KANSAS SCIENCE STANDARDS

High School Biology

Unpacked Standards

KANSAS STATE DEPARTMENT OF EDUCATION

Kansas leads the world in the success of each student.

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Overview

Purpose of the Tool

The science unpacked standards serve as a tool for teachers and school leaders to provide clarity and consistency around implementing the Kansas State Science Standards.

This tool removes the need for teachers to individually "unpack" each standard, and instead provides key experiences, ideas, and concepts to support the work of standards alignment. This tool intentionally breaks down each standard into the three dimensions of science and engineering practices, disciplinary core ideas, and cross cutting concepts to promote three dimensional instruction and assessment.

There is a need for teachers to intentionally work with and make sense of standards. for each standard, it is encouraged to use the "Student-Standard Alignment Tool" on page 9 to intentionally plan for how the standards can be aligned to the students in each unique class. This tool was developed as a way to incorporate analysis of the students' interests and abilities.[1]

The organization of this document follows the recommended scope and sequence that may be found in the Science Graduation Guidance High School Science Scope and Sequence.[2]

The information for this document came from three locations:

- Disciplinary Core Idea Appendix[1]
- Cross Cutting Concepts Appendix[3]
- Science and Engineering Appendix[3]

Kansas Science Standards

The Kansas State standards reflect what students should know and be able to do at each grade level. We do not recommend prioritizing standards at the exclusion of other standards. High quality instruction includes teaching **all standards for all students** at the appropriate depth and rigor and includes reteaching standards that students have not mastered.[4]

The Next Generation Science Standards (NGSS) standards document and its appendices are the board adopted standards and should supersede this tool. This tool is intended to provide an outline of the vertical alignment of all three dimensions of each standard in this course and to provide clarity in expectations of each standard to ensure appropriate rigor of content.

Kansas NGSS are three-dimensional standards. The Performance Expectation (PE) and its supporting elements are considered the standard. Each standard consists of a Science and Engineering Practice (SEP), a Disciplinary Core Idea (DCI), and a Cross Cutting Concept (CCC). Science is a multi-dimensional discipline and all three dimensions must be considered and taught. Throughout this document, the vertical alignment, K-12, of each dimension is provided for every single standard. The full appendix for the SEPs, DCIs, and CCCs were used to create this document.

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1 https://docs.google.com/document/d/1N2ciKuxcgIyEhD4s1RwmO_GBvjsLv2dAwrqFFI8JFTY/edit

2 https://community.ksde.gov/LinkClick.aspx?fileticket=wmQyOpyeCBs%3d&tabid=5675&mid=13857

3 https://www.nextgenscience.org/sites/default/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf

4 Addressing the Prioritization of Standards, Fact Sheet https://www.ksde.gov/LinkClick.aspx?fileticket=Z5tBLSYTR9k%3D&tabid=472&portalid=0&mid=4744

OVERVIEW

Unpacked Science Standards

The KSDE science team has unpacked each standard for the 3-dimensions of content. There should not be an expectation for an individual teacher to do the work of unpacking standards in science, but instead to engage deeply with the unpacked science standards to consider how to best plan instruction and assessment of the students in their classrooms. Below is an overview of the process used to systematically identify the key ideas, experiences, and concepts a student needs to show mastery of a standard.

1. Identify the Standards
    - Performance Expectation (PE) and its supporting elements are considered the standard.
        - Each standard consists of a Science and Engineering Practice (SEP), a Disciplinary Core Idea (DCI), and a Cross Cutting Concept (CCC).
        - Students need access to each of the three dimensions of the standard to be successful
    - The standards have been arranged into Standards Bundles that are aligned to KSDE's 2023 Science HS Scope and Sequence Guidance
2. Closely examine **vertical alignment** of the elements of the standard.
    - For each dimension of the standard (DCI, SEP, CCC) the elements from grades K-8 that specifically build towards each specific high school standard have been included in this document.
        - For the DCI elements, the foundational concepts that bridge the gap between prior grade level standards and the grade 9-12 standard were identified as the key information that must be taught before reaching the intent of the standard.
        - For the SEP and CCC dimensions, the differences between prior grade level elements and the 9-12 elements were identified.
3. Determine the key experiences, ideas, and concepts necessary to show mastery
    - Only content that is explicitly indicated in the standard (in the performance expectation and/or defined elements) is included and expected of students.
    - Each standard has key experiences, ideas, and concepts that are necessary to meet the full standard.
        - The key experiences are aligned to the Science and Engineering Practices (SEPs).
        - The key ideas are aligned to the Disciplinary Core Ideas (DCIs).
        - The key concepts are aligned to the Cross Cutting Concepts (CCCs).
4. Identify any additional information needed to understand the unpacked standard
    - This could include decisions that were made about what to include and/or not include in the key experiences, ideas, or concepts.
    - This could include clarification around the intention of the standard as determined during the unpacking process
    - This could include clarification needed

Note: Engineering and Technology Standards (ETS)

ETS are included in NGSS, however each is explicitly tied to an additional performance expectation aligned to either life, physical, or earth and space science and are not intended to be taught in isolation.

The ETS standards were not unpacked in this document. However, components of engineering design were considered when unpacking standards that are linked to ETS and are included in multiple SEPs.

Recommended High School Life Science (Biology) Standards Alignment

The graduation requirements outlined by the Kansas Department of Education state that students should earn three credits in the areas of science that include concepts of Life Science (LS), Physical Science (PS) and Earth/ Space Science (ESS). The intent is that all the standards in these areas are mapped to courses at the local level and KSDE does not dictate which courses are required and we recognize that the scope and sequence of courses vary greatly across the state.

Historically across the nation a sequence including the Physics, Biology, and Chemistry has been identified as the most common. for this reason we have bundled the high school standards to align to these three courses and incorporated the Earth and Space standards into discipline courses where it best aligns. The standards included in this document would be most commonly associated with the introductory course called "Biology" with course code 03051.

We recognize that student choice and agency is important and as such intend for the recommended standards' bundles to only serve as guidance while making decisions at the local level.

The shaded area below shows an overview of the recommended biology standards bundles.

Life Science - Biology (03051)

STRUCTURES AND PROCESSES OF LIFE	ECOSYSTEMS	NATURAL SELECTION	BIODIVERSITY
HS-LS1-1	HS-LS2-1	HS-ESS2-7	HS-LS2-2
HS-LS1-2	HS-LS2-4	HS-LS3-3	HS-LS2-7
HS-LS1-3	HS-LS2-6	HS-LS4-5	HS-LS4-6
HS-LS1-4		HS-LS4-1	HS-ESS2-2
HS-LS3-1		HS-LS4-2	HS-ESS3-3
HS-LS3-2		HS-LS4-3	HS-ESS3-2
		HS-LS4-4	
		HS-LS2-8	

Student Standard Alignment Process

(Analyze Students' Interests and Identities.[1])

The standards are the expectation for every student in the state of Kansas. However, we acknowledge that Kansas students are a diverse population. Teachers should think intentionally about how the ideas and experiences that students bring to the classroom relate to the science standards in order to plan for the unique students in your classroom.

Question	Ideas and Experiences
What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?	
Where are students using and experiencing these ideas, practices, and concepts outside of the classroom?	
What questions may students have related to these ideas about how the world works?	
What scaffolding might my students need to fully understand this particular standard?	
What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?	

1 https://dpi.wi.gov/science

Kansas Standards for Science

BUNDLE: Structures and Functions of Life

Standards included:

HS-LS1-1
HS-LS1-2
HS-LS1-3
HS-LS1-4
HS-LS3-1
HS-LS3-2

FOCUS SEPs:

Constructing Explanations and Designing Solutions
Developing and Using Models
Developing and Using Models
Planning and Carrying Out Investigations
Asking Questions and Defining Problems
Obtaining, Evaluating, and Communicating Information
Engaging in Argument From Evidence

FOCUS DCIs:

LS1.A	Structure and Function
LS1.B	Growth and Development of Organisms
LS3.A	Inheritance of Traits
LS3.B	Variation of Traits

FOCUS CCCs:

Cause and Effect
Systems and System Models
Stability and Change

HS-LS1-1

Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells. [**Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.**]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Constructing Explanations and Designing Solutions

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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. • Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real world phenomena, examples, or events.
Grades 3-5	• Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

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

What ideas or skills are truly unique to this grade band?

- Variety of sources.
- Sources can include students' own investigations, models, theories, simulations, peer review.

Key experiences students need access to in order to be successful:

- Access to evidence that would support an explanation of the relationship between DNA, proteins, and specialized cell functions.
- Evaluate the evidence for what is most valid and reliable to support an explanation of how the structure of DNA determines the structure of proteins which then determines the function of the proteins.
- Use the evidence to write an explanation about . . .
  - Most cells contain DNA.
  - The specific sequence of genes determines the structure of the proteins.
  - The structure of a protein determines the function of the protein.
  - The function of the protein determines the function and specialization of the cell which is needed to support life's functions.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS1.A: Structure and Function

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). [MS-LS1-1] • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. [MS-LS1-2] • In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. [MS-LS1-3]
Grades 3-5	• Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. [4-LS1-1]
Grades K-2	• All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. [1-LS1-1]

9-12 GRADE LEVEL ELEMENT(S)

- Systems of specialized cells within organisms help them perform the essential functions of life.
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)

Foundational concepts necessary for success that are not covered in previous grade bands:

- Most cells contain DNA.
- DNA is the genetic information stored in cells.
- Cells within an organism can be specialized to carry out different functions (i.e., blood cells vs. bone cells).

Key ideas that students need to apply in order to be successful:

- DNA contains regions that are called genes
- The sequence of genes contains instructions that code for proteins
- Different gene sequences may produce different protein structures.
- Different protein structures allow for specialized functions.
- Many different types of proteins are necessary for cells to perform life's functions
- Groups of specialized cells (tissues) function as a system
- Systems of specialized cells use specialized proteins to carry out the specific functions that are essential to the organism.

Additional information:

- The critical content of this performance expectation is for students to conceptually understand the relationship between genetic information, proteins, and protein functions within specialized cells to support life.
- The standards do NOT include:
  - identifying specific amino acids,
  - describing transcription or translation,
  - describing the role of RNA,
  - describing specific protein structures,
  - identifying protein folding mechanisms or 3D structure,
  - naming specific proteins.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Systems and Systems Models*

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. • Models can be used to represent systems and their interactions - such as inputs, processes and outputs - and energy, matter, and information flows within systems. • Models are limited in that they only represent certain aspects of the system under study.
Grades 3-5	• A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. • A system can be described in terms of its components and their interactions.
Grades K-2	• Objects and organisms can be described in terms of their parts. • Systems in the natural and designed world have parts that work together.

9-12 GRADE LEVEL ELEMENT(S)

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions - including energy, matter, and information flows - within and between systems at different scales.

What ideas or concepts are truly unique to this grade band?

- Models can be physical, mathematical, or computer models.
- Models can be used to simulate systems and interactions.
- Energy, matter, and information can flow between systems.
- Different scales.

Key ideas that students need access in order to be successful:

- Experience defining the system under study as the body system at a cellular scale.
- Identify the components of the system as DNA, protein, cells.
- Trace the flow of information from the DNA to proteins to cellular functions.
- Identify that different DNA sequences will make different proteins, which will in turn carry out different functions.
- Experience using models that show matter and information flowing within the system from different types of DNA sequences all the way through to the ultimate different cellular functions
- Explain how the information flow at the cellular scale influences life's essential functions at the organism scale.

*****Additional Information:

- While the identified CCC in this standard is structure and function and the subelement is: Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. The review team has decided that the Systems and Systems Models CCC element should be considered during classroom instruction.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS1-2

Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [*Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.*] [**Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.**]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Developing and Using Models

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Develop and/or use a model to predict and/or describe phenomena. • Develop a model to describe unobservable mechanisms.
Grades 3-5	• Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. • Develop and/or use models to describe and/or predict phenomena.
Grades K-2	• Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).

9-12 GRADE LEVEL ELEMENT(S)

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.

What ideas or skills are truly unique to this grade band?

- Modeling multiple systems in one model.
- Modeling the relationship between interacting systems.
- Modeling the relationship between components of a system.

Key experiences students need access to in order to be successful:

- Gather evidence about multiple systems and their functions.
- Gather evidence about multiple systems and the components of each system.
- Organize the evidence to identify one system to model including necessary components and interacting systems.
- Model the components of a system within a multicellular organism and how those components interact to support the larger system's functions.
- Model one or more components of the larger system to show how each is its own system made up of interacting parts.
- Model how in order for the organism as a whole to function, the modeled system interacts with one or more additional systems.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS1.A: Structure and Function

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). [MS-LS1-1] • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. [MS-LS1-2] • In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. [MS-LS1-3]
Grades 3-5	• Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. [4-LS1-1]
Grades K-2	• All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. [1-LS1-1]

9-12 GRADE LEVEL ELEMENT(S)

- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.

