Selection and Adaptation

Overview

Unit abstract

Students will be able to construct explanations based on evidence to support fundamental understandings of natural selection and evolution. They will use ideas of genetic variation in a population to make sense of how organisms survive and reproduce, thus passing on the traits of the species.

Students will use the practices of constructing explanations; obtaining, evaluating, and communicating information; and using mathematical and computational thinking. Crosscutting concepts of patterns and structure and function contribute to the evidence students can use to describe biological evolution will support understanding across this unit of study.

Essential question

- How do organisms change over time in response to changes in the environment?

Written Curriculum

Next Generation Science Standards

MS. Natural Selection and Adaptations
Students who demonstrate understanding can:
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.** [Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations]
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 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 ideas, principles, and theories. ▪ Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena. (MS-LS4-4)	**LS4.B: Natural Selection** ▪ Natural selection leads to the predominance of certain traits in a population, and the suppression of others. (MS-LS4-4)	**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-LS4-4)

Connections to other DCIs in this grade-band: **MS.LS2.A** (MS-LS4-4); **MS.LS3.A** (MS-LS4-4); **MS.LS3.B** (MS-LS4-4)
Articulation across grade-bands: **3.LS3.B** (MS-LS4-4); **3. LS4.B** (MS-LS4-4); **HS.LS2.A** (MS-LS4-4); **HS.LS3.B** (MS-LS4-4); **HS.LS4.B** (MS-LS4-4); **HS.LS4.C** (MS-LS4-4)
Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1   Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions *(MS-LS4-4)*

RST.6-8.9   Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. *(MS-LS4-4)*

WHST.6-8.2   Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. *(MS-LS4-4)*

WHST.6-8.9   Draw evidence from informational texts to support analysis, reflection, and research. *(MS-LS4-4)*

SL.8.1   Engage effectively in a range of collaborative discussions (one-on-one, in groups, teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. *(MS-LS4-4)*

SL.8.4   Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. *(MS-LS4-4)*

Mathematics –

6.RP.A.1   Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-LS4-4)*

6.SP.B.5   Summarize numerical data sets in relation to their context. *(MS-LS4-4)*

7.RP.A.2   Recognize and represent proportional relationships between quantities. *(MS-LS4-4)*

MS. Growth, Development, and Reproduction of Organisms

Students who demonstrate understanding can:

MS-LS4-5.   **Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.** [Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods. ▪ 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. (MS-LS4-5)	**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. (MS-LS4-5)	**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-LS4-5) -- ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** ▪ Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-LS4-5) -------------------------------------- ***Connections to Nature of Science*** **Science Addresses Questions About the Natural and Material World** ▪ Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-LS4-5)

Connections to other DCIs in this grade-band: N/A

Articulation to DCIs across grade-bands: **HS.LS3.B** (MS-LS4-5); **HS.LS4.C** (MS-LS4-5)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1   Cite specific textual evidence to support analysis of science and technical texts. (MS-LS4-5)

WHST.6-8.8   Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. *(MS-LS4-5)*

MS. Natural Selection and Adaptations
Students who demonstrate understanding can:
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.**   [Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.]   [Assessment Boundary: Assessment does not include Hardy Weinberg calculations.]
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. ▪ Use mathematical representations to support scientific conclusions and design solutions. (MS-LS4-6)	**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. (MS-LS4-6)	**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-LS4-6)

Connections to other DCIs in this grade-band: **MS.LS2.A** (MS-LS4-6); **MS.LS2.C** (MS-LS4-6); **MS.LS3.B** (MS-LS4-6); **MS.ESS1.C** (MS-LS4-6)
Articulation across grade-bands: **3.LS4.C** (MS-LS4-6); **HS.LS2.A** (MS-LS4-6); **HS.LS2.C** (MS-LS4-6); **HS.LS3.B** (MS-LS4-6); **HS.LS4.B** (MS-LS4-6); **HS.LS4.C** (MS-LS4-6)
Common Core State Standards Connections: *Mathematics –*

MP.4	Model with mathematics. (MS-LS4-6)
6.RP.A.1	Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-LS4-6)*
6.SP.B.5	Summarize numerical data sets in relation to their context. *(MS-LS4-6)*
7.RP.A.2	Recognize and represent proportional relationships between quantities. *(MS-LS4-6)*

Clarifying the standards

Prior learning

The following disciplinary core ideas are prior learning for the concepts in this unit of study. By the end of Grade 5, students know that:

- Different organisms vary in how they look and function because they have different inherited information.

