Life Science Teacher's Guide to the Nebraska College and Career Ready Standards for Science Standards 2024

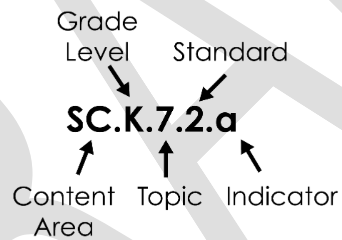
Table of Contents

Content Area Standards Structure

The overall structure of Nebraska's College and Career Ready Standards for Science (CCR-Science) reflects the two-tier structure common across all Nebraska content area standards. The two levels within the structure include **standards** and **indicators**. The **standards** are broad, overarching content-based statements that describe the basic cognitive, affective, or psychomotor expectations of student learning. The standards, across all grade levels, reflect long-term goals for learning. **Indicators** further describe what students must know and be able to do to meet the standard. These performance-based statements provide clear expectations related to student learning in each content area. Additionally, indicators provide guidance related to the assessment of student learning. This guidance is articulated by including ***assessment boundary*** statements.

The CCR-Science standards describe the knowledge and skills that students should learn, but they do not prescribe particular curriculum, lessons, teaching techniques, or activities. Standards describe what students are expected to know and be able to do, while the local curriculum describes how teachers will help students master the standards. A wide variety of instructional resources may be used to meet the state content area standards. Decisions about curriculum and instruction are made locally by individual school districts and classroom teachers. The Nebraska Department of Education provides guidance related to high-quality instructional materials selection and implementation. Please visit the **Nebraska Instructional Materials Collaborative**.

In addition to a common structure for content area standards, a consistent numbering system is used for content area standards. The numbering system is as follows:



Content Area Standards Overview

Nebraska Revised Statute 79-760.01 requires the State Board of Education to adopt measurable academic content standards for the areas of reading, writing, mathematics, science, and social studies. Standards describe grade-level expectations for given content areas and provide a framework upon which Nebraska districts develop, establish, and implement curriculum. For effective teaching and learning to occur, the content area standards should drive local decisions related to instructional materials, resources, and interim, formative, and summative assessments.

The Nebraska Department of Education has identified quality criteria in the development of content area standards. These criteria ensure that standards are grounded in a strong research base of human cognition, motivation, and teaching and learning and describe essential knowledge and skills for college, career, and civic readiness. The revised science standards, written by teams of Nebraska educators and reviewed by local and national experts, were developed with the following indicators of quality:

Measurable: Standards provide benchmarks against which student progress toward learning goals can be measured.

Appropriately challenging: Standards must build in complexity so that by the end of grade 12, students are prepared for postsecondary education and the workforce.

Connected: Student learning is most effective when it connects knowledge and skills to related topics and authentic applications.

Clearly worded: Content area standards must effectively communicate what students should know and be able to do.

Scaffolded: Indicators in the Nebraska content area standards scaffold student learning by sequencing connected knowledge and skills across grades so that students build and deepen understanding and ability over time.

Specific: Specificity assures that the language used in standards and indicators is sufficiently detailed to be accurately interpreted by educators.

Organization and Structure of College and Career Ready Standards for Science (CCR-Science)

Nebraska's College and Career Ready Standards for Science (CCR-Science) are organized by grade level for grades K-8 and by grade span in high school. K-5 standards are organized to reflect the developmental nature of learning for elementary students and attend to the learning progressions that build foundational understandings of science. By the time students reach middle school (Grades 6-8), they build on this foundation in order to develop more sophisticated understandings of science concepts through high school. The topic progression for the CCR-Science standards is included in Appendix A: Topic Progression.

Within each grade level/span the standards are organized around topics, and each standard addresses one topic. Each CCR-Science standard begins with the common stem: "Gather, analyze, and communicate…" This stem highlights long-term learning goals associated with rigorous science standards and provides guidance for high quality classroom instruction. To facilitate high-quality instruction, students actively gather evidence from multiple sources related to the topics. Evidence is carefully analyzed in order to describe and explain natural phenomena, and then, students communicate their understanding of the content using a variety of tools and strategies. It is important to note that while topics are introduced in a spiraled model, they are connected, and deeper understanding at subsequent grade levels and spans requires foundational understanding of multiple topics.

The indicators reflect the three dimensions of science learning outlined in *A Framework for K-12 Science Education*[1]. Each CCR-Science indicator includes a disciplinary core idea, a crosscutting concept (underline), and a **science and engineering practice** (**bold**).

Disciplinary Core Ideas (DCI)

The disciplinary core ideas are the focused, limited set of science ideas identified in the Framework as necessary for ALL students throughout their education and beyond their K-12 school years to achieve scientific literacy. The limited number of disciplinary core ideas allows more time for students and teachers to engage in the science and engineering practices as they deeply explore science ideas. To allow students to continually build on and revise their knowledge and abilities, the disciplinary core ideas are built on developmental learning progressions (Appendix A).