Foundational concepts necessary for success that are not covered in previous grade bands:

- Cells within an organism can be specialized to carry out different functions (i.e., blood cells vs. bone cells).
- An organism can be studied at different system levels.
- A system at one level may make up a component of another system at a different level.

Key ideas that students need to apply in order to be successful

- Multi-cellular organisms are made up of hierarchical structural organization
- The organism as a whole is one system
  - The organism is made up of smaller systems that interact to perform life's functions
- Each interacting system can be made up of interacting simpler systems
  - Each system within the organism is made up of components (i.e., organs, specialized tissue)
  - The components of a system are made up of systems of specialized cells
  - Specialized cells include specific proteins, organelles, and/or other molecules that are necessary to perform their specialized functions.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Systems and System Models

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. • Models can be used to represent systems and their interactions - such as inputs, processes and outputs - and energy, matter, and information flows within systems. • Models are limited in that they only represent certain aspects of the system under study.
Grades 3-5	• A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. • A system can be described in terms of its components and their interactions.
Grades K-2	• Objects and organisms can be described in terms of their parts. • Systems in the natural and designed world have parts that work together.

9-12 GRADE LEVEL ELEMENT(S)

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions - including energy, matter, and information flows - within and between systems at different scales.

What ideas or concepts are truly unique to this grade band?

- Systems at different scales.
- Models can be physical, mathematical, or computer.
- Interactions include energy, matter, and information flows between systems.

Key ideas that students need access in order to be successful:

- Determine the best type of model (physical, mathematical, computer models) to represent interacting systems within a multicellular organism.
- Gather evidence of how multiple systems in an organism interact in terms of energy, matter, and/or information flows between the systems.
- Develop a model that shows how energy, matter, or information flows between two interacting systems (systems chosen will determine which flow is shown).
- Develop a model that shows how one system studied at different scales supports the flow of energy, matter, or information.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS1-3

Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. *[Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.*] [**Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanism.**]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Planning and Carrying Out Investigations

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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. • Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.
Grades 3-5	• Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
Grades K-2	• With guidance, plan and conduct an investigation in collaboration with peers (for K). • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.

9-12 GRADE LEVEL ELEMENT(S)

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

What ideas or skills are truly unique to this grade band?

- Decide on types and accuracy of data needed to produce reliable measurements.
- Consider limitations on the precision of the data (e.g., number of trials, cost, risk, time).
- Refine the design based on the limitations identified.
- Planning design to account for:
  - accuracy of data
  - reliability of measurements
  - limitations on precision of data
- Refining experimental design as needed

Key experiences students need access to in order to be successful:

- Identify the purpose of the investigation in order to effectively plan
- Experience planning an investigation where the procedure is justified to explain the methods of data collection to account for accuracy and reliability and acknowledge any limitations.
- Experience with laboratory activities where data is highly variable among students so that they see the

need for accuracy, reliability, or reproducibility in their own experimental design
- Writing procedures/directions for activities that use only the provided materials and that can be followed by anyone, not just partners or themselves.
- Experience in planning investigations that must be refined/modified after initial data collection.
  - Students need to know that they can go back and do more, try something else if they don't get enough or the type of data they initially thought they would.
- Experience with laboratory investigations specifically related to homeostasis and feedback mechanisms so that they have an idea of types of things that can reasonably be done in their specific classroom situation
  - Example: measuring heart rate, body temperature, etc in response to exercise, measuring stomate

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS1.A: Structure and Function

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). [MS-LS1-1] • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. [MS-LS1-2] • In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. [MS-LS1-3]
Grades 3-5	• Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. [4-LS1-1]
Grades K-2	• All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. [1-LS1-1]

9-12 GRADE LEVEL ELEMENT(S)

- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.

  Foundational concepts necessary for success that are not covered in previous grade bands:

  - A feedback mechanism is a process where an organism's systems respond to external stimuli in order to maintain internal conditions.
  - If the feedback response amplifies or speeds up a process that would be considered a positive feedback
  - If the feedback response stops or slows a process that would be considered a negative feedback
  - Homeostasis is a state of balance within and between all the body systems needed for the body to survive and function correctly.

Key ideas that students need to apply in order to be successful:

- When external conditions change and moves a body away from its stable conditions, the body systems will work to return to stability through processes that support homeostasis so that the organism can remain alive and functional.
- An organism uses both positive and negative feedback mechanisms as necessary to maintain homeostasis
- Feedback mechanisms maintain a living system's internal conditions through either positive feedback or negative feedback to maintain the body functions within certain limits and mediate behaviors to keep the organism alive and functional

TARGET CROSS CUTTING CONCEPT PROGRESSION

Stability and Change

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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..
Grades 3-5	• Change is measured in terms of differences over time and may occur at different rates. • Some systems appear stable, but over long periods of time will eventually change.
Grades K-2	• Some things stay the same while other things change. • Things may change slowly or rapidly.

9-12 GRADE LEVEL ELEMENT(S)

- Feedback (negative or positive) can stabilize or destabilize a system.

What ideas or concepts are truly unique to this grade band?

- Feedback can be positive or negative
- Feedback can stabilize or destabilize

Key concepts students need access to in order to be successful:

- Identify if the feedback leading to homeostasis is positive (starts or speeds up a process) or negative (stops or slows down a process).
- Describe how an external stimulus leads to changes in internal conditions which triggers the feedback mechanism.
- Describe how the feedback mechanism leads to homeostasis.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS1-4

Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. [**Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.**]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Developing and Using Models

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. • Develop and/or use a model to predict and/or describe phenomena. • Develop a model to describe unobservable mechanisms.
Grades 3-5	• Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events. • Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. • Develop and/or use models to describe and/or predict phenomena.
Grades K-2	• Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).

9-12 GRADE LEVEL ELEMENT(S)

- Use a model based on evidence to illustrate the relationships between systems or between components of a system.

What ideas or skills are truly unique to this grade band?

- Use of models to show relationships between systems and components of systems, not just variables or phenomena.
- Use of an already developed and accepted model as a source of information.

Key experiences students need access to in order to be successful:

- When given a model that includes information about parent cell, daughter cells, genetic information, cellular division, gene expression, differentiation, multicellular organism as the system
- Identify the system (whole organism) and the components (cells) that make up the system being studied
    - Describe the relationship between cellular division (mitosis) and the development of multicellular organisms to demonstrate how components of a system can make up the larger system.
    - Describe that differences in gene expression cause cells to differentiate and become specialized.
    - Describe the role of differentiated cells as components of tissues and organs which are then components of the whole organism.
    - Describe the relationship between mitosis and differentiation in supporting growth, repair, and reproduction to maintain life and the role of differentiation to support those varied needs
- Identify the limitations of the given model

Additional Information:

- The critical content of this performance expectation is for students to use a given model to identify the connection between mitosis and differentiation. The standard does not require students to develop/ create a model of the steps of mitosis, identify specific steps of mitosis, identify specific specialized cells, or identify specific bodily functions.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS1.B: Growth and Development of Organisms

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Genetic factors as well as local conditions affect the growth of the adult plant. [MS-LS1-5)]
Grades 3-5	• Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. [3-LS1-1]
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

- In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.

  Foundational concepts necessary for success that are not covered in previous grade bands:

  - Most cells contain DNA.
  - DNA is the genetic information stored in cells.
  - All organisms begin as a single cell and grow through cellular division.
  - Mitosis is the process of a parent cell dividing into two identical daughter cells.
  - Each cell contains genetic material in the form of chromosomes which is made up of DNA.
  - After cell division both daughter cells now carry identical genetic information.
  - While all cells contain the same genetic information, individual cells may express their genes differently from the genetic information which leads to differentiation in the cell structure and function.
  - Cells within an organism can be specialized to carry out different functions (i.e., blood cells vs. bone cells).

  Key ideas that students need to apply in order to be successful:

  - An organism grows in size as the number of cells that make up the organism increases through mitosis (cellular division).
  - The individual cells that make up a multicellular organism have a shorter life-span than the organism. The process of mitosis allows for new cells to replace older cells in order to support the continued life and functions of the overall organism.
  - Specialized cells are cells that express the genes differently which leads to differentiation of cells.
  - Mitosis can maintain differentiation through cell division.
  - As mitosis continues and new cells are made the specialized cells fulfill a specific function for the overall maintenance of the organism.
  - The specialized cells with specific structure and function can work together to form tissues and organs that are specialized for particular body functions.

Additional Information:

- Many of the foundational DCIs from LS1.B do not build towards the 9-12 DCI. However, the foundational (below grade level) DCIs from LS1.A may provide foundational knowledge to support this concept. This information can be found in HS-LS1-1 in this document.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Systems and System Models

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. • Models can be used to represent systems and their interactions - such as inputs, processes and outputs - and energy, matter, and information flows within systems. • Models are limited in that they only represent certain aspects of the system under study.
Grades 3-5	• A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. • A system can be described in terms of its components and their interactions.
Grades K-2	• Objects and organisms can be described in terms of their parts. • Systems in the natural and designed world have parts that work together.

9-12 GRADE LEVEL ELEMENT(S)

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions - including energy, matter, and information flows - within and between systems at different scales.

What ideas or concepts are truly unique to this grade band?

Systems at different scales
Models can be physical, mathematical, or computer
Interactions include energy, matter, and information flows between systems

Key concepts students need access to in order to be successful:

- Identify the different scales that can be studied within the body related to mitosis and differentiation (single cell, multi-cell systems (tissues/organs), and whole organism).
- Describe the interaction between the processes at the different scales to produce and maintain a complex organism:
    - Complex organism is one system made up of several subsystems at different scales.
    - Single cells must go through mitosis in order to grow to a multicellular organism (single cell vs. whole organism).
    - Single cells differentiate through gene expression (cellular level) which creates specialized tissues which maintain the whole organism.
    - Each subsystem from the cellular scale upward is necessary for producing and maintaining complex organisms.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS3-1

Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. [**Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.**]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Asking Questions and Defining Problems; Obtaining, Evaluating, and Communicating Information

Asking Questions and Defining Problems

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. • Ask questions to identify and/or clarify evidence and/or the premise(s) of an argument. • Ask questions to determine relationships between independent and dependent variables and relationships in models. • Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.
Grades 3-5	• Ask questions about what would happen if a variable is changed.
Grades K-2	• Ask questions based on observations to find more information about the natural and/or designed world(s).

9-12 GRADE LEVEL ELEMENT(S)

- Ask questions that arise from examining models or a theory to clarify relationships.

Obtaining, Evaluating, and Communicating Information

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.
Grades 3-5	• Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.
Grades K-2	• Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas.

9-12 GRADE LEVEL ELEMENT(S)

- Communicate scientific information or ideas about phenomena in multiple formats (including orally, graphically, textually, and mathematically).

What ideas or skills are truly unique to this grade band?

- Ask questions based on a theory
- Clarify relationships based on models
- Communicate about phenomena
- Communicate in multiple formats
    - including orally, graphically, textually, and mathematically

Key experiences students need access to in order to be successful:

- Given a model or a theory that would explain the role of DNA and chromosomes in coding instructions in characteristic traits passed from parents to offspring
- Ask questions based on the model or theory related to the relationship between DNA, chromosomes, traits, and inheritance
- Determine reasonable answers based on evidence to the previously asked questions
    - Answers can be determined based on the provided model or theory if possible
    - Answers can be determined from other learning experiences that support student investigation of their questions
- Communicate their findings in two or more formats

Additional Information:

- During the unpacking process the KSDE writing team decided to include an additional SEP element for this performance expectation in order to support student learning and assessment beyond “asking questions”. The team determined that students needed to also have answers to their questions and be able to communicate about their learning.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS1.A: Structure and Function and LS3.A: Inheritance of Traits

LS1.A: Structure and Function

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). [MS-LS1-1] • Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. [secondary to MS-LS3-2]
Grades 3-5	• Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. [4-LS1-1]
Grades K-2	• All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. [1-LS1-1]

9-12 GRADE LEVEL ELEMENT(S)

- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. (secondary) [Note: This Disciplinary Core Idea is also addressed by HS-LS1-1.]

LS3.A: Inheritance of Traits

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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]
Grades 3-5	• 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]
Grades K-2	• 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]

9-12 GRADE LEVEL ELEMENT(S)

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

Foundational concepts necessary for success that are not covered in previous grade bands:

- Most cells contain DNA.
- DNA is the genetic information stored in cells.
- DNA is stored in the nucleus as a set of chromosomes.
- A gene is a specific segment of genetic information which can be described as a segment of DNA or a segment of a chromosome.
- A chromosome pair is made up of DNA from each parent.
- All cells carry all of the genetic information (all of the chromosomes) for an organism.
- The genetic information carries the instructions for forming the unique traits of each individual.