- The environment also affects the traits that an organism develops.

- Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.

- For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.

Progression of current learning

Driving question 1

How do genetic variations of traits in a population increase or decrease some individuals' probability of surviving and reproducing in a specific environment?

Concepts

- Genetic variations of traits in a population increase or decrease some individuals' probability of surviving and reproducing in a specific environment.

- Natural selection leads to the predominance of certain traits in a population and the suppression of others.

- Natural selection may have more than one cause, and some cause-and-effect relationships within natural selection can only be described using probability.

Practices

- Construct an explanation that includes probability statements regarding variables and proportional reasoning of how genetic variations of traits in a population increase some individuals' probability surviving and reproducing in a specific environment.

- Use probability to describe some cause-and-effect relationships that can be used to explain why some individuals survive and reproduce in a specific environment.

Driving question 2

How can mathematical representations be used to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time?

Concepts

- Natural selection, which over generations leads to adaptations, is one important process through which species change over time in response to changes in environmental conditions.

- The distribution of traits in a population changes.

- Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common.

- Natural selection may have more than one cause, and some cause-and-effect relationships in natural selection can only be described using probability.

- Mathematical representations can be used to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

Practices

- Explain some causes of natural selection and the effect it has on the increase or decrease of specific traits in populations over time.

- Use mathematical representations to support conclusions about how natural selection may lead to increases and decreases of genetic traits in populations over time.

- Mathematical models, probability statements, and proportional reasoning can be used to support explanations of trends in changes to populations over time.

Driving question 3
How have technologies changed the way humans influence the inheritance of desired traits in organisms?

Concepts

- In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding.

- In artificial selection, humans choose desirable, genetically determined traits in to pass on to offspring.

- Phenomena, such as genetic outcomes in artificial selection, may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.

- Technologies have changed the way humans influence the inheritance of desired traits in organisms.

- Engineering advances have led to important discoveries in the field of selective breeding.

- Engineering advances in the field of selective breeding have led to the development of entire industries and engineered systems.

- Scientific discoveries have led to the development of entire industries and engineered systems.

Practices

- Gather, read, and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms (artificial selection) from multiple appropriate sources.

- Describe how information from publications about technologies and methods that have changed the way humans influence the inheritance of desired traits in organisms (artificial selection) used are supported or not supported by evidence.

- Assess the credibility, accuracy, and possible bias of publications and they methods they used when gathering information about technologies that have changed the way humans influence the inheritance of desired traits in organisms (artificial selection).

Integration of content, practices, and crosscutting concepts

In this unit of study, students will build on their prior knowledge by constructing explanations that describe how genetic variations increase some individuals' probability of surviving and reproducing. Mathematical representations will be used to support explanations of how natural selection leads to increases and decreases of specific traits in populations over time. Students will analyze numerical data sets that represent a proportional relationship between some change in the environment and corresponding changes in genetic variation over time. Students will summarize these numerical data sets and construct explanations for how the

proportional relationship could impact the probability of some individuals surviving and reproducing in a specific environment.

Students will construct explanations based on evidence that describes how genetic variations can provide a survival and reproductive advantage over other traits. This evidence could be provided through activities that model these phenomena or by examining and analyzing data from informative texts. Based on their findings, students can write claims about how natural selection leads to a predominance of some traits in a population and the suppression of other traits. Students will pay attention to precise details in explanations from specific textual evidence and will cite this evidence to support their analysis and reflection on research that explains how genetic variation of traits in a population increases some individuals' probability of surviving and reproducing in a specific environment. Students will compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading these texts and write informative/explanatory texts on how natural selection leads to the predominance of some traits and the suppression of others in a population.

Students will engage effectively in a range of collaborative discussions where they will present their claims and findings. These discussions may be one-on-one between students, in small groups, or teacher-led large-group discussions. In these discussions, students will build on others' ideas while expressing their own clearly. Claims must emphasize salient points in a focused, coherent manner, supported with relevant evidence, sound valid reasoning, and well-chosen details. Students must use appropriate eye contact, adequate volume, and clear pronunciation.

There are multiple activities available that show students how one trait can provide a survival advantage over another in a specific environment. As part of these activities, students can analyze data and determine ratio relationships to provide evidence of cause-and-effect relationships. These ratios can be used to explain why some inherited traits result in individuals that have a survival advantage in a specific environment over time or why other traits in a population are suppressed. When an environment changes as a result of human influence and/or natural processes on Earth, traits that were present in populations of organisms and that led to a survival advantage in that environment before the change may no longer offer an advantage. Changes in environmental conditions can be the driving cause of the suppression of traits in populations.