Crosscutting Concepts (CCC)

The crosscutting concepts are used to organize and make sense of disciplinary core ideas. They serve as tools that bridge disciplinary boundaries and deepen understanding of science content. With grade-appropriate proficiency, students are expected to use patterns (cause and effect, scale, proportion, and quantity), systems and system models (energy and matter, structure and function) and stability and change as they gather, analyze, and communicate scientific understanding. These crosscutting concepts provide structure for synthesizing knowledge from various fields into a coherent and scientifically-based view of the world.

Science and Engineering Practices (SEP)

The science and engineering practices are used by students to demonstrate understanding of the disciplinary core ideas and crosscutting concepts. Engaging in the practices of science and engineering helps students understand the wide range of approaches used to investigate natural phenomena and develop solutions to challenges. Students are expected to demonstrate grade-appropriate proficiency in asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information as they gather, analyze, and communicate scientific information.

Each science indicator focuses on one crosscutting concept and one science and engineering practice as an example to guide assessment. Curriculum, instruction, and assessment should reflect authentic science practice and be phenomena-based. Furthermore, curriculum, instruction, and assessment should use crosscutting concepts and science and engineering practices that go beyond what is stated in the indicator to better reflect authentic science practice. Utilizing the range of SEPs and CCCs will support deeper learning and greater understanding of the DCIs.

The following table lists the disciplinary core ideas, crosscutting concepts, and **science and engineering practices**:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems	**LS1: From Molecules to Organisms: Structures and Processes**	**Patterns** **Cause and Effect**

Developing and Using Models Planning and Carrying Out Investigations Analyzing and Interpreting Data Using Mathematics and Computational Thinking Constructing Explanations and Designing Solutions Engaging in Argument from Evidence Obtaining, Evaluating, and Communicating Information	LS2: Ecosystems: Interactions, Energy, and Dynamics LS3: Heredity: Inheritance and Variation of Traits LS4: Biological Evolution: Unity & Diversity PS1: Matter and Its Interactions PS2: Motion and Stability: Forces and Interactions PS3: Energy PS4: Waves and Their Applications in Technologies for Information Transfer ESS1: Earth's Place in the Universe ESS2: Earth's Systems ESS3: Earth and Human Activity ETS1: Engineering Design	Scale, Proportion, and Quantity Systems and System Models Energy and Matter Structure and Function Stability and Change

[1] *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Washington, DC: The National Academies Press, 2012.

Icon Titles & Descriptions

Nebraska Connections

Opportunities to teach science using topics directly relevant to our state (e.g. Ogallala Aquifer, agriculture, Nebraska-specific flora and fauna, Nebraska's rich geologic history, etc.) are listed throughout the CCR-Science standards as "Nebraska Connections." These connections allow educators to use local, regional, and state-specific contexts for teaching, learning, and assessment. Educators should use these as recommendations for investigation with students. Additionally, assessment developers have the opportunity to use the Nebraska contexts to develop Nebraska-specific examples or scenarios from which students would demonstrate their general understanding. This approach provides the opportunity for educators to draw upon Nebraska's natural environment and rich history and resources in engineering design and scientific research to support student learning.

Educator Support & Resources

Implementation

Effective science teaching, learning, and assessments should integrate disciplinary core ideas, crosscutting concepts, and **science and engineering practices**. Integration of the three dimensions will allow students to explain scientific phenomena, engage in sensemaking, design solutions to problems, and build a foundation upon which they can continue to learn and be able to apply science knowledge and skills within and outside the K-12 education arena. While each indicator incorporates the three dimensions, this alone does not drive student outcomes. Ultimately, student learning depends on how the standards are translated to instructional practices.

To support educators while they explore and implement content standards, the Nebraska Department of Education has developed the **Content Area Standards Implementation Framework**. The Framework is based on implementation science and includes stages from "Exploration" to "Deep Implementation," the types of work and activities associated with each stage, and roles of educators in ensuring successful implementation. The goal of the framework is to guide the alignment of standards, instruction, materials, and assessment to create a coherent system of learning.

Phenomenon-based Instruction

Three-dimensional instruction offers authentic learning experiences when students engage in describing and explaining the natural world. This involves focusing the conceptual learning on anchoring and investigative phenomena to better comprehend their observations. Students utilize evidence in the sensemaking process to build concepts in their minds. Phenomena are natural, observable events that we can explain or predict using our science knowledge (the singular form of phenomena is phenomenon).

Teachers are encouraged to adopt phenomenon-based instruction to fully engage students in three-dimensional science learning. This method can be summarized in three steps:

Introduce a new unit or concept with a phenomenon: Start by presenting a phenomenon that is relevant to students' lives. This engages them in asking questions about their observations and fosters a desire to learn more. Many teachers already use this approach by introducing new units or concepts with tangible examples such as pictures, videos, demonstrations, or laboratory experiences.

Engaging in science and engineering practices: Provide opportunities for students to gather and reason about information to explain the phenomenon. Sensemaking represents a shift in science instruction where teachers refrain from giving students direct answers. Instead, they should offer multiple opportunities for students to explore the phenomenon individually and in groups, while scaffolding their learning. This approach supports students in developing an understanding of scientific concepts and constructing their own explanations for the phenomenon.