Key ideas that students need to apply in order to be successful:

- The differences in sequencing within the DNA segments that make up each chromosome carries the genetic information that determines how individuals are different from each other.
- Each individual has a unique combination of genetic information that comes from both parents.
- The sequence of genes contains instructions that code for proteins.
- DNA regulation processes allow for specific gene sequences to be expressed by individual cells and may result in different specialized proteins within specialized cells.
- The specialized proteins and cells that are determined by genetic information determine the traits expressed by an organism.
- Not all genetic information is used to code for proteins or traits, some genetic information is used for regulation and some has unknown purposes.

Additional Information:

- The standard indicates that students only need to know conceptually that not all DNA codes for a protein because some is used for regulation and some has no known use. The standard does not include the need to understand or be able to name specific regulation processes.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Cause and Effect

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. • 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 and efect relationships in systems can only be described using probability. .
Grades 3-5	• Cause and effect relationships are routinely identified, tested, and used to explain change. • Events that occur together with regularity might or might not be a cause and effect relationship.
Grades K-2	• Events have causes that generate observable patterns. • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

9-12 GRADE LEVEL ELEMENT(S)

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

What ideas or concepts are truly unique to this grade band?

- Empirical evidence
  - Empirical evidence is information gathered directly from observation or experimentation
- Distinguishing between a correlational relationship or a specific cause and effect based on the evidence.

Key concepts students need access to in order to be successful:

- Opportunities to gather empirical evidence from observations of given models and/or investigations that answer student questions
- Identify evidence related to DNA and/or chromosome gene sequencing and characteristic traits
- Identify evidence related to relationship between genetic information in DNA/chromosomes and inheritance
- Use evidence to support the cause and effect relationship between parent genetic information and offspring characteristics and traits.
- Use evidence to support the cause and effect relationships between DNA, the proteins it codes for, and the resulting traits observed in an organism.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS3-2

Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. [*Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.*] [**Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.**]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Engaging in Argument From Evidence

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system, based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.
Grades 3-5	• Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.
Grades K-2	• Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.

9-12 GRADE LEVEL ELEMENT(S)

- Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence.

What ideas or skills are truly unique to this grade band?

- Defending the claim.
- Claim about the natural world.
- Claim reflects students' scientific knowledge and student-generated evidence.

Key experiences students need access to in order to be successful:

- Access to multiple sources of evidence related to the topic of genetic variation and causes of genetic variation.
    - When possible students should have opportunities to generate evidence from experiences like computer simulations.
- Make a claim related to the three ways (new genetic combinations through meiosis, viable errors occurring during replication, and mutations caused by environmental factors) that inheritable genetic variation is caused.
- Identify what evidence can be used to support a claim related to the three ways that inheritable genetic variation is caused.
- Evaluate the evidence for strength in validity and reliability to support the claim.
- Determine if the evidence is sufficient to support the claim.
- Evaluate the claim and evidence for strength against a possible counterclaim.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS3.B: Variation of Traits

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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] • 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. [MS-LS3-1]
Grades 3-5	• 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]
Grades K-2	• Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways. [1-LS3-1]

9-12 GRADE LEVEL ELEMENT(S)

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

Foundational concepts necessary for success that are not covered in previous grade bands:

- For each trait inherited from a parent, there may be different variations of that trait passed onto offspring
- Expression of a specific variation of a trait is dependent on the genetic code that is passed from parent to offspring
- Individuals have two copies of each chromosome and hence two alleles of each gene, one acquired from each parent.
- DNA replication involves regulatory processes to ensure that DNA is accurately replicated
- Viable genetic errors and mutations are changes to the genetic code that do not inhibit life.

Key ideas that students need to apply in order to be successful:

- During meiosis the two chromosomes (one from each parent) may cross over so that corresponding sections of genes exchange places which creates variation in the DNA that will be replicated for reproduction before splitting into new sex cells
- There are times when DNA regulatory processes do not correct a replication mistake and the change to the genetic code caused by the mistake is called a mutation.
- Environmental factors that can cause genetic mutations may include (but not limited to) things like radiation, viruses, chemicals, etc.
- Genetic errors and mutations are only passed onto offspring if the error or mutation occurs in a cell that will be passed on and is not lethal (i.e., single celled organisms or sex-cells).
- An individual offspring will have variation from related individuals in their traits due to variation in their genetic codes due to the process of meiosis, viable errors during replication, or viable mutations from environmental factors.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Cause and Effect

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. • 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 and efect relationships in systems can only be described using probability. .
Grades 3-5	• Cause and effect relationships are routinely identified, tested, and used to explain change. • Events that occur together with regularity might or might not be a cause and effect relationship.
Grades K-2	• Events have causes that generate observable patterns. • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

9-12 GRADE LEVEL ELEMENT(S)

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

What ideas or concepts are truly unique to this grade band?

- Empirical evidence
  - Empirical evidence is information gathered directly from observation or experimentation
- Distinguishing between a correlational relationship or a specific cause and effect based on the evidence.

Key concepts students need access to in order to be successful:

- Access to evidence that allows students to identify the causes of inheritable genetic variation
- Students can justify the evidence they select to support a claim related to the three ways that inheritable variation occurs
- Make a claim based on the evidence for how meiosis, errors during replication, and environmental mutations could lead to inheritable genetic variation
- Use reasoning to support how the evidence helps prove a cause and effect relationship between the causes of genetic variation and the resulting genetic variation.
- Use reasoning to support how the evidence helps prove that the genetic variation caused by meiosis, errors during replication, and environmental mutations could lead to inheritance of the variation on the genetic material.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

BUNDLE: Ecosystems

Standards included:

HS-LS2-1
HS-LS2-4
HS-LS2-6

FOCUS SEPs:

Using Mathematics And Computational Thinking
Engaging In Argument From Evidence

FOCUS DCIs:

LS2.A	Interdependent Relationships in Ecosystems
LS2.B	Cycles of Matter and Energy Transfer in Ecosystems
LS2.C	Ecosystem Dynamics, Functioning, and Resilience

FOCUS CCCs:

Scale, Proportion, and Quantity
Energy and Matter
Stability and Change

HS-LS2-1

Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [*Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.*] [**Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.**]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Using Mathematics and Computational Thinking

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Use mathematical representations to describe and/or support scientific conclusions and design solutions.
Grades 3-5	• Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems.
Grades K-2	• Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs.

9-12 GRADE LEVEL ELEMENT(S)

- Use mathematical and/or computational representations of phenomena or design solutions to support explanations.

What ideas or skills are truly unique to this grade band?

- Phenomena
- Computational representations

Key experiences students need access to in order to be successful:

- Exposure to graphs, charts, and/or histograms from simulations or historical data that show the relationship between a limiting factor and a population size
- Identify the pattern or trend visible in the mathematical representation that shows how changing the limiting factor would change the maximum size of the population (carrying capacity).
- Use the mathematical and/or computational representation to quantitatively describe a relationship between a limiting factor and population size
    - Ex: minimum amount resource needed to support a population, a measurement of the population size before and after a disruptive event, measurement of the impact of changing climate on a population
- Reference the mathematical and/or computational representation as evidence to support an explanation of the relationship between ecosystem factors and carrying capacity

Additional Information:

- Emphasis is on graphs related to the limiting factors, analyzing a carrying capacity graph alone does not support the explanations asked for.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS2.A: Interdependent Relationships in Ecosystems

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. [MS-LS2-1] • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. [MS-LS2-1] • The growth of organisms and population increases are limited by access to resources. [MS-LS2-1] • Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. [MS-LS2-2]
Grades 3-5	• The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. [5-LS2-1]
Grades K-2	• Plants depend on water and light to grow. [2-LS2-1] • Plants depend on animals for pollination or to move their seeds around. [2-LS2-2]

9-12 GRADE LEVEL ELEMENT(S)

- Ecosystems have carrying capacities, which are limits to the number of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as 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.

  Foundational concepts necessary for success that are not covered in previous grade bands:

  - Definition of carrying capacity: limits to the numbers of organisms in a population that an ecosystem can support
  - A population would grow indefinitely if there were no limits within the ecosystem
  - Populations of organisms can be affected by diseases.

  Key ideas that students need to apply in order to be successful:

  - Describe how the limits on resources lead to a limit on the total number of organisms that can survive in the ecosystem (carrying capacity)
  - Describe the interdependence of factors (both living and nonliving) within an ecosystem and the effect on the carrying capacity of a population.
  - Describe the dynamic changes in population size that occur as the population approaches the carrying capacity and therefore causes a strain on the available resources which can then cause the population to decline before recovering.

- Explain how changing a component of the ecosystem would change the total number of organisms and/or populations that can be supported within the ecosystem
  - Boundaries
  - Disease
  - Food Resources
  - Change in climate
  - Competition between species for one or more resource

TARGET CROSS CUTTING CONCEPT PROGRESSION

Scale, Proportion, and Quantity

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. • The observed function of natural and designed systems may change with scale. • 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. • Scientific relationships can be represented through the use of algebraic expressions and equations. • Phenomena that can be observed at one scale may not be observable at another scale.
Grades 3-5	• Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. • Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.
Grades K-2	• Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). • Standard units are used to measure length.

9-12 GRADE LEVEL ELEMENT(S)

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

What ideas or concepts are truly unique to this grade band?

- Phenomena can be described as more or less significant
- Significance is dependent on the scale, proportion, and quantity at which it occurs

Key concepts students need access to in order to be successful:

- Defining the boundaries of the ecosystem being considered
  - Scale of area of land being studied (i.e., small area vs. large area, portion of river vs entire length of river)
  - Scale of population (i.e., single pack of dogs vs. population across continent)
- Describe how limiting factors affect population differently depending on the defined boundary of the ecosystem
- Compare how limiting factors have different effects on populations at the different scales of different defined boundaries
  - Example: A wildfire may impact the population in a small area significantly, but not as much if the area of the ecosystem studied is larger

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS2-4

Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. [*Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.*] [**Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.**]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Using Mathematical and Computational Thinking

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Use mathematical representations to describe and/or support scientific conclusions and design solutions.
Grades 3-5	• Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems.
Grades K-2	• Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs.

9-12 GRADE LEVEL ELEMENT(S)

- Use mathematical representations of phenomena or design solutions to support claims.

What ideas or skills are truly unique to this grade band?

- The mathematical representations are of phenomena or design solutions
- Supporting claims

Key experiences students need access to in order to be successful:

- Describe the components of the mathematical representation provided (i.e., organisms, matter, and energy in an ecosystem.)
- Use mathematical representations of the food web to…
  - Describe the relative proportions of organisms at each trophic level
  - Identify the transfer of matter between trophic levels and the environment
  - Identify the energy flow and proportion of transfer between trophic levels
  - Identify that some energy is used by the organism to for growth, maintenance, repair, etc and may not be efficiently moved to the next trophic level
  - Identify the energy that flows into the environment instead of upward through trophic levels
- Describe how the mathematical representation shows that matter is transferred as atoms and molecules combine and recombine
- Describe how the mathematical representation shows that energy transfers between organisms and the environment
- Describe how energy and matter are conserved even when the transfer from one trophic level to the next is not 100% efficient

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. [MS-LS2-3]
Grades 3-5	• Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gasses, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. [5-LS2-1]
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.

  Foundational concepts necessary for success that are not covered in previous grade bands:

  - Energy can be converted between different forms including from light/radiant energy to chemical potential energy to thermal energy
  - Producers (plants and algae) are the lowest level of the food web and get the necessary energy from the sun and matter from the environment.
  - Only a small portion of the total matter and energy at a lower trophic level is transferred to the next higher trophic level when consumed
  - Matter that is transferred up through trophic levels is used for the organism to grow and produce energy through respiration
  - An ecosystem needs many more producers than consumers to support the ecosystem dynamics
  - Due to the energy conversions necessary for life's processes as energy transfers up the trophic levels there are typically fewer organisms in higher levels.