Students will examine a variety of environmental factors that may influence the natural selection that is taking place in populations. Students will need to use simple probability statements and proportional reasoning to explain why each factor may or may not be responsible for the changes being observed. Students will compare and contrast the information gained from experiments, simulations, video, or multimedia sources with information gained from reading science and technical texts to support their explanations. After students have constructed their explanations, they will participate in collaborative discussions in small groups; in larger, teacher-led groups, or in pair..

After students have developed a strong understanding of natural selection, they will need to begin gathering evidence from multiple sources, including print and digital, to support analysis of information about technologies that have changed how humans can influence the inheritance of desired traits in organisms (artificial selection). Students need to examine current technologies as well as the technologies that have led to these scientific discoveries. Students will cite the information they gathered and quote or paraphrase relevant data and conclusions from their resources to describe the impact that current technologies have on society. Some of the influences of humans on genetic outcomes in artificial selection that students can examine include genetic modifications, animal husbandry, and gene therapy.

Students can be provided with multiple sources to determine the credibility, accuracy, and possible bias of the resources. In order to determine the best sources, students can investigate and describe how information in these resources is supported or not supported by evidence. Once students have determined appropriate sources, they can begin to synthesize information about the technologies that have changed how humans can influence the inheritance of desired traits in organisms (artificial selection). Students can quote or paraphrase the data

and conclusions and provide basic bibliographic information. They can do this in a variety of ways (e.g., in writing, verbal discussion, debate, Socratic seminar, etc.).

Integration of mathematics and/or English Language Arts/literacy

Mathematics

Understand the concept of a ratio and use ratio language to describe a ratio relationship between specific genetic variations in a population and the probability of some individuals in that populations surviving and reproducing in a specific environment.

Summarize numerical data sets about a ratio relationship between genetic variations in a population and the probability of some individuals in that population surviving and reproducing in a specific environment.

Recognize and represent proportional relationships in trends in changes to populations over time.

Use mathematical models to support explanations of trends in changes to populations over time.

Understand the concept of a ratio and use ratio language to describe a ratio relationship between natural selection and decreases of specific traits in populations over time.

Summarize numerical data sets to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

English language arts/literacy

Cite specific textual evidence to support analysis of scientific and technical texts about how genetic variations in a population increase some individuals' probability of surviving and reproducing in a specific environment. Attention must be paid to precise details of explanations or descriptions.

Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with information gained from reading a text on how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

Write informative/explanatory texts examining how natural selection leads to the predominance of some traits in a population and the suppression of others. Convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Draw evidence from informational texts to support the analysis, reflection, and research used to construct an explanation of how genetic variation of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

Engage effectively in a range of collaborative discussions with diverse partners to discuss how natural selection leads to the predominance of certain traits in a population and the suppression of others. Discussions may be one-on-one, in groups, or teacher-led; in these discussions, students should build on others' ideas while expressing their own clearly.

Present claims and findings about how natural selection leads to the predominance of certain traits in a population and the suppression of others. Claims must emphasize salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details. Students must use appropriate eye contact, adequate volume, and clear pronunciation.

Cite specific textual evidence to support analysis of information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms (artificial selection).

Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others about technologies that have changed the way humans

influence the inheritance of desired traits. Avoid plagiarism and provide basic bibliographic information for sources.

Future learning

- Ecosystems have carrying capacities, which are limits on the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources, predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, the ecosystem may return to its original status, more or less (i.e., the ecosystem is resilient) as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. Moreover, anthropogenic changes (i.e, changes induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.

- In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited.

- Environmental factors also affect the expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed in a population depends on both genetic and environmental factors.

- Natural selection occurs only if there is both (1) variation in the genetic information among organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals.

- The traits that positively affect survival are more likely to be reproduced and thus are more common in the population.

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

- Natural selection leads to adaptation—that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. The differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.

- Adaptation also means that the distribution of traits in a population can change when conditions change.

- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new, distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.

Number of Instructional Days

Recommended number of instructional days: 15 (1 day = approximately 50 minutes)

Note—The recommended number of days is an estimate based on the information available at this time. Teachers are strongly encouraged to review the entire unit of study carefully and collaboratively to determine whether adjustments to this estimate need to be made.