Communicating understanding: Ensure students have multiple opportunities to articulate their thinking about why the phenomenon occurs. To deepen their understanding, check that student explanations progress from simple descriptions of what they observe to more complex explanations and predictions of what they think is happening with the phenomenon.

Throughout this process, teachers should not provide direct answers about the phenomenon. Instead, they should facilitate experiences that help students reach an appropriate understanding. Often, this involves engaging students in scientific arguments where they challenge each other's claims and explanations using their observations and collected evidence.

Teacher Guides

The Teacher Guides were created to provide guidance for developing effective instruction aligned to Nebraska's College and Career Ready Science Standards. They are intended to support teachers, administrators, science specialists, ESU's, instructional coaches, parents, and other stakeholders as they plan instruction and assessment at a local level.

The Teacher Guides are meant as a resource document which unwraps the indicators to support teacher's understanding of the standards. They are not meant to be used by students, and therefore they are not written in student-friendly language.

Nebraska Science Classroom Formative Task Repository

The Nebraska Science Classroom Formative Task Repository is a collection of K-12 formative tasks aligned to the indicator level of the standards. Tasks were developed by Nebraska educators and cover the breadth of the standards giving students an opportunity to provide evidence of what they can know and can do related to that standard.

Graduation Requirements

The high school life science, physical science, and Earth and space science standards are intended for ALL students to have learned by the end of 30 credit hours of high school science courses.

Rule 10

003.05 Graduation Requirements. Each high school must require from grades nine through twelve at least 200 credit hours for graduation, for which at least 80 percent must be from the core curriculum. The number of credit hours given for a course may be less than the number of instructional units and may be increased up to 25 percent above the number of instructional units.

003.05A3 Science. Thirty credit hours of science with course content that includes biological, earth/space, and physical science concepts with corresponding science inquiry skills and laboratory experience.

Course examples that offer the scope and sequence to include all three domains are included in Appendix B: HS Integrated Science Course Model.

High School Plus Standards (HSP)

The High School Plus (HSP) standards represent advanced science topics designed to enhance the rigor of general science curricula or supplement additional advanced science courses. The standards were developed using postsecondary syllabi from entry level science courses for science majors (e.g. UNL LIFE 120, CHEM 109). Introducing the content to high school students will scaffold their learning providing a bridge between high school science coursework and postsecondary level coursework. If the indicator includes HSP, it is a plus standard which is supplemental.

Explanation of the Teacher's Guide to the Nebraska CCR-Science Standards

Standard

Standard Code [Content Area].[Grade Level].[Topic].[Standard]

The standard description is listed here to give broader context to this and other indicators in the standard. The standard description articulates the core ideas and theme. Standards represent significant areas of learning within grade-level progressions and content areas. Each standard introduction is an orientation for the teacher in order to provide an overall view of the concepts needed for foundational understanding.

Indicator

Indicator Code [Content Area].[Grade Level].[Topic].[Standard].[Indicator]

Within each standard are indicators. The indicator is listed here as found in the CCR-Science Standards. Indicators in the CCR-Science Standards are written as student performance expectations that describe what students must know and be able to do by the end of an instructional sequence. An indicator represents a proficiency level for that grade. An indicator articulates how a learner may demonstrate their proficiency, incorporating not only the disciplinary core idea but also a crosscutting concept and a science and engineering practice. While some indicators within a standard may be more comprehensive than others, all indicators are essential for a comprehensive understanding of a standard's purpose.

The DCIs will be in ordinary text. <u>The CCCs will be underlined.</u> **The SEPs will be in bold.** Indicators also include clarification statements and assessment boundaries when needed. Clarification statements offer further clarification to the indicators content or offer examples and are indicated with gray text. Assessment boundaries are the limitations given to the state-developed assessments and are indicated with red text.

NGSS Comparison: [NGSS Code]

The CCR-Science Standards are strongly influenced by the Next Generation Science Standards (NGSS). Teachers can use the NGSS code to find instructional resources. There are many resources that have been created that compare to each NGSS code. It is important to note that the NGSS codes use dashes and end in a number (e.g., 5-PS1-3), and the DCIs use dots and end in a letter (e.g., PS1.A).

Other Indicators in this Standard

Each standard requires all of the indicators to provide the full understanding of the concept knowledge, skills, and lenses needed to demonstrate proficiency for that standard. The indicators included in the standard will be listed here under their code.

Concepts and Skills to Master

Foundation Boxes:

The foundation boxes provide clarity for planning by explicitly and intentionally identifying the three dimensions found in the standard. Teachers should frame their planning around what students will be doing to demonstrate 3D learning. The table identifies the minimum level of complexity expected for proficiency in each of the three dimensions of a standard. Individual classroom instruction can and should use additional Science and Engineering Practices (SEPs) and Crosscutting Concepts (CCCs) to support student sense-making. The information in this table is based on research found in A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (NRC, 2012), adds specificity on how a standard should be interpreted and provides additional ideas of instructional practices related to the standard. The intent is to help the teacher move students into deeper and more focused use of the SEP, CCC, and DCI. The use of supporting SEPs and CCCs is an integral part of robust instruction. The purpose of supporting SEPs and CCCs are to allow multiple ways to approach knowledge, skills, and abilities. Teachers should use the focal SEPs and CCCs during instruction but may utilize supporting SEPs and CCCs to broaden instruction.