  Key ideas that students need to apply in order to be successful:

  - When plants and algae undergo photosynthesis, energy from the sun is converted into forms (chemical potential energy) necessary for growth and no heat is released to the environment.
  - When an organism consumes food some of the matter reacts to form new substances and is stored in the consumer, some of the matter reacts to release energy for life functions, and some of the matter becomes waste.
  - When an organism consumes food some of the energy consumed is released back into the environment as thermal energy.
  - The matter and energy that is transferred in and out of the food web follows the laws of conservation.
  - The same atoms are combined and recombined in different ways as they move from organism to organism within the food web and into the atmosphere and soil in the environment that makes up the ecosystem.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Energy and Matter

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Matter is conserved because atoms are conserved in physical and chemical processes. • Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. • Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). • The transfer of energy can be tracked as energy flows through a designed or natural system.
Grades 3-5	• Matter is made of particles. • Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. • This is what is meant by conservation of matter. Matter is transported into, out of, and within systems. Energy can be transferred in various ways and between objects.
Grades K-2	• Objects may break into smaller pieces, be put together into larger pieces, or change shapes.

9-12 GRADE LEVEL ELEMENT(S)

- Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.

What ideas or concepts are truly unique to this grade band?

- Energy cannot be created or destroyed
- Energy can move between systems

Key concepts students need access to in order to be successful:

- When given representations of an ecosystem food web that shows energy transfer…
  - Identify the energy that is moved from one trophic level to the next or from one organism to the next
  - Identify energy that moves from the organism(s) to the environment (i.e., heat)
  - Identify energy that is used by the organism for life functions and not passed on to the next trophic level
- Describe how all energy from an organism can be accounted for within the ecosystem, even if it does not transfer to the next trophic level (i.e., energy is conserved)
- When given representations of an ecosystem food web that shows matter transfer…
  - Identify the matter that is moved from one trophic level to the next or from one organism to the next
  - Identify matter that is moved to the environment (i.e., waste)
  - Identify matter whose atoms are rearranged and used by the organism for life functions
- Describe how all matter from an organism can be accounted for within the ecosystem, even if it does not transfer to the next trophic level (i.e., matter is conserved)

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS2-6

Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. [*Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.*]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Engaging in Argument from Evidence

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.
Grades 3-5	• Compare and refine arguments based on an evaluation of the evidence presented. • Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.
Grades K-2	• Identify arguments that are supported by evidence. • Distinguish between explanations that account for all gathered evidence and those that do not. • Analyze why some evidence is relevant to a scientific question and some is not. • Distinguish between opinions and evidence in one's own explanations..

9-12 GRADE LEVEL ELEMENT(S)

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

What ideas or skills are truly unique to this grade band?

- Determining merits of arguments
- Evaluation of claims, evidence, and reasoning of a given argument

Key experiences students need access to in order to be successful:

- Identify claim, evidence and reasoning in a provided argument related to the stability of an ecosystem with changing conditions
- Determine if the evidence is appropriate to support the claim
- Determine if the reasoning about the evidence is sound
- Evaluate the provided argument based on the strengths and weaknesses of the claim, evidence, and reasoning to determine if the argument is valid and reasonable.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. [MS-LS2-4] • Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. [MS-LS2-5]
Grades 3-5	• When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. [secondary to 3-LS4-4]
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

- 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, it may return to its more or less original status (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.

  Foundational concepts necessary for success that are not covered in previous grade bands:

  - Stable ecosystems maintain relatively consistent numbers and types of organisms, even if there is some fluctuation
  - A modest disturbance (biological or physical) may cause temporary changes to the ecosystem, but if the ecosystem was stable prior to the disturbance it may eventually return to the original stability
  - Extreme disturbances can disrupt an ecosystem to the point of no recovery and may eventually lead to a very different ecosystem
  - An ecosystem with extreme fluctuations in the biotic or abiotic factors is not considered stable.
  - Describe how a given change to the ecosystem would impact some of the individual species within the ecosystem

  Key ideas that students need to apply in order to be successful:

  - Identify and describe the biotic and abiotic factors that make up the ecosystem.
  - Identify and describe the interactions between different biotic and abiotic factors in the ecosystem.
  - Describe how a change to one species in an ecosystem can also affect other species within the ecosystem due to the interactions between them.
  - An ecosystem with a more complex food web would have more opportunities for diverse interactions between populations which can support stability of the ecosystem.
  - Identify and describe which factors and interactions could lead to an increase or decrease in the biodiversity of the ecosystem.
  - An ecosystem with more biodiversity allows more interactions between species which can support stability of the ecosystem.
  - Use current and historical information about the population sizes and/or abiotic conditions of the ecosystem to determine if the ecosystem would be considered stable prior to a disturbance.

- Classify a given disturbance as modest (such as moderate hunting or a seasonal flood) or extreme (such as volcanic eruption or sea level rise) for a specific ecosystem.
- Make a prediction about the impact of a disturbance on a specific ecosystem and predict if the ecosystem will be able to recover or if a new ecosystem would be developed

TARGET CROSS CUTTING CONCEPT PROGRESSION

Stability and Change

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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.
Grades 3-5	• Change is measured in terms of differences over time and may occur at different rates. • Some systems appear stable, but over long periods of time will eventually change.
Grades K-2	• Some things stay the same while other things change. • Things may change slowly or rapidly.

9-12 GRADE LEVEL ELEMENT(S)

- Much of science deals with constructing explanations of how things change and how they remain stable.

What ideas or concepts are truly unique to this grade band?

- N/A

Key concepts students need access to in order to be successful:

- Identify disruptions to an ecosystem that will not cause a long term change in stability of the ecosystem
- Identify disruptions to an ecosystem that will lead to a change in the ecosystem, leading to a new ecosystem
- Identify the factors within an ecosystem that support stability in the face of minor disruptions
- Identify the factors within an ecosystem that can lead to instability in the face of disruptions
- Identify the conditions that may lead an ecosystem to be susceptible to large scale change

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

BUNDLE: Evolution and Natural Selection

Standards included:

HS-ESS2-7
HS-LS3-3
HS-LS4-5
HS-LS4-1
HS-LS4-2
HS-LS4-3
HS-LS4-4
HS-LS2-8

FOCUS SEPs:

Engaging in Argument From Evidence
Analyzing and Interpreting Data
Obtaining, Evaluating, and Communicating Information
Constructing Explanations and Designing Solutions

FOCUS DCIs:

ESS2.D Weather and Climate
ESS2.E Biogeology
LS2.D Social Interactions and Group Behavior
LS3.B Variation of Traits
LS4.A Evidence of Common Ancestry and Diversity
LS4.B Natural Selection
LS4.C Adaptation

FOCUS CCCs:

Stability and Change
Scale, Proportion, and Quantity
Patterns
Cause and Effect

HS-ESS2-7

Construct an argument based on evidence about the simultaneous coevolution here of Earth's systems and life on Earth. [*Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.*] [**Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.**]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Engaging in Argument From Evidence

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Construct, use, and/or present 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.
Grades 3-5	• Construct and/or support an argument with evidence, data, and/or a model. Use data to evaluate claims about cause and effect.
Grades K-2	• Construct an argument with evidence to support a claim.

9-12 GRADE LEVEL ELEMENT(S)

- Construct an oral and written argument or counter-arguments based on data and evidence.

What ideas or skills are truly unique to this grade band?

- Possible inclusion of counter-arguments

Key experiences students need access to in order to be successful:

- Make a claim related to coevolution of earth's systems and life on earth
- Identify evidence that supports the claim
- Use reasoning to describe the link between the evidence chosen and the claim made
- Construct the argument for both written and oral communication

TARGET DISCIPLINARY CORE IDEA PROGRESSION

ESS2.D: Weather and Climate, ESS2.E: Biogeology

ESS2.D: Weather and Climate

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. [MS-ESS2-6] • Because these patterns are so complex, weather can only be predicted probabilistically. [MS-ESS2-5] • The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. [MS-ESS2-6]
Grades 3-5	• Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. [3-ESS2-1] • Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. [3-ESS2-2]
Grades K-2	• Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. [K-ESS2-1]

9-12 GRADE LEVEL ELEMENT(S)

- The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth's surface and the life that exists on it.

ESS2.E Biogeology

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• N/A
Grades 3-5	• Living things affect the physical characteristics of their regions. [4-ESS2-1]
Grades K-2	• Plants and animals can change their environment. [K-ESS2-2]

9-12 GRADE LEVEL ELEMENT(S)

- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.

Foundational concepts necessary for success that are not covered in previous grade bands:

- Identify which conditions are necessary for life
- Identify how different organisms impact earth's systems (i.e., plants allow for more land because root systems prevent erosion)
- Identify how a specific earth system has changed over a given long period of time (i.e., atmosphere composition)
- Identify how life on earth changed during the same given period of time as the earth system change
- Identify the relationship between the given earth system and the conditions necessary for life

Key ideas that students need to apply in order to be successful:

- Describe the feedback loops between the living things and the conditions in earth's systems
- Describe the chain reaction that occurs as changing earth's systems change living things which in turn change earth's system which is the continual co-evolution between the biosphere and earth's other systems.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Stability and Change

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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.
Grades 3-5	• Change is measured in terms of differences over time and may occur at different rates. • Some systems appear stable, but over long periods of time will eventually change.
Grades K-2	• Some things stay the same while other things change. • Things may change slowly or rapidly.

9-12 GRADE LEVEL ELEMENT(S)

- Much of science deals with constructing explanations of how things change and how they remain stable.

What ideas or concepts are truly unique to this grade band?

- N/A

Key concepts students need access to in order to be successful:

- Explain how earth's systems have changed over time based on accepted science
- Explain how the life on earth has changed over time based on accepted science
- Explain how the changes in earth's system and life on earth are interrelated
- Identify from the provided evidence times when earth's systems were stable because there were no changes to the life on earth and vice versa

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS3-3

Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [*Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.*] [**Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.**]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Analyzing and Interpreting Data

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.
Grades 3-5	• Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.
Grades K-2	• Record information (observations, thoughts, and ideas). • Use and share pictures, drawings, and/or writings of observations. • Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems. • Compare predictions (based on prior experiences) to what occurred (observable events).

9-12 GRADE LEVEL ELEMENT(S)

- Apply concepts of statistics and probability (such as* determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

What ideas or skills are truly unique to this grade band?

- Statistical analysis can include: determining function fits to data, slope, intercept, and correlation coefficient for linear fits
- Apply statistics and probability to address scientific and engineering questions and problems

Key experiences students need access to in order to be successful:

- Students have access to data related to distribution of a trait within a population
- Use mathematical tools (tables, charts, graphs) to organize data based on trait distribution within the population
- Use mathematical analysis to determine the proportional distribution of each trait variation within the population
- Identify possible correlations between the identified mathematical distribution of a trait and genetic or environmental factors.

Additional Information:

- The critical content of this performance expectation is for students to use mathematical processes to describe a population based on proportionality of trait distribution within a population at a static time. Students are not describing traits of individuals and therefore Punnett squares would not be an appropriate application of probability. Students are not expected to use Hardy-Weinberg or allele frequency calculations to describe the population. Statistical analysis based on chart or graph representations would be a more appropriate application of the intended critical content of this standard.
- Within this standard bundle HS-LS4-3 uses this SEP to describe how trait distribution changes over time. It would be recommended to teach HS-LS3-3 before HS-LS4-3 in order to support student progression of learning.
- *During the unpacking process the KSDE writing team modified this SEP element to change the wording from "including" to "such as" because we do not expect students to apply all of these concepts of statistics and probability, but instead engage in some of these mathematical concepts.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS3.B: Variation of Traits

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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] • 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. [MS-LS3-1]
Grades 3-5	• 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]
Grades K-2	• Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways. [1-LS3-1]

9-12 GRADE LEVEL ELEMENT(S)

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

Foundational concepts necessary for success that are not covered in previous grade bands:

- The environment can influence expressed traits.
- While genetic information is inherited from both parents but not all inherited traits are expressed by the individual
- Probability of occurrence of traits.
- Looking at traits across a defined population.

Key ideas that students need to apply in order to be successful:

- A trait can be described across a population by describing the variations present in the population
- The expression of a trait can be described across a population by describing the distribution of the trait within the population
- The probability of the expression of a trait by an individual within the population is dependent on genetic information passed from parents
- The probability of the expression of a trait being passed to an offspring within the population may be influenced by environmental factors.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Scale, Proportion, and Quantity

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. • The observed function of natural and designed systems may change with scale. • 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. • Scientific relationships can be represented through the use of algebraic expressions and equations. • Phenomena that can be observed at one scale may not be observable at another scale.
Grades 3-5	• Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. • Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.
Grades K-2	• Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). • Standard units are used to measure length..

9-12 GRADE LEVEL ELEMENT(S)

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

What ideas or concepts are truly unique to this grade band?

