of the fossils. They watch a video that describes the discovery of such an organism and confirm or modify their prediction. Students turn their attention to modern organisms, dissect an owl pellet, and search for limb-structure similarities between the prey organisms and the extinct organisms they learned about earlier.	6	● The chronological fossil record documents the existence, diversity, extinction, and change of life-forms throughout Earth's history. ● The fossil record is incomplete because of the nature of fossilization. ● Structural similarities between ancient and modern organisms is one kind of evidence from which we can infer relatedness.	• **MS-LS4-1.** Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. • **MS-LS4-2.** Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. • **MS-ESS1-4**. Construct a scientific explanation based on evidence from rock strata for how the geological timescale is used to organize Earth's 4.6-billion-year-old history. (foundational)	**LS4.A: Evidence of Common Ancestry and Diversity §** ● The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MS-LS4-1) ● Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. (MS-LS4-2) § **ESS1.C: The History of Planet Earth** ● The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analysis of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4)	**Patterns** • Patterns in rates of change and other numerical relationships can provide information about natural systems. Patterns can be used to identify cause-and-effect relationships. Graphs, charts, and images can be used to identify patterns in data. **Scale, proportion, and quantity** • The observed function of natural and designed systems may change with scale. Phenomena that can be observed at one scale may not be observable at another scale. **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.			**SP**	**SP**		**SP**		**SP**
2	**Heredity**	1	**Lines of Descent** Students examine a human family tree and then build a vertebrate cladogram. They learn about common ancestors and deduce that the more recent common ancestor organisms share, the more closely related they are. They use embryological data to determine where a dolphin fits in their cladogram.	3	● A cladogram is a model that demonstrates evolutionary relationships among organisms. ● Embryo development can be used to identify relationships not evident in adults of different species.	• **MS-LS4-2.** Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. • **MS-LS4-3.** Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.	**LS4.A: Evidence of Common Ancestry and Diversity §** • Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. (MS-LS4-2) § • Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy. (MS-LS4-3)	**Patterns** • Patterns can be used to identify cause-and-effect relationships. Graphs, charts, and images can be used to identify patterns in data.	**SP**	**SP**					
2	**Heredity**	2	**Inheriting Traits** Students explore the variation of four features to determine what traits they have. They determine the distribution of the traits in the class. Students then study a population of larkeys, a make-believe animal, to analyze their traits. Students are introduced to the structures and mechanisms of heredity, using a slide show and then return to the larkeys.	3	● Heredity explains why organisms are similar but not identical to their parents. ● Genes on DNA code for proteins that are responsible for an organism's traits. ● Variation of traits in a population is established in part as a result of sexual reproduction.	• **MS-LS3-1.** Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. (foundational) • **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.	**LS3.A: Inheritance of Traits §** • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1) § • 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)	**Patterns** • Patterns can be used to identify cause-and-effect relationships. Graphs, charts, and images can be used to identify patterns in data. **Cause and effect** • Cause-and-effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause-andeffect relationships in systems can only be described using probability.	**SP**			**SP**		**SP**		**SP**

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2	**Heredity**	3	**Modeling Heredity** Students use online simulations to model and predict the inheritance of traits in a larkey population.	2	● Heredity explains why organisms are similar but not identical to their parents. ● Genes on DNA code for proteins that are responsible for an organism's traits. ● Variation of traits in a population is established in part as a result of sexual reproduction.	• **MS-LS3-1.** Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. (foundational) • **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.	**LS3.A: Inheritance of Traits §** • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1) § • 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)	**Patterns** • Patterns can be used to identify cause-and-effect relationships. Graphs, charts, and images can be used to identify patterns in data.		**SP**		**SP**	**SP**	**SP**		**SP**
2	**Heredity**	4	**Punnett Squares** Students learn how to use Punnett squares to predict the probability of offspring traits when the genotypes of parents are known. They compare the probabilities of inheritance in individual offspring and populations.	4	● A Punnett square is a model used to predict the probability of inheriting genotypes in individuals of a population. .	• **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.	**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)	**Patterns** • Patterns can be used to identify cause-and-effect relationships. Graphs, charts, and images can be used to identify patterns in data. **Cause and effect** • Cause-and-effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause-andeffect relationships in systems can only be described using probability.		**SP**		**SP**	**SP**			**SP**
3	**Evolution**	1	**Adaptation** Students learn how genetic mutations can be adverse, advantageous, or neutral for individual organisms. They consider that mutations are a source of variation in populations and that positive mutations can lead to better adaptations in a population. They use online activities to explore the adaptation of color in walking sticks.	2	● Variation in a population can occur due to random genetic mutations, which can have harmful, helpful, or no effects. ● An adaptation is an inherited trait that increases an organism's chances of surviving in an environment long enough to pass on its genes.	• **MS-LS3-1.** Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. • **MS-LS4-4.** Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.	**LS3.A: Inheritance of traits** • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. **LS3.B: Variation of traits** • 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. **LS4.C: Adaptation** • Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support 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.	**Patterns** • Patterns can be used to identify cause-and-effect relationships. Graphs, charts, and images can be used to identify patterns in data. **Cause and effect** • Cause-and-effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause-andeffect relationships in systems can only be described using probability. **Stability and change** • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale. Small changes in one part of a system might cause large changes in another part. Stability might be disturbed either by sudden events or gradual changes that accumulate over time. Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.		**SP**		**SP**				**SP**

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3	**Evolution**	**2**	**Natural Selection** Using online activities, students track a population of walking sticks over five generations. They consider how natural selection affects the incidence of walking stick color over time. They watch two videos about current research projects that lead to a deeper understanding of natural selection and speciation. Finally, they encounter evolution as the unifying theory that encompasses all they have learned in the course.	5	• Natural selection is a process by which individuals in a population best adapted to their environment tend to survive and pass their traits to subsequent generations. • Change in populations by means of natural selection is the basis for the theory of evolution, which best explains the biodiversity on Earth.	• **MS-LS4-4.** Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. • **MS-LS4-6.** Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.	**LS4.B: Natural selection** • Natural selection leads to the predominance of certain traits in a population, and the suppression of others. **LS4.C: Adaptation** • Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support 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.	**Patterns** • Patterns can be used to identify cause-and-effect relationships. Graphs, charts, and images can be used to identify patterns in data. **Cause and effect** • Cause-and-effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause-andeffect relationships in systems can only be described using probability. **• Stability and change** Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale. Small changes in one part of a system might cause large changes in another part. Stability might be disturbed either by sudden events or gradual changes that accumulate over time. Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.		**SP**		**SP**	**SP**	**SP**		**SP**
3	**Evolution**	**3**	**Genetic Technology** Students research different genetic technologies. They assess how those technologies might address current genetic issues. They communicate their findings to classmates, using a modified jigsaw.	3	• Humans use genetic technologies to influence inheritance.	• **MS-LS4-5.** Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.	**LS4.B: Natural selection** • In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.	**Patterns** • Patterns can be used to identify cause-and-effect relationships. Graphs, charts, and images can be used to identify patterns in data. **Cause and effect** • Cause-and-effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause-andeffect relationships in systems can only be described using probability. **• Systems and system models** Models are limited in that they only represent certain aspects of the system under study. **• Stability and change** Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale. Small changes in one part of a system might cause large changes in another part. Stability might be disturbed either by sudden events or gradual changes that accumulate over time. Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.	**SP**					**SP**	**SP**	**SP**