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
[Science and Engineering Practice Name]: • **The science and engineering practice(s) found in the indicator written in the context of the content (DCI).** • Students do and use the Science and Engineering Practice (SEP). Practices refer to the things that scientists and engineers do and how they actively engage in their work. This section provides more clarification for what students should be doing to engage in this practice. There are various ways that each practice can be used, as articulated in the K-12 Framework for Science Education (NRC, 2012). This information primarily comes from the NSTA's SEP Matrix.	**[Crosscutting Concept Name]:** • **The crosscutting concept(s) found in the indicator written in the context of the content (DCI).** • Students think and connect through the Crosscutting Concept (CCC) in order to reason. Crosscutting concepts provide a lens to focus student thinking in order to support students to make sense of science and engineering concepts to be able to explain phenomena. Teachers encourage students to frame their thinking around the terminology of the CCCs through questions and classroom discussions. This information primarily comes from the NSTA's CCC Matrix.
Disciplinary Core Idea (DCI)	
([DCI Code]): [DCI Name] • **Students know and apply the Disciplinary Core Idea (DCI) in their thinking and reasoning.** • These are the core ideas from the K-12 Framework for Science Education (NRC, 2012) that align to this standard. This section is NOT a checklist of content for students to memorize. The purpose of this section is to articulate what core ideas students should know and be able to use to support the explanation of phenomena. If a standard identifies multiple DCIs, this section will be repeated for each core idea. This information primarily comes from the K-12 Framework for Science Education.	
Possible Science and/or Engineering Phenomena to Support 3D Instruction	
In 3D classroom instruction, a real-world phenomenon centered around a scientific concept or engineering problem is used as the starting point for student learning. The phenomenon encourages students to ask questions, investigate, and ultimately construct explanations for why the phenomenon occurs. Each core guide lists potential phenomena that could be used during instruction. It is important for teachers to understand that the best phenomena are those that are relevant to the context of their students' lives and experiences. Phenomena are also a critical component of science assessment. When developing classroom assessments, teachers should select different phenomena than those used during standard instruction but require the use of the same concepts. This allows the assessment to measure student proficiency in each of the three dimensions through a novel situation rather than simply assessing students' ability to recall a previous classroom experience. This document provides a list of possible phenomena; however, teachers should not consider this list all-inclusive. Many appropriate phenomena could be used to investigate and assess each standard.	

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

This section provides statements that delineate what students should be able to know and do to demonstrate proficiency of an indicator. These statements can be used for learning goals, tasks, and assessments during the instructional sequence and should address how the three dimensions interact. These proficiency statements are not intended to be used as curriculum.

Critical Background Knowledge

Grade Band Progressions:

This section illustrates how the three dimensions of science, aligned specifically to an indicator, progress developmentally through grade bands and grade levels. Progressions provide insight into what background knowledge and experience students should have had in prior grades, where teachers should focus science learning in the current grade level, and where students will extend their learning in future grades. Grade band progressions identify where teachers should focus instruction for that grade level in each of the three dimensions. Additionally, progressions are intended to be used to identify areas for student intervention. By looking at previous grade bands, teachers can support students where they are currently and scaffold them to where they need to be by the end of the grade level. The progression table is not intended as a guide for supporting accelerated learning by looking to future grade bands. Accelerated learning should remain in the appropriate grade band, but students could be provided with more depth in their learning experience. This information primarily comes from the NGSS Appendices.

Science and Engineering Practices (SEPs): [SEP name]

The SEPs progress over a student's K-12 science experience. The SEP progressions inform teachers as to how students should be engaging in science and engineering practices. These progressions emphasize the importance of teaching science skills at every grade level because it cannot be assumed that students will develop proficiency in using science and engineering practices independently. With increased developmental ability, students can engage in these practices in more complex ways. Teachers can use the progressions to pre-assess student learning from previous grade bands, adjust instruction, and develop necessary interventions. The science and engineering practices should be addressed to an appropriate developmental level in every grade and science course. In each grade within a grade band, students should be progressing towards mastery of these expectations. Each row of the SEP table delineates a different component of the SEP and how it developmentally progresses.

K-2	3-5	6-8	9-12
[SEP name] in K–2 builds on prior experiences and progresses to ...	**[SEP name] in 3–5 builds on K–2 experiences and progresses to ...**	**[SEP name] in 6– 8 builds on K–5 experiences and progresses to...**	**[SEP name] in 9-12 builds on K–8 experiences and progresses to college or career experiences.**

Crosscutting Concepts (CCCs): [CCC name]

The CCCs progress over a student's K-12 science experience. These progressions inform teachers as to how students should frame their thinking and reasoning. These progressions emphasize the importance of teaching science at every grade level because it cannot be assumed that students will independently be able to use the CCCs to frame their thinking. With increased developmental ability, students will be able to use the crosscutting concepts to think and reason about more complex tasks and phenomena. Teachers can use the progressions to pre-assess student learning from previous grade bands, adjust instruction, and develop interventions as needed. The crosscutting concepts should be addressed to an appropriate developmental level in every grade and science course. In each grade within a grade band, students should be progressing towards mastery of these expectations.