- Significance of scale for a given phenomena
- Quantity impacts significance of phenomena
- Proportions in a system impact significance of phenomena

Key concepts students need access to in order to be successful:

- Identify a trait and its variants to study as the phenomenon for a population
- Describe the population in terms of distribution of variants using either proportion or quantity representations
- Use the proportion or quantity measurements of trait variations to determine the significance of each variant in the population.
- Identify possible environmental factors that may be influencing the distribution of the identified traits within the population
- Explain whether or not the distribution of the identified variants is a significant indicator of the environment affecting the expression of traits in the population

Additional Information:

- This standard includes a different element for the CCC of scale, proportion, and quantity in the NGSS performance expectation. The review team determined that the element from NGSS was in conflict with the DCI and SEP from this standard and made a substitution in order to support 3-dimensional teaching and assessment.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS4-1

Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. [*Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.*]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Obtaining, Evaluating, and Communicating Information

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations..
Grades 3-5	• Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.
Grades K-2	• Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas.

9-12 GRADE LEVEL ELEMENT(S)

- Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

What ideas or skills are truly unique to this grade band?

- Communicating in multiple formats.
- Communication can be mathematical.

Key experiences students need access to in order to be successful:

- Determining best methods of communication for the ideas related to the topic and intended audience
  - Students need to choose at least two different formats to communicate information about the evidence that supports common ancestry and biological evolution.
  - Formats can include: oral, graphical, textual, mathematical
- Technical writing experiences
  - As needed graphic organizers and/or other scaffolds for organizing thinking
- Oral presentation experiences
  - As needed graphic organizers and/or other scaffolds for organizing thinking
- Organizing information graphically
  - i.e., if using a slide style or infographic format having it organized in a visually engaging manner that is accessible to all who will be receiving the information; or ensuring all graphics are correct, legible, relevant, proper citations, in a poster or paper presentation etc
- Students cite information used as appropriate

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS4.A: Evidence of Common Ancestry and Diversity

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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] • Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy. [MS-LS4-3]
Grades 3-5	• Some kinds of plants and animals that once lived on Earth are no longer found anywhere. (Note: moved from K-2) [3-LS4-1] • Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments. [3-LS4-1]
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

- Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.

  Foundational concepts necessary for success that are not covered in previous grade bands:

  - Genetic information is made up of DNA which codes for a species' characteristics.
  - Specific amino acid sequences are used to build proteins.
  - Genetic information (DNA) can be used to determine the closeness of the relationship between organisms
  - Organisms that physically appear to be unrelated can have similarities in their DNA sequences which implies some relationship

  Key ideas that students need to apply in order to be successful:

  - When comparing DNA sequences or amino acid sequences for two organisms the larger amount of similar code implies a closer relationship and a more recent common ancestor
  - The DNA evidence, fossil record, anatomical structure, and order of appearance of embryological structures can each be used as evidence to support the concept of common ancestry and biological evolution.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Patterns

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Macroscopic patterns are related to the nature of microscopic and atomic-level structure. • Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. • Patterns can be used to identify cause and effect relationships. • Graphs, charts, and images can be used to identify patterns in data.
Grades 3-5	• Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products. • Patterns of change can be used to make predictions. • Patterns can be used as evidence to support an explanation.
Grades K-2	• Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.

9-12 GRADE LEVEL ELEMENT(S)

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

What ideas or concepts are truly unique to this grade band?

- Observation of patterns at multiple of scales of a system
- Causal explanation of phenomena.

Key concepts students need access to in order to be successful:

- When given information about multiple species that includes evidence of common ancestry and biological evolution students can analyze the evidence to…
  - Compare species for commonalities at different scales (i.e., DNA, embryological, anatomical) to determine patterns of similarities.
  - Compare species across time (temporal scale of fossil record) to determine patterns of similarities.
  - Identify that the similarities between organisms observable at different scales is supported by evolution from a common ancestor
- Use patterns from evidence at various scales to support an explanation of evolution and common ancestry

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS4-2

Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. [*Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on the number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.*] [**Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.**]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Constructing Explanations and Designing Solutions

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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. • Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real world phenomena, examples, or events.
Grades 3-5	• Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
Grades K-2	• Use information from observations (firsthand and from media) to construct an evidence-based account for natural phenomena.

9-12 GRADE LEVEL ELEMENT(S)

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

What ideas or skills are truly unique to this grade band?

- Explanations are supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
- Students determine the best evidence sources to support their explanation
- Evidence can include models, theories, simulations, peer review
- Revision of explanations based on further evidence or peer review
- Student-developed evidence can include investigations, models, theories, simulations, peer review

Key experiences students need access to in order to be successful:

- Students need access to one or more sources of valid and reliable evidence supporting the four factors that influence evolution.
- Students need access to multiple examples of species that support evidence of evolution where they can identify factors that led to this evolution.
- Evaluate multiple sources of evidence (provided or student-generated) that support the explanation of the process of evolution.
- Write explanations using evidence to explain how the process of evolution results from the four factors listed in the DCI.

Additional Information:

- Within this standard bundle HS-LS4-4 has identical SEP and CCC and related DCI content and should be taught and assessed together

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS4.B: Natural Selection, LS4.C: Adaptation

LS4.B: Natural Selection

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Natural selection leads to the predominance of certain traits in a population, and the suppression of others. [MS-LS4-4] • 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 onto offspring. [MS-LS4-5]
Grades 3-5	• Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. [3-LS4-2]
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

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

LS4.C: Adaptation

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Natural selection leads to the predominance of certain traits in a population, and the suppression of others. [MS-LS4-4] • 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 onto offspring. [MS-LS4-5]
Grades 3-5	• Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. [3-LS4-2]
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

- 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.

  Foundational concepts necessary for success that are not covered in previous grade bands:

  - Evolution is the process of gradual change where the physical characteristics of a species change over the course of many generations.
  - Natural selection requires both variation in genetic information and variation in the expression of genetic information.
  - For species to increase in number, the population must be able to reproduce
  - Genetic information is passed from parents to offspring.
  - Genetic variation in a population is due to crossing over during sexual reproduction or random mutations.
  - Variation within the population can be expressed through observable traits, but there can also be genetic variation that is not expressed.
  - Each population has a carrying capacity where the population size is limited by the resources available
  - When a population is at or near carrying capacity, the individuals within the population better able to get necessary resources to survive are more likely to reproduce.
  - Key ideas that students need to apply in order to be successful:
  - In the limited resource environment, the individuals that are more likely to survive to reproduce will pass on their genetic information resulting in offspring with the traits needed to survive in the conditions of this environment.
  - Over time each new generation will have a greater proportion of individuals with the genetic information for the advantageous trait(s). This is natural selection.
  - Over many generations it is possible for a group of individuals within the species to develop distinct enough traits and genetics that help them survive and reproduce in their specific environment that they can evolve into a different species.
  - Natural selection and therefore evolution cannot occur unless all four of the following factors are present: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment
  - Students need to be able to differentiate between the process of natural selection and the possible outcome of evolution.

  Additional Information:

  - Within this standard bundle HS-LS4-2, HS-LS4-3, and HS-LS4-4 share DCI content and should be taught together. However, students need to be able to differentiate between natural selection, adaptations of populations, and evolution.
  - While a portion of the critical content of this standard involves understanding the role of sexual reproduction in inheritance students are not expected to identify or describe the steps of meiosis. Students only need to have a conceptual understanding that crossing over occurs within chromosome pairs which causes variation in genetic inheritance.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Cause and Effect

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. • 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 and effect relationships in systems can only be described using probability.
Grades 3-5	• Cause and effect relationships are routinely identified, tested, and used to explain change. • Events that occur together with regularity might or might not be a cause and effect relationship.
Grades K-2	• Events have causes that generate observable patterns. • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

9-12 GRADE LEVEL ELEMENT(S)

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects

What ideas or concepts are truly unique to this grade band?

- Empirical evidence
- Empirical evidence is information gathered directly from observation or experimentation
- Distinguishing between a correlational relationship or a specific cause and effect based on the evidence.

Key concepts students need access to in order to be successful:

- Access to data that allows students to draw a conclusion about the cause and effect relationship between the four factors of natural selection on a species' evolution.
- Students can justify the evidence they select to support the cause and effect relationship
- Make a claim that the four factors of natural selection are the cause of evolution
- Use reasoning to support how the evidence helps support a cause-and-effect relationship between the four factors of natural selection on a species' evolution.

Additional Information:

- Within this standard bundle HS-LS4-4 has identical SEP and CCC and related DCI content and should be taught and assessed together.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS4-3

Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. [*Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.*] [**Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.**]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Analyzing and Interpreting Data

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.
Grades 3-5	• Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.
Grades K-2	• Record information (observations, thoughts, and ideas). • Use and share pictures, drawings, and/or writings of observations. • Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems. • Compare predictions (based on prior experiences) to what occurred (observable events).

9-12 GRADE LEVEL ELEMENT(S)

- Apply concepts of statistics and probability (such as* determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

What ideas or skills are truly unique to this grade band?

- Statistical analysis can include: determining function fits to data, slope, intercept, and correlation coefficient for linear fits)
- Apply statistics and probably to address scientific and engineering questions and problems

Key experiences students need access to in order to be successful:

- Students have access to data related to distribution of a trait within a population
- Use mathematical tools (such as tables, charts, and/or graphs) to organize data based on trait distribution over time.
- Use mathematical analysis to determine changes in distribution of traits over time.
- Describe how the patterns from the data show that an advantageous trait increased over time.
- Use the patterns in proportionality to make predictions based on probability of survival and reproductive success based on traits.

Additional Information:

- During the unpacking process the KSDE writing team modified this SEP element to change the wording from "including" to "such as" because we do not expect students to apply all of these concepts of statistics and probability, but instead engage in some of these mathematical concepts.
- The critical content of this performance expectation is for students to use mathematical processes to describe how a population changes over time based on proportionality of trait distribution. Students are not describing traits of individuals and therefore Punnett squares would not be an appropriate application of probability. Students are not expected to use Hardy-Weinberg or allele frequency calculations to describe the population. Statistical analysis based on chart or graph representations would be a more appropriate application of the intended critical content of this standard.
- Within this standard bundle HS-LS4-3 uses this SEP to describe how trait distribution changes over time. It would be recommended to teach HS-LS3-3 before HS-LS4-3 in order to support student progression of learning.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS4.B: Natural Selection, **LS4.C**: Adaptation

LS4.B: Natural Selection

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Natural selection leads to the predominance of certain traits in a population, and the suppression of others. [MS-LS4-4] • 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 onto offspring. [MS-LS4-5]
Grades 3-5	• Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. [3-LS4-2]
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

- Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information — that is, trait variation — that leads to differences in performance among individuals.
- The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.

LS4.C: Adaptation

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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]
Grades 3-5	• For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. [3-LS4-3])
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

- Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.
- Adaptation also means that the distribution of traits in a population can change when conditions change.

Foundational concepts necessary for success that are not covered in previous grade bands:

- Natural selection requires both variation in genetic information and variation in the expression of genetic information.
- Genetic information is passed from parents to offspring.
- Genetic variation in a population is due to crossing over during sexual reproduction or mutations (random or environmental).
- Variation within the population can be expressed through observable traits, but there can also be genetic variation that is not expressed.
- Individuals within the population that are better able to get the necessary resources to survive are more likely to reproduce.
- The traits within a population that are considered advantageous are dependent on the conditions of the environment. Which traits are advantageous can change if the environmental conditions change.

Key ideas that students need to apply in order to be successful:

- Individuals within the population with advantageous traits are more likely to survive and reproduce and pass on the heritable trait.
- As more individuals with the advantageous heritable trait reproduce a larger proportion of the population will inherit and express the advantageous trait.
- As the proportion of individuals with the advantageous trait increases over time, the proportion of individuals who do not have the advantageous trait will decrease.
- Through the process of natural selection the population becomes better adapted to the environment as a larger proportion of individuals express advantageous traits for the conditions of the environment.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Patterns

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Macroscopic patterns are related to the nature of microscopic and atomic-level structure. • Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. • Patterns can be used to identify cause and effect relationships. • Graphs, charts, and images can be used to identify patterns in data.
Grades 3-5	• Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products. • Patterns of change can be used to make predictions. • Patterns can be used as evidence to support an explanation.
Grades K-2	• Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.

9-12 GRADE LEVEL ELEMENT(S)

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

What ideas or concepts are truly unique to this grade band?

- Patterns can exist across the components of a system
- The patterns at different scales may be different from each other
- The patterns at different scales can be used as evidence of the cause/effect relationship
- The patterns are used to explain the phenomenon (as opposed to describe).

Key concepts students need access to in order to be successful:

- Asked to make connections between the observed proportions of expressed traits and what is happening at genetic scale
- Finding/recognizing patterns in data to determine which observations can serve as evidence of proportions within the population of organisms with advantageous traits
- Use patterns to explain why the proportions of expressed traits change in a population over time.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS4-4.

Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [*Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.*]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Constructing Explanations and Designing Solutions

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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. • Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real world phenomena, examples, or events.
Grades 3-5	• Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
Grades K-2	• Use information from observations (firsthand and from media) to construct an evidence-based account for natural phenomena.

9-12 GRADE LEVEL ELEMENT(S)

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

What ideas or skills are truly unique to this grade band?

- Explanations are supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
- Students determine the best evidence sources to support their explanation
- Evidence can include models, theories, simulations, peer review
- Revision of explanations based on further evidence or peer review
- Student-developed evidence can include investigations, models, theories, simulations, peer review

Key experiences students need access to in order to be successful:

- Students need access to one or more sources of valid and reliable evidence supporting the process of natural selection and the outcome of adaptation.
- Students need access to multiple examples of species that support evidence of adaptation due to natural selection.
- Evaluate multiple sources of evidence (provided or student-generated) for each source's relevance to support an explanation of how natural selection leads to adaptation.
- Write explanations using evidence to explain how the process of natural selection leads to the adaptation of a population to its specific environment.

Additional Information:

- Within this standard bundle HS-LS4-2 has identical SEP and CCC and related DCI content and should be taught and assessed together.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS4.C: Adaptation

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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]
Grades 3-5	• For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. [3-LS4-3])
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

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

Foundational concepts necessary for success that are not covered in previous grade bands:

- An ecosystem can be described using both biotic and abiotic factors
- Genetic information is passed from parents to offspring.
- Genetic variation in a population is due to crossing over during sexual reproduction or random mutations.
- Variation within the population can be expressed through observable traits, but there can also be genetic variation that is not expressed.
- Individuals within the population who are better able to get the necessary resources to survive are more likely to reproduce.
- Natural selection is the process where a population adapts to their environments because the individuals which are better adapted will survive and reproduce more successfully.
- Natural selection requires both variation in genetic information and variation in the expression of genetic information.
- Anatomical, behavioral, and physiological traits can be described as advantageous depending on the biotic or abiotic factors that stress a population based on the environment
- Which traits are advantageous can change if the environmental conditions change.

Key ideas that students need to apply in order to be successful:

- Individuals within the population with advantageous traits are more likely to survive and reproduce and pass on the heritable trait.
- As more individuals with advantageous heritable traits reproduce a larger proportion of the population will inherit and express the advantageous trait.
- As the proportion of individuals with the advantageous trait increases over time, the proportion of individuals who do not have the advantageous trait may decrease.

- As the population has a higher proportion of individuals with the advantageous trait then the population is considered better adapted to the environment
- Through the process of natural selection the population becomes better adapted over generations to the environment as a larger proportion of individuals express advantageous traits for the conditions of the environment.
- Two populations of the same species in different environments may have different advantageous traits based on the environment while still being the same species (natural selection vs. evolution).

Additional Information:

- Within this standard bundle HS-LS4-2, HS-LS4-3, and HS-LS4-4 share DCI content and should be taught together. However, students need to be able to differentiate between natural selection, adaptations of populations, and evolution.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Cause and Effect

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. • 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 and effect relationships in systems can only be described using probability.
Grades 3-5	• Cause and effect relationships are routinely identified, tested, and used to explain change. • Events that occur together with regularity might or might not be a cause and effect relationship.
Grades K-2	• Events have causes that generate observable patterns. • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

9-12 GRADE LEVEL ELEMENT(S)

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

What ideas or concepts are truly unique to this grade band?

- Empirical evidence
  - Empirical evidence is information gathered directly from observation or experimentation
- Distinguishing between a correlational relationship or a specific cause and effect based on the evidence.

Key concepts students need access to in order to be successful:

- Access to data that allows students to identify the biotic or abiotic factors in an environment that would favor a specific trait.
- Students can justify the evidence they select to support an explanation of how a change in the environment would cause a change in which traits are advantageous for a population.
- Make a claim based on the evidence for how the environmental factors lead to natural selection within the population which leads to a better adapted population.
- Use reasoning to support how the evidence helps support a cause-and-effect relationship between environmental factors, natural selection, and adaptation.

Additional Information:

- Within this standard bundle HS-LS4-2 has identical SEP and CCC and related DCI content and should be taught and assessed together.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS4-5.

Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [*Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.*]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Engaging in Argument From Evidence

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.
Grades 3-5	• Compare and refine arguments based on an evaluation of the evidence presented. • Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.
Grades K-2	• Identify arguments that are supported by evidence. • Distinguish between explanations that account for all gathered evidence and those that do not. • Analyze why some evidence is relevant to a scientific question and some is not. • Distinguish between opinions and evidence in one's own explanations.

9-12 GRADE LEVEL ELEMENT(S)

- Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.

What ideas or skills are truly unique to this grade band?

- Evaluate evidence related to currently accepted explanations.
- Determine the merits of an argument related to a currently accepted explanation.

Key experiences students need access to in order to be successful:

- Students need to be given one or more currently accepted arguments related to changing environment and the three possible changes in populations.
- Students identify valid and reliable evidence related to the argument.
- Students evaluate given evidence for how well the evidence supports the provided argument.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS4.C: Adaptation

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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]
Grades 3-5	• For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. [3-LS4-3])
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

- 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.

Foundational concepts necessary for success that are not covered in previous grade bands:

- The earth's processes are constantly changing the earth's surface at large and small scales both temporally and geographically.
- Humans can change the environment in addition to natural changes.
- Human activity can cause the timescale of natural changes to speed up.
- Individuals within the population that are better able to get the necessary resources to survive are more likely to reproduce.
- Genetic information is passed from parents to offspring and determines an individual's traits
- Which traits are advantageous can change if the environmental conditions change.
- Extinction is the process where a species that is no longer well adapted to the environment and cannot survive and reproduce at a rate to sustain the population; the population will cease to exist.
- Speciation is the process where a group within a species becomes isolated from other members of its species and develops its own unique genetic characteristics and is no longer able to successfully reproduce with the original population.
- Natural selection is the process where a population adapts to their environments because the individuals which are better adapted will survive and reproduce.
- A population that is well adapted to the environment may more successfully reproduce and increase the size of the population until reaching carrying capacity.

Key ideas that students need to apply in order to be successful:

- When an environment changes, some species adapt and increase, some adapt and change, and some do not adapt and may eventually go extinct.
- When an environmental change is more gradual it is more likely for populations to be able to adapt to the environment through natural selection and speciation may occur.
- When an environment changes too rapidly or too drastically it becomes more difficult for a population to adapt and more likely to decrease in population size and may lead to extinction.
- When a population already includes individuals with a trait that becomes advantageous after a change to the environment then that population is likely to increase in numbers after the environment changes.
- Human activity often causes changes that are too drastic or too rapid for a population to be able to adapt
- Human-induced changes to the environment often can be connected to changes in the populations of species in the environment which could lead to an increase in population, decrease in population, or the development of a new species.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Cause and Effect

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. • 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 and effect relationships in systems can only be described using probability.
Grades 3-5	• Cause and effect relationships are routinely identified, tested, and used to explain change. • Events that occur together with regularity might or might not be a cause and effect relationship.
Grades K-2	• Events have causes that generate observable patterns. • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

9-12 GRADE LEVEL ELEMENT(S)

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects

What ideas or concepts are truly unique to this grade band?

- Empirical evidence
  - Empirical evidence is information gathered directly from observation or experimentation
- Distinguishing between a correlational relationship or a specific cause and effect based on the evidence.

Key concepts students need access to in order to be successful:

- Identify the evidence that supports a cause and effect relationship between environmental conditions and changes to a population
- Use reasoning to support how the evidence helps prove the claim that changes in environmental conditions result in one of three changes to a population.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS2-8

Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. [*Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.*]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Engaging in Argument From Evidence

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.
Grades 3-5	• Compare and refine arguments based on an evaluation of the evidence presented. • Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.
Grades K-2	• Identify arguments that are supported by evidence. • Distinguish between explanations that account for all gathered evidence and those that do not. • Analyze why some evidence is relevant to a scientific question and some is not. • Distinguish between opinions and evidence in one's own explanations.

9-12 GRADE LEVEL ELEMENT(S)

- Evaluate the evidence behind currently accepted explanations to determine the merits of arguments.

What ideas or skills are truly unique to this grade band?

- Evaluate evidence related to currently accepted explanations
- Determine the merits of an argument related to a currently accepted explanation

Key experiences students need access to in order to be successful:

- Students need to be given a currently accepted argument related to the idea that group behavior can increase the chances for an individual and a species to survive and reproduce.
- Students identify valid and reliable evidence related to the argument.
- Students evaluate given evidence for how well the evidence supports the provided argument.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS2.D: Social Interactions and Group Behavior

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. [secondary to MS-LS2-5]
Grades 3-5	• Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size (Note: Moved from K–2). [3-LS2-1]
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

- Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.

Foundational concepts necessary for success that are not covered in previous grade bands:

- Behavior can be a heritable trait
- Individuals that survive and reproduce pass on their genetic traits
- Traits that are better suited to the environment are more likely to be passed on to the next generation
- Populations made up of a higher proportion of individuals that demonstrate an advantageous group behavior are more likely to survive, reproduce

Key ideas that students need to apply in order to be successful:

- Advantageous group behavior will increase the likelihood that an individual within the population will survive and reproduce
- Advantageous group behavior will increase the likelihood that a species will be able to survive and reproduce.
- Individuals that survive and reproduce will pass on their genetic traits to their offspring which will continue the advantageous group behavior that will increase the likelihood that the species will continue to survive and reproduce.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Cause and Effect

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. • 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 and effect relationships in systems can only be described using probability.
Grades 3-5	• Cause and effect relationships are routinely identified, tested, and used to explain change. • Events that occur together with regularity might or might not be a cause and effect relationship.
Grades K-2	• Events have causes that generate observable patterns. • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

9-12 GRADE LEVEL ELEMENT(S)

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

What ideas or concepts are truly unique to this grade band?

- Empirical evidence
  - Empirical evidence is information gathered directly from observation or experimentation
- Distinguishing between a correlational relationship or a specific cause and effect based on the evidence.

Key concepts students need access to in order to be successful:

- Identify the evidence that supports a cause and effect relationship between group behavior and the survival and reproduction rates of individuals and species.
- Use reasoning to support how the evidence helps support the claim that group behavior can increase the chances for an individual and a species to survive and reproduce.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

BUNDLE: Biodiversity

Standards included:

HS-LS2-2
HS-LS2-7
HS-LS4-6
HS-ESS2-2
HS-ESS3-3
HS-ESS3-2

FOCUS SEPs:

Analyzing and Interpreting Data
Using Mathematics and Computational Thinking
Constructing Explanations and Designing Solutions
Engaging in Argument From Evidence

FOCUS DCIs:

ESS2.A	Earth Materials and Systems
ESS2.D	Weather and Climate
ESS3.A	Natural Resources
ESS3.C	Human Impacts on Earth Systems
LS2.A	Interdependent Relationships in Ecosystems
LS2.C	Ecosystem Dynamics, Functioning, and Resilience
LS4.C	Adaptation
LS4.D	Biodiversity and Humans

FOCUS CCCs:

Scale, Proportion, and Quantity
Stability and Change
Cause and Effect

HS-LS2-2

Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [*Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.*] [**Assessment Boundary: IAssessment is limited to provided data.**]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Using Mathematics and Computational Thinking

LS2.A: Interdependent Relationships in Ecosystems

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Use mathematical representations to describe and/or support scientific conclusions and design solutions.
Grades 3-5	• Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems.
Grades K-2	• Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs.

9-12 GRADE LEVEL ELEMENT(S)

- Use mathematical representations of phenomena or design solutions to support and revise explanations.

What ideas or skills are truly unique to this grade band?

- Representations of phenomena
- Revision of explanations using mathematical representations

Key experiences students need access to in order to be successful:

- Analyze given information related to key environmental factors for ecosystems at different scales for the possible impact on the biodiversity or specific population size for each ecosystem.
- Analyze mathematical representations (including trends, averages, and graphs) of population size or biodiversity within each identified ecosystem related to the environmental data provided.
- For each ecosystem identify the relationship between the environmental factors of the ecosystem and the biodiversity and/or specific population sizes present.
- Write an explanation for how factors within each ecosystem affect the biodiversity and/or population sizes within the ecosystem using the data provided as evidence.
- When provided additional data students revise claims and/or explanations based on new information.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS2.A: Interdependent Relationships in Ecosystems and LS2.C: Ecosystem Dynamics, Functioning, and Resilience

LS2.A: Interdependent Relationships in Ecosystems

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. [MS-LS2-1] • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. [MS-LS2-1] • Growth of organisms and population increases are limited by access to resources. [MS-LS2-1] • Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. [MS-LS2-2]
Grades 3-5	• The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. [5-LS2-1]
Grades K-2	• Plants depend on water and light to grow. [2-LS2-1] • Plants depend on animals for pollination or to move their seeds around. [2-LS2-2]

9-12 GRADE LEVEL ELEMENT(S)

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as 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.