K-2	3-5	6-8	9-12
[CCC name] in K–2 builds on prior experiences and progresses to ...	**[CCC name] in 3–5 builds on K–2 experiences and progresses to ...**	**[CCC name] in 6– 8 builds on K–5 experiences and progresses to...**	**[CCC name] in 9-12 builds on K–8 experiences and progresses to college or career experiences.**

Disciplinary Core Ideas (DCIs): [DCI code] [DCI title]

The core ideas progress over a student's K-12 science experience. These progressions inform teachers as to what core ideas the student should know and be able to use in this grade band. This progression emphasizes the importance of teaching science and engineering at every level because it cannot be assumed that students will develop science and engineering conceptual understanding independently. The core ideas build in complexity as students progress through grade bands. Thus, core ideas must be taught sequentially. Teachers can use the progressions to pre-assess student learning from previous grade bands, adjust instruction, and develop interventions as needed. Note: Most core ideas are taught, at minimum, once within a grade band and not necessarily in sequential grade levels. For example, the DCI PS1.A is taught in 2nd-grade, 5th-grade, 6th-grade, 8th-grade, and chemistry. To clarify this, the provided table identifies the grade and standard for which the DCI is taught in each grade band.

K-2	3-5	6-8	9-12
[NGSS DCI code] in K–2 builds on prior experiences and progresses to ...	**[NGSS DCI code] in 3–5 builds on K–2 experiences and progresses to ...**	**[NGSS DCI code] in 6– 8 builds on K–5 experiences and knowledge and progresses to...**	**[NGSS DCI code] in 9–12 builds on K–8 experiences and knowledge and progresses to...**

Connection to other grade level indicators

This section helps teachers identify potential integration with other indicators that have related disciplinary core ideas at the same grade level or band. When designing curriculum around an anchoring phenomenon and investigative phenomena, identifying how other DCIs relate is pivotal for student understanding of the phenomena and the indicators as significant areas of learning culminating in standards.

Related Cross-Curricular Standards: Current Grade Level

Authentic Connections to Other Content Standards:

This section helps teachers identify potential integration with other content area standards within their grade level. The expectation of the CCR-Science Standards is for all students to be scientifically literate. Scientists use literacy, mathematics, and critical thinking components for gathering, reasoning, and communicating information. In science, students use reading, writing, speaking, listening, and language in ways specific to the discipline of science. ISTE computer science standards are also included when appropriate.

Academic Language Development

Effective science instruction requires discipline-specific communication skills. This means that effective science learning occurs when students are expected to speak, listen, read, and write in ways that are appropriate to science. The tools in this section help teachers facilitate the acquisition of science discourse, which includes academic scientific language. Teaching words or concepts in isolation or prior to experiences that give context (frontloading) robs students of sense-making opportunities that lead to a greater depth of conceptual understanding.

Below is a list of words that students should use during science discourse. These words are not meant to be used as a vocabulary list or to frontload vocabulary prior to instruction. The teacher should introduce these words only after students have first experienced the related concept and used their own words to describe it.

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- Supporting discourse words will be listed here.

Supporting resources to aide in student discourse:

STEM Teaching Tool 48: How can teachers guide classroom conversations to support students' science learning?

STEM Teaching Tool 41: Prompts for Integrating Crosscutting Concepts Into Assessment and Instruction (Download the PDF for example prompts).

Assessment Considerations

Formative Assessment:

A link is provided to the Nebraska-created formative task repository sign-in on the Nebraska Department of Education's website. Exemplar assessments developed by Nebraska teachers are aligned to the indicator. Formative assessments are available for every standard, not every indicator, for grades K-8, and in the domains of physical science, earth science, and life science at the high school level.

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

"This website houses tools, information, and resources developed as part of the Stackable, Instructionally-embedded, Portable Science (SIPS) Assessments project funded for a 36-month period from 2020 through 2023 by a Competitive Grants for State Assessments Grant from the Office of Elementary and Secondary Education at the US Department of Education, awarded to the Nebraska Department of Education." https://sipsassessments.org/

The principled design process found on this website explains how NSCAS tasks and the formative task repository tasks are developed. The SCILLSS Digital Workbook on Designing High Quality Three-dimensional Science Assessments for Classroom Use are found in the "Resources" tab, then select the "Assessment Resources." There are curriculum, instruction, and assessment resources for fifth and eighth grade found in the "Resources" tab, then select "SIPS Resources."

Knowledge, Skills, and Abilities:

These are statements developed from the Evidence Statements when writing tasks that specify what is expected of students to demonstrate (i.e., knowledge, skills, and abilities) to provide evidence that they have learned one or more aspects of the CCR-Science Indicator. These are example broad statements that scaffold the logic of the concept and skill development.