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. [MS-LS2-4] • Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. [MS-LS2-5]
Grades 3-5	• When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. [secondary to 3-LS4-4]
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

- 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, it may return to its more or less original status (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.

  Foundational concepts necessary for success that are not covered in previous grade bands:

  - Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).
  - Carrying capacity is a limit to the numbers of organisms and populations an ecosystem can support.
  - Factors that affect carrying capacity include the availability of living and nonliving resources and from challenges such as predation, competition, and disease.
  - Ecosystems are dependent on the complex interactions between individuals and populations to maintain stability.

  Key ideas that students need to apply in order to be successful:

  - The carrying capacity of an ecosystem can fluctuate when the biotic or abiotic factors within the ecosystem fluctuate.
  - Types of factors that affect carrying capacity for ecosystems at a macroscopic scale can be the same for ecosystems at a microscopic scale
  - The complex interactions within an ecosystem keep the biodiversity and size of populations stable when conditions are favorable
  - A stable ecosystem is resilient to small fluctuations in conditions and can recover from the impact to populations and biodiversity.
  - Extreme fluctuations in conditions can affect the size of populations or amount of biodiversity in the ecosystem which can impact the stability of the overall ecosystem.

  Additional Information:

  - LS4.D would be good supporting information related to biodiversity that is not currently covered in the identified DCIs.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Scale, Proportion, and Quantity

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. • The observed function of natural and designed systems may change with scale. • 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. • Scientific relationships can be represented through the use of algebraic expressions and equations. • Phenomena that can be observed at one scale may not be observable at another scale.
Grades 3-5	• Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. • Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.
Grades K-2	• Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). • Standard units are used to measure length.

9-12 GRADE LEVEL ELEMENT(S)

- Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

What ideas or concepts are truly unique to this grade band?

- Orders of magnitude
- Two different scales can be related

Key concepts students need access to in order to be successful:

- Identify and define two ecosystems at different orders of magnitude (i.e., macroscale vs microscale)
- Compare similarities between the two ecosystems and the factors that affect the biodiversity and population sizes within each.
- Explain how ecosystems at different scales have similar types of factors that affect their dynamics.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS2-7

Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. [*Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.*]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Constructing Explanations and Designing Solutions

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system. • Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. • Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and retesting.
Grades 3-5	• Apply scientific ideas to solve design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.
Grades K-2	• Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem. • Generate and/or compare multiple solutions to a problem.

9-12 GRADE LEVEL ELEMENT(S)

- Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.

What ideas or skills are truly unique to this grade band?

- Solutions to real-world problems
- Refining of solution.
- Use of student-generated sources of evidence.

Key experiences students need access to in order to be successful:

- Identify a real-world problem related to how human activity negatively impacts the environment and/or biodiversity.
- Design a solution for the identified problem based on scientific knowledge of ecosystem dynamics.
- Describe how the designed solution could reduce the negative impact of human activity on the environment and/or biodiversity.
- Evaluate the designed solution based on prioritized criteria and trade-off considerations
- Revise the design to optimize the prioritized criteria and limit trade-offs.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS2.C: Ecosystem Dynamics, Functioning, and Resilience, LS4.D: Biodiversity and Humans

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. [MS-LS2-4] • Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. [MS-LS2-5]
Grades 3-5	• When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. [secondary to 3-LS4-4]
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

- Moreover, anthropogenic 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.

LS4.D: Biodiversity and Humans

Grades	Grade Level Elements
Grades 6-8	• N/A
Grades 3-5	• Populations live in a variety of habitats, and change in those habitats affects the organisms living there. [3-LS4-4]
Grades K-2	• There are many different kinds of living things in any area, and they exist in different places on land and in water. [2-LS4-1]

9-12 GRADE LEVEL ELEMENT(S)

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary)
- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)

ETS1.B: Developing Possible Solutions

- When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (secondary)

Foundational concepts necessary for success that are not covered in previous grade bands:

- Human activity can negatively impact the environment through habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change
- Humans rely on the environment for resources (food, medicine, supplies for shelter, etc) necessary to support our population
- Human activity can be designed to positively impact the environment through conservation or restoration
- Biodiversity is necessary for the complex interactions that support stable ecosystems
- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).

Key ideas that students need to apply in order to be successful:

- If humans continue to have the same or more negative impacts on the environment, biodiversity will decrease
- As biodiversity decreases, ecosystems function less effectively which can threaten the survival of other species
- If biodiversity decreases then resources that humans rely on will become more scarce
- Humans need to reduce negative impacts on the environment in order to support biodiversity which supports human life.

Additional Information:

- This standard should be taught alongside HS-LS4-6 as there is overlap in the DCI elements and both are aiming to mitigate or reduce human impact on biodiversity.
- Within this standard bundle it is recommended to teach this performance expectation with HS-ESS3-2 and use energy and resource management as the human activity that may impact biodiversity and the environment.
- ESS3.C would be good supporting information related to human impacts on earth's systems that is not currently covered in the identified DCIs.
- The ETS element was not specifically unpacked in the DCI because the critical content of this ETS element is covered through the SEP for this standard.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Stability and Change

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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.
Grades 3-5	• Change is measured in terms of differences over time and may occur at different rates. • Some systems appear stable, but over long periods of time will eventually change.
Grades K-2	• Some things stay the same while other things change. • Things may change slowly or rapidly.

9-12 GRADE LEVEL ELEMENT(S)

- Much of science deals with constructing explanations of how things change and how they remain stable.

What ideas or concepts are truly unique to this grade band?

- N/A

Key concepts students need access to in order to be successful:

- Exposure to scientific explanations about how human impact is causing change to the environment which impacts the stability of ecosystems.
- Identify how human-caused changes impact the stability of the environment or biodiversity
- Explain how a proposed solution would change the impact that humans have on the environment

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-LS4-6

Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.[*Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.*]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Using Mathematics and Computational Thinking

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.
Grades 3-5	• Organize simple data sets to reveal patterns that suggest relationships.
Grades K-2	• Use counting and numbers to identify and describe patterns in the natural and designed world(s).

9-12 GRADE LEVEL ELEMENT(S)

- Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

What ideas or skills are truly unique to this grade band?

- Create or revise simulation
- Computational model
- Modeling/simulating phenomenon, designed device, or system

Key experiences students need access to in order to be successful:

- Exposure to computational models of human activity and biodiversity.
- Collect biodiversity data using the model without any solutions applied.
- Be given or determine a possible solution that could mitigate adverse impacts.
- Have multiple mitigation options to run in the model to measure the predicted impact each has.
- Use or revise the computational model with the proposed solution and gather data on biodiversity before and after applying the solution.

Additional Information:

- The element listed with this performance expectation was missing and/or computational modeling, which is a part of this element based on NGSS appendix F.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

LS4.C: Adaptation, LS4.D: Biodiversity and Humans

LS4.C: Adaption

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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]
Grades 3-5	• For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. [3-LS4-3]
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

- 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.

LS4.D: Biodiversity and Humans

Grades	Grade Level Elements
Grades 6-8	• N/A
Grades 3-5	• Populations live in a variety of habitats, and change in those habitats affects the organisms living there. [3-LS4-4]
Grades K-2	• N/A

9-12 GRADE LEVEL ELEMENT(S)

- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (Note: This Disciplinary Core Idea is also addressed by HS-LS2-7.)

  ETS1.B: Developing Possible Solutions

  - When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary)
  - Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (secondary)

Foundational concepts necessary for success that are not covered in previous grade bands:

- Individuals within the population who are better able to get the necessary resources to survive are more likely to reproduce.
- Anatomical, behavioral, and physiological traits can be described as advantageous depending on the biotic or abiotic factors that stress a population based on the environment
- Variation within the population can be expressed through observable traits, but there can also be genetic variation that is not expressed.
- Traits which are advantageous can change if the environmental conditions change.
- Human activity can negatively impact the environment through: habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change
- Humans rely on the environment for resources (food, medicine, supplies for shelter, etc) necessary to support our population
- Biodiversity is necessary for the complex interactions that support stable ecosystems
- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).

Key ideas that students need to apply in order to be successful:

- As more individuals with the advantageous heritable trait reproduce a larger proportion of the population will inherit and express the advantageous trait.
- As the proportion of individuals with the advantageous trait increases over time, the proportion of individuals who do not have the advantageous trait will decrease.
- As the population has a higher proportion of individuals with the advantageous trait then the population is considered better adapted to the environment
- Through the process of natural selection, the population becomes better adapted over generations to the environment as a larger proportion of individuals express advantageous traits for the conditions of the environment.
- If humans continue to have the same or more negative impacts on the environment, biodiversity will change as some species expand, some decline or become extinct, and other species diverge and result in the emergence of new species based on adaptation to the environment.
- As biodiversity decreases, ecosystems function less effectively which can threaten the survival of other species
- If biodiversity decreases then resources that humans rely on will become more scarce
- Humans need to reduce negative impacts on the environment in order to support biodiversity which supports human life.

Additional Information:

- This standard should be taught alongside HS-LS2-7 as there is overlap in the DCI elements and both are aiming to mitigate or reduce human impact on biodiversity.
- Within this standard bundle it is recommended to teach this performance expectation with HS-ESS3-2 and use energy and resource management as the human activity that may impact biodiversity and the environment.
- ESS3.C would be good supporting information related to human impacts on earth's systems that is not currently covered in the identified DCIs.
- The ETS element was not specifically unpacked in the DCI because the critical content of this ETS element is covered through the SEP for this standard.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Cause and Effect

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. • 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 and effect relationships in systems can only be described using probability.
Grades 3-5	• Cause and effect relationships are routinely identified, tested, and used to explain change. • Events that occur together with regularity might or might not be a cause and effect relationship.
Grades K-2	• Events have causes that generate observable patterns. • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

9-12 GRADE LEVEL ELEMENT(S)

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

What ideas or concepts are truly unique to this grade band?

- Empirical evidence
  - Empirical evidence is information gathered directly from observation or experimentation
- Distinguishing between a correlational relationship or a specific cause and effect based on the evidence.

Key concepts students need access to in order to be successful:

- Gather data from computational models or simulations to identify the adverse impacts on biodiversity caused by human activity.
- Students can justify the evidence they select to support the use of a specific solution to mitigate adverse impacts caused by human activity.
- Make a claim based on the evidence for the efficacy of the proposed mitigation solution in reducing adverse impacts caused by human activity.
- Use reasoning to show how the evidence supports a cause and effect relationship between use of the mitigation solution and reduction of adverse impacts caused by human activity.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-ESS3-2

Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [*Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems - not what should happen.*]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Engaging in Argument From Evidence

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system, based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.
Grades 3-5	• Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.
Grades K-2	• Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.

9-12 GRADE LEVEL ELEMENT(S)

- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).

What ideas or skills are truly unique to this grade band?

- Real-world problem
- Evaluation based on scientific principles
- Evaluation based on logical arguments regarding relevant factors (e.g., economic, societal, environmental, and ethical considerations).

Key experiences students need access to in order to be successful:

- Identify a real-world problem related to the extraction/use of an energy or mineral resource
- Describe two competing design solutions to address the problem.
- Describe the scientific principles related to the problem and/or solutions.
- Evaluate each solution based on cost-benefit ratios including relevant factors like economic, societal, environmental, ethical, and geopolitical considerations.
- Compare the two solutions based on the evaluation of cost-benefit ratios.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

ESS3.A: Natural Resources

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. [MS-ESS3-1]
Grades 3-5	• Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. [4-ESS3-1]
Grades K-2	• Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. [K-ESS3-1]

9-12 GRADE LEVEL ELEMENT(S)

- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary)

Foundational concepts necessary for success that are not covered in previous grade bands:

- Human reliance on energy production is increasing.
- Extracting the resources needed for energy has many costs including economic, social, environmental, geopolitical.
- The processes involved with extraction, production, and use of natural resources have associated risks for humans and the environment to be considered.
- Advancement of technology has led to an increased need for mineral resources.
- Regulations that affect the management of natural resources change with society.