Achievement Level Descriptors:

Achievement Level Descriptors are scaled evidence statements of the SEPs and CCCs combined by grade that are used in test score interpretation to determine if a student is performing in the categories of developing, on task, or advanced. Currently these statements are only available in fifth grade and eighth grade.

Life Science Teacher's Guide to the Nebraska CCR-Science Standards

Standard

Topic Code: SC.HS.6 Structure and Function

Standard Code: SC.HS.6.1 Gather, analyze, and communicate evidence of the relationship between structure and function in living things.

How do the structures of organisms enable life's functions? Students are expected to investigate explanations for the structure and function of cells as the basic units of life, the hierarchical systems of organisms, and the role of specialized cells for maintenance and growth. Students will demonstrate understanding of how systems of cells function together to support the life processes.

Indicator

Indicator Code: SC.HS.6.1.a

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 does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.

NGSS Comparison: HS-LS1-1

Other Indicators in this Standard

SC.HS.6.1.b, SC.HS.6.1.c, SC.HS.6.1.d

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Constructing Explanations and Designing Solutions: Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • 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.	**Structure and Function:** • 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.

Disciplinary Core Idea (DCI)
LS1.A: Structure and Function: • 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.9.4.A.)*
Possible Science and/or Engineering Phenomena to Support 3D Instruction
• Fur/skin color (https://learn.concord.org/cbio-deer-mouse) • Hemoglobin and Sickle Cell Disease • Mutations affecting protein function (e.g. Cystic Fibrosis) • Enzymatic function (substrate/active site binding errors due to changes in enzyme protein structure changes) • HHMI leukemia gene structure and function activity: BCR-ABL: Protein Structure and Function (biointeractive.org)

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.6.1.a 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.			
1	Articulating the explanation of phenomena		
	a	Students construct an explanation that includes the idea that regions of DNA called genes determine the structure of proteins, which carry out the essential functions of life through systems of specialized cells.	
2	Evidence		
	a	Students identify and describe* the evidence to construct their explanation, including that:	
		i.	All cells contain DNA;
		ii.	DNA contains regions that are called genes;
		iii.	The sequence of genes contains instructions that code for proteins; and
		iv.	Groups of specialized cells (tissues) use proteins to carry out functions essential to the organism.
	b	Students use a variety of valid and reliable sources for the evidence (e.g., theories, simulations, peer review, students' own investigations).	
3	Reasoning		
	a	Students use reasoning to connect evidence, along with 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, to construct the explanation. Students describe* the following chain of reasoning in their explanation:	
		i.	Because all cells contain DNA, all cells contain genes that can code for the formation of proteins.
		ii.	Body tissues are systems of specialized cells with similar structures and functions, each of whose functions are mainly carried out by the proteins they produce.
		iii.	Proper function of many proteins is necessary for the proper functioning of the cells.
		iv.	Gene sequence affects protein function, which in turn affects the function of body tissues.

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Constructing Explanations and Designing Solutions

K-2	3-5	6-8	9-12
Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.	Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. • Identify the evidence that supports particular points in an explanation.	Constructing explanations and designing solutions in 6–8 builds on K– 5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. • Construct an explanation using models or representations. • 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 explain real-world phenomena, examples, or events. • Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.	Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise 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. • Apply scientific ideas, principles, and/or evidence to explain phenomena and solve design problems, considering possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Crosscutting Concepts (CCCs): Structure and Function

K-2	3-5	6-8	9-12
In grades K-2, students observe the shape and stability of structures of natural and designed objects related to their function(s).	In grades 3-5, students learn different materials have different substructures, which can sometimes be observed; and substructures have shapes and parts that serve functions of natural and designed objects are related to their function(s).	In grades 6-8, students model complex and microscopic structures and systems and visualize how their function depends on the shapes, composition, and relationships among its parts. They analyze many complex natural and designed structures and systems to determine how they function. They design structures to serve functions by considering properties of different materials and how materials can be shaped and used.	In grades 9-12, students investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal the system's function and/or solve a problem. They infer the functions and properties of natural and designed objects and systems from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials.

Disciplinary Core Ideas (DCIs): LS1.A: Structure and Function

K-2	3-5	6-8	9-12
LS1.A: All organisms have external parts that they use to perform daily functions.	**LS1.A**: Organisms have both internal and external macroscopic structures that allow for growth, survival, behavior, and reproduction.	**LS1.A**: All living things are made up of cells. In organisms, cells work together to form tissues and organs that are specialized for particular body functions.	**LS1.A**: Systems of specialized cells within organisms help perform essential functions of life. Any one system in an organism is made up of numerous parts. Feedback mechanisms maintain an organism's internal conditions within certain limits and mediate behaviors.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics Connections:

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 3 Bundle 3 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
    - SC.HS.6.1.a, SC.HS.6.1.d, SC.HS.9.4.a, SC.HS.9.4.b, SC.HS.9.4.c, SC.HS.10.5.a, SC.HS.10.5.b
- NGSS Conceptual Progressions Bundle Course 2 Bundle 5 (https://nextgenscience.org/high-school-conceptual-progression-model-course-2)
    - SC.HS.6.1.a, SC.HS.9.4.a, SC.HS.9.4.b, SC.HS.9.4.c

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- structure, DNA, DNA replication, RNA, protein, nucleotide, amino acid, transcription, translation, protein synthesis, cell, nucleus, chromosome, gene, double helix, adenine, guanine, cytosine, thymine, deoxyribose, phosphate, hydrogen bond, base, ribosome, mRNA (messenger RNA)
- function, proportion, quantity, organelle, specialized, mitochondria, nerve cells, chloroplasts, ribosomes, cell, nucleus, cell membrane, cell wall, chromosome, neuron, pancreatic cells, muscle cell, skin cell, blood cell

Assessment Considerations

Formative Assessment:

- NDE Formative Task Repository (get password from nde.stateassessmentnebraska.gov)

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.6 Structure and Function
Standard Code: SC.HS.6.1 Gather, analyze, and communicate evidence of the relationship between structure and function in living things.

How do the structures of organisms enable life's functions? Students are expected to investigate explanations for the structure and function of cells as the basic units of life, the hierarchical systems of organisms, and the role of specialized cells for maintenance and growth. Students will demonstrate understanding of how systems of cells function together to support the life processes.

Indicator

Indicator Code: SC.HS.6.1.b

Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

Emphasis is on functions at the organism system level such as nutrient uptake or water delivery in plants or an organism's 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 does not include interactions and functions at the molecular or chemical reaction level.

NGSS Comparison: HS-LS1-2

Other Indicators in this Standard

SC.HS.6.1.a, SC.HS.6.1.c, SC.HS.6.1.d

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Developing and Using Models: Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world. • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**Systems and System Models:** • 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.

Disciplinary Core Idea (DCI)

LS1.A: Structure and Function:

- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- Malaria and Sickle Cell Disease (https://thewonderofscience.com/phenomenon/2018/7/5/malaria-and-sickle-cell-anemia)
- Runner's High (https://thewonderofscience.com/phenomenon/2018/7/9/runners-high)
- Duchenne Muscular Dystrophy
- Ears are structures with function (https://www.ngssphenomena.com/#/ears-are-structures-with-function/)
- Thorny Devil's Drink (https://www.ngssphenomena.com/thornydevilsdrink/)

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.6.1.b Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.		
1	Components of the model	
	a	Students develop a model in which they identify and describe* the relevant parts (e.g., organ system, organs, and their component tissues) and processes (e.g., transport of fluids, motion) of body systems in multicellular organisms.
2	Relationships	
	a	In the model, students describe* the relationships between components, including:

		i.	The functions of at least two major body systems in terms of contributions to overall function of an organism;
		ii.	Ways the functions of two different systems affect one another; and
		iii.	A system's function and how that relates both to the system's parts and to the overall function of the organism.
3	Connections		
	a	Students use the model to illustrate how the interaction between systems provides specific functions in multicellular organisms.	
	b	Students make a distinction between the accuracy of the model and actual body systems and functions it represents.	

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Developing and Using Models

K-2	3-5	6-8	9-12
Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. • Distinguish between a model and the actual object, process, and/or events the model represents. • Compare models to identify common features and differences. • Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). • Develop a simple model based on evidence to represent a proposed object or tool.	Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Identify limitations of models. • 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. • Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. • Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Evaluate limitations of a model for a proposed object or tool. • Develop or modify a model— based on evidence – to match what happens if a variable or component of a system is changed. • Use and/or develop a model of simple systems with uncertain and less predictable factors. • 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.	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena and move flexibly between model types based on merits and limitations.

		• Develop a model to describe unobservable mechanisms. • Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	• Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Crosscutting Concepts (CCCs): Systems and System Models

K-2	3-5	6-8	9-12
In grades K-2, students understand objects and organisms can be described in terms of their parts; and systems in the natural and designed world have parts that work together.	In grades 3-5, students understand that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. They can also describe a system in terms of its components and their interactions.	In grades 6-8, students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study.	In grades 9-12, students can investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They can use models (e.g., physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales. They can also use models and simulations to predict the behavior of a system and recognize that these predictions have limited precision and reliability due to the assumptions and approximations inherent in the models. They can also design systems to do specific tasks.

Disciplinary Core Ideas (DCIs): LS1.A: Structure and Function

K-2	3-5	6-8	9-12
LS1.A: All organisms have external parts that they use to perform daily functions.	**LS1.A**: Organisms have both internal and external macroscopic structures that allow for growth, survival, behavior, and reproduction.	**LS1.A**: All living things are made up of cells. In organisms, cells work together to form tissues and organs that are specialized for particular body functions.	**LS1.A**: Systems of specialized cells within organisms help perform essential functions of life. Any one system in an organism is made up of numerous parts. Feedback mechanisms maintain an organism's internal conditions within certain limits and mediate behaviors.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- SL.11-12.5: Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-LS1-2)

Mathematics Connections:

- [Indicator code]: Indicator description (from the teacher's guide or look in standards documents).

Social Studies Connections:

- [Indicator code]: Indicator description (from the teacher's guide or look in standards documents).