Key ideas that students need to apply in order to be successful:

- Identify associated costs, risks, and benefits of developing and using a specific energy or mineral resource
- Identify where new technology could be used to improve the cost-benefit ratio of extracting and using an energy or mineral resource
- Describe regulations currently in place related to the extraction and/or use of an energy or mineral resource
- Identify ways that regulations could be changed to improve the cost-benefit ratio of extracting and using an energy or mineral resource

Additional Information:

- This standard should be taught alongside HS-LS2-7 and HS-LS4-6 as there is overlap in the DCI elements and both are aiming to mitigate or reduce human impact on biodiversity.
- ESS3.C would be good supporting information related to human impacts on earth's systems that is not currently covered in the identified DCIs.
- The ETS element was not specifically unpacked in the DCI because the critical content of this ETS element is covered through the SEP for this standard.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Cause and Effect

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. • 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 and effect relationships in systems can only be described using probability.
Grades 3-5	• Cause and effect relationships are routinely identified, tested, and used to explain change. • Events that occur together with regularity might or might not be a cause and effect relationship.
Grades K-2	• Events have causes that generate observable patterns. • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

9-12 GRADE LEVEL ELEMENT(S)

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

What ideas or concepts are truly unique to this grade band?

- Empirical evidence
  - Empirical evidence is information gathered directly from observation or experimentation
- Distinguishing between a correlational relationship or a specific cause and effect based on the evidence.

Key concepts students need access to in order to be successful:

- Be given two or more design solutions for energy and mineral resources including estimated costs including economic, societal, cultural, environmental, ethical, and geopolitical impacts
- Gather data to identify the potential benefits of each design solution with emphasis on conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not.
- Identify which design solution will have the most beneficial effect based on comparing the costs and benefits.

Additional Information:

- This standard does not include a CCC on the NGSS performance expectation. The review team identified a CCC in order to maintain 3-dimensional instruction and assessment. “Cause and Effect” was chosen for this standard to create alignment with HS-LS4-6 which uses the same Cause and Effect element.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-ESS2-2

Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes here to other Earth systems. [*Clarification Statement: Examples should include climate feedback, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.*]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Analyzing and Interpreting Data

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. • Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships. • Distinguish between causal and correlational relationships in data. • Analyze and interpret data to provide evidence for phenomena.
Grades 3-5	• Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships.
Grades K-2	• Record information (observations, thoughts, and ideas). • Use and share pictures, drawings, and/or writings of observations. • Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems. • Compare predictions (based on prior experiences) to what occurred (observable events).

9-12 GRADE LEVEL ELEMENT(S)

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

What ideas or skills are truly unique to this grade band?

- Use different tools, technologies, and/or models (e.g., computational, mathematical)
- Making valid and reliable scientific claims
- Determine an optimal design solution.

Key experiences students need access to in order to be successful:

- Given data about Earth's systems that include before and after a change to Earth's surface
- Within the data identify the change to the earth's surface
- Analyze given geoscience data about interacting conditions within earth's systems for patterns before and after the identified change.
- Use patterns in data to determine which conditions within Earth's systems were affected by the initial change
- Make a claim about how the change to earth's surface leads to changes in other systems which may lead to continued change to the surface.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

ESS2.A: Earth Materials and Systems, and ESS2.D: Weather and Climate

ESS2.A: Earth Materials and Systems

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. [MS-ESS2-1] • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. [MS-ESS2-2]
Grades 3-5	• Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. [4-ESS2-1] • Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. [5-ESS2-1]
Grades K-2	• Wind and water can change the shape of the land. [2-ESS2-1]

9-12 GRADE LEVEL ELEMENT(S)

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

ESS2.D: Weather and Climate

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. [MS-ESS2-6] • Because these patterns are so complex, weather can only be predicted probabilistically. [MS-ESS2-5] • The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. [MS-ESS2-6]
Grades 3-5	• Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. [3-ESS2-1] • Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. [3- ESS2-2]
Grades K-2	• Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. [K-ESS2-1]

9-12 GRADE LEVEL ELEMENT(S)

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.

  Foundational concepts necessary for success that are not covered in previous grade bands:

  - Earth's surface can be changed rapidly or slowly.
  - Earth's surface changes through naturally occurring processes as well as through human activity.
  - Because Earth's systems interact changing one component of one system can lead to a change in the other systems.
  - Feedback effects can either amplify or inhibit interactions within the system.
  - Climate in influenced by feedback loops involving solar radiation:
    - Glaciers reflect solar radiation back to space.
    - Vegetation absorbs solar radiation to hold in the Earth and atmosphere.
    - Electromagnetic radiation can be reflected or absorbed.
    - Climate is the average temperature and precipitation of a region over a long period of time.
    - Global climate patterns are determined by ocean currents that circulate warm and cold water across the globe and the ocean currents impact the prevailing winds that determine climate.

  Key ideas that students need to apply in order to be successful:

  - A change to Earth's surface can lead to changes in the other systems that interact with earth's surface.
  - Feedback effects in an ecosystem happen when changing one component of the system leads to a chain of events that cycle back to the original component causing an amplification or inhibition of the system functions.

  Additional Information:

  - This standard asks for students to identify how changes to earth's surface creates feedback to other systems. In a biology classroom while students may be asked to analyze the resulting changes in various systems, the emphasis should be on student analysis of impacts to the biosphere.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Stability and Change

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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.
Grades 3-5	• Change is measured in terms of differences over time and may occur at different rates. • Some systems appear stable, but over long periods of time will eventually change.
Grades K-2	• Some things stay the same while other things change. • Things may change slowly or rapidly.

9-12 GRADE LEVEL ELEMENT(S)

- Feedback (negative or positive) can stabilize or destabilize a system.

What ideas or concepts are truly unique to this grade band?

- Feedback can be positive or negative
- Feedback can stabilize or destabilize

Key concepts students need access to in order to be successful:

- Identify a change to the earth's surface that leads to changes in other systems which leads to continued change to the surface (feedback)
- Identify if the feedback is positive (increasing the ongoing change) or negative (reducing the ongoing change)
- Identify if the feedback is stabilizing or destabilizing Earth's systems

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

HS-ESS3-3

Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [*Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.*] [**Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.**]

TARGET SCIENCE AND ENGINEERING PRACTICE PROGRESSION

Using Mathematics and Computational Thinking

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.
Grades 3-5	• Organize simple data sets to reveal patterns that suggest relationships.
Grades K-2	• Use counting and numbers to identify and describe patterns in the natural and designed world(s).

9-12 GRADE LEVEL ELEMENT(S)

- Create a computational model or simulation of a phenomenon, designed device, process, or system.

What ideas or skills are truly unique to this grade band?

- Create simulation
- Computational model
- Modeling/simulating phenomenon, designed device, or system

Key experiences students need access to in order to be successful:

- Exposure to computational models of human activity and biodiversity.
- Collect biodiversity data using the model without any solutions applied.
- Be given or determine a possible solution that could mitigate adverse impacts.
- Have multiple mitigation options to run in the model to measure the predicted impact each has.
- Use or revise the computational model with the proposed solution and gather data on biodiversity before and after applying the solution.

TARGET DISCIPLINARY CORE IDEA PROGRESSION

ESS3.C: Human Impacts on Earth Systems

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. [MS-ESS3-3] • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. [MS-ESS3-3], [MS-ESS3-4]
Grades 3-5	• Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. [5-ESS3-1]
Grades K-2	• Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things. [K-ESS3-3] [secondary to K-ESS2-2]

9-12 GRADE LEVEL ELEMENT(S)

- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

Foundational concepts necessary for success that are not covered in previous grade bands:

- Biodiversity is necessary to support human populations by providing resources
- Current societal needs include the management of natural resources like usable freshwater sources, fossil fuels, metals, and minerals
- Humans consider many factors in managing natural resources including cost of extraction, waste management, rate of resource consumption, and impact of technological advancement
- The overall human population is growing and will eventually reach a carrying capacity for our global society, some local populations are growing at an even faster rate.

Key ideas that students need to apply in order to be successful:

- Responsible management of natural resources supports the conservation of biodiversity
- Human population growth could be sustainable with human management of natural resources and conservation of biodiversity
- The relationship between the human population, ecosystem biodiversity, and the management of resources can be illustrated through agriculture, urban planning, and land conservation initiatives.

TARGET CROSS CUTTING CONCEPT PROGRESSION

Stability and Change

BELOW GRADE LEVEL

Grades	Grade Level Elements
Grades 6-8	• 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.
Grades 3-5	• Change is measured in terms of differences over time and may occur at different rates. • Some systems appear stable, but over long periods of time will eventually change.
Grades K-2	• Some things stay the same while other things change. • Things may change slowly or rapidly.

9-12 GRADE LEVEL ELEMENT(S)

- Systems can be designed for greater or lesser stability.
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

What ideas or concepts are truly unique to this grade band?

- Purposeful design of a system to impact stability
- Some changes are irreversible
- Quantifications and modeling of change can be done over various time periods

Key concepts students need access to in order to be successful:

- Define the components of a system as natural resources, human population, and biodiversity
- Identify the relationships between the components of the system
- Collect data on how changing one component of the system would impact the other components
- Analyze the data to determine how changing management of natural resources or biodiversity would impact the sustainability of the human population.
- Describe how greater stability within the all three components of the system supports sustainability of the human population.

ALIGNING THIS STANDARD TO YOUR STUDENTS:

- What everyday experiences or knowledge from other content areas might students bring to help them develop the targets from the SEP, DCI, and CCC?
- Where are students using and experiencing these ideas, practices, and concepts outside of the science classroom?
- What questions may students have related to these ideas about how the world works?
- What scaffolding might my students need to fully understand this particular standard?
- What phenomena could capture students' interest and provide opportunities to use the science covered in this standard to understand the phenomena?

Glossary of Terms

Cross Cutting Concept[1]

These are concepts that hold true across the natural and engineered world. Students can use them to make connections across seemingly disparate disciplines or situations, connect new learning to prior experiences, and more deeply engage with material across the other dimensions. The NGSS requires that students explicitly use their understanding of the CCCs to make sense of phenomena or solve problems.

Disciplinary Core Idea[1]

The fundamental ideas that are necessary for understanding a given science discipline. The core ideas all have broad importance within or across science or engineering disciplines, provide a key tool for understanding or investigating complex ideas and solving problems, relate to societal or personal concerns, and can be taught over multiple grade levels at progressive levels of depth and complexity.

Elements[1]

The bulleted practices, disciplinary core ideas, and crosscutting concepts that are articulated in the foundation boxes of the standards as well as the in the NGSS appendices on each dimension.

Next Generation Science Standards (NGSS)

K–12 science content standards. Standards set the expectations for what students should know and be able to do. Adopted in as Kansas Science Standards in 2013

Performance Expectation[1]

Each NGSS standard is written as a performance expectation that sets the learning goals for students, but does not describe how students get there. Each standard is not a daily standard but an expectation of what students should be able to do by the end of instruction (years or grade-bands).

Science and Engineering Practice[1]

The practices are what students DO to make sense of phenomena. They are both a set of skills and a set of knowledge to be internalized. The SEPs reflect the major practices that scientists and engineers use to investigate the world and design and build systems.

Standards[2]

End of instruction goals or benchmarks for student proficiency.

Standards Alignment[3]

Standards-Aligned instruction has clearly defined student learning expectations aligned to Kansas State Standards and supported with evidence-based instruction and materials.

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1 Next Generation Science Standards https://www.nextgenscience.org/

2 NGSS Glossary https://www.nextgenscience.org/glossary

3 Disciplinary Core Ideas in the Next Generation Science Standards (NGSS) Final Release https://www.nextgenscience.org/sites/default/files/Handout%2004%20-%20NSTA%20DCIs%20Matrix.pdf

Standards Bundles[1]

Grouping elements or concepts from multiple PEs in lessons, units, and/or assessments that students can develop and use together to build toward proficiency on a set of PEs in a coherent manner.

Standards Unpacking

A systematic process of identifying the key ideas, experiences, and concepts that students need to demonstrate to show mastery of a standard.

Three-Dimensions[1]

These are the three strands of knowledge and skills that students should explicitly be able to use to explain phenomena and design solutions to problems. The three dimensions are the Disciplinary Core Ideas (DCIs), Crosscutting Concepts (CCCs), and Science and Engineering Practices (*"the Practices"* or SEPs).

Unpacked Standard

The key ideas, experiences, and concepts that are identified as necessary for a student to demonstrate to show mastery of a standard. An unpacked standard is intended to provide clarity on the expectations of the standard and intentionally does not include any ideas, concepts, or experiences beyond the standard.

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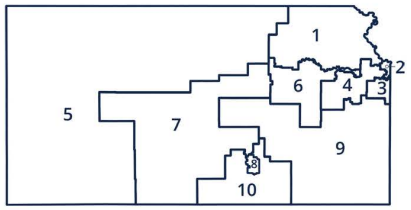


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Kansas divided into the ten State Board of Education districts.

KANSAS STATE DEPARTMENT OF EDUCATION

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May 27, 2026

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