Fine and Performing Arts Connections:

- [Indicator code]: Indicator description (from the teacher's guide or look in standards documents).

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 3 Bundle 2 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
    - SC.HS.6.1.b, SC.HS.6.1.c, SC.HS.8.3.a, SC.HS.8.3.b SC.HS.8.3.c, SC.HS.8.3.d, SC.HS.8.3.f,
- NGSS Conceptual Progressions Bundle Course 2 Bundle 4 (https://nextgenscience.org/high-school-conceptual-progression-model-course-2)
    - SC.HS.6.1.b, SC.HS.6.4.c, SC.HS.6.1.d

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- Structure, function, organs, organ systems, levels of organization, organism, tissue, cells, homeostasis, immune system, endocrine system, nervous system, feedback, stimuli

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.6 Structure and Function

Standard Code: SC.HS.6.1 Gather, analyze, and communicate evidence of the relationship between structure and function in living things.

How do the structures of organisms enable life's functions? Students are expected to investigate explanations for the structure and function of cells as the basic units of life, the hierarchical systems of organisms, and the role of specialized cells for maintenance and growth. Students will demonstrate understanding of how systems of cells function together to support the life processes.

Indicator

Indicator Code: SC.HS.6.1.c

Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. 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 does not include the cellular processes involved in the feedback mechanism.

NGSS Comparison: HS-LS1-3

Other Indicators in this Standard

SC.HS.6.1.a, SC.HS.6.1.b, SC.HS.6.1.d

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Planning and Carrying Out Investigations: Planning and carrying out in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • 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. ***Connections to the nature of science*** **Scientific Investigations Use a Variety of Methods:** • Scientific inquiry is characterized by a common set of values that include logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.	**Stability and Change:** • Feedback (negative or positive) can stabilize or destabilize a system.

Disciplinary Core Idea (DCI)

LS1.A: Structure and Function:

- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- Runner's High (https://thewonderofscience.com/phenomenon/2018/7/9/runners-high)
- Why do Sunflowers Follow the Sun? (https://thewonderofscience.com/phenomenon/2018/6/15/why-do-sunflowers-follow-the-sun)
- Blood oxygen vs. Activity
- Shamrocks at night (https://www.youtube.com/watch?v=jBW11QzbkiQ&feature=youtu.be)

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.6.1.b	**Plan and conduct an investigation** to provide evidence that feedback mechanisms maintain homeostasis.		
1	Identifying the phenomenon under investigation		
	a	Students describe* the phenomenon under investigation, which includes the following idea: that feedback mechanisms maintain homeostasis.	
2	Identifying the evidence to answer this question		
	a	Students develop an investigation plan and describe* the data that will be collected and the evidence to be derived from the data, including:	
		i.	Changes within a chosen range in the external environment of a living system; and
		ii.	Responses of a living system that would stabilize and maintain the system's internal conditions (homeostasis), even though external conditions change, thus establishing the positive or negative feedback mechanism.
	b	Students describe* why the data will provide information relevant to the purpose of the investigation.	
3	Planning for the investigation		
	a	In the investigation plan, students describe*:	
		i.	How the change in the external environment is to be measured or identified;
		ii.	How the response of the living system will be measured or identified;
		iii.	How the stabilization or destabilization of the system's internal conditions will be measured or determined;
		iv.	The experimental procedure, the minimum number of different systems (and the factors that affect them) that would allow generalization of results, the evidence derived from the data, and identification of limitations on the precision of data to include types and amounts; and
		v.	Whether the investigation will be conducted individually or collaboratively.
4	Collecting the data		
	a	Students collect and record changes in the external environment and organism responses as a function of time.	
5	Refining the design		
	a	Students evaluate their investigation, including:	
		i.	Assessment of the accuracy and precision of the data, as well as limitations (e.g., cost, risk, time) of the investigation, and make suggestions for refinement; and
		ii.	Assessment of the ability of the data to provide the evidence required.
	b	If necessary, students refine the investigation plan to produce more generalizable data.	

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Planning and Carrying Out Investigations

K-2	3-5	6-8	9-12
Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • 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. • Evaluate different ways of observing and/or measuring a phenomenon to determine which way can answer a question. • Make observations (firsthand or from media) and/or measurements to collect data that can be used to make comparisons. • Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal. • Make predictions based on prior experiences.	Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K– 2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • 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. • Evaluate appropriate methods and/or tools for collecting data. Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. • Make predictions about what would happen if a variable changes. • Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success.	Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. • 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. • Evaluate the accuracy of various methods for collecting data. • Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. • Collect data about the performance of a proposed object, tool, process or system under a range of conditions.	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • 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. • Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. • Select appropriate tools to collect, record, analyze, and evaluate data. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables

Crosscutting Concepts (CCCs): Stability and Change

K-2	3-5	6-8	9-12
In grades K-2, students observe some things stay the same while other things change, and things may change slowly or rapidly.	In grades 3-5, students measure change in terms of differences over time and observe that change may occur at different rates. Students learn some systems appear stable, but over long periods of time they will eventually change.	In grades 6-8, students explain stability and change in natural or designed systems by examining changes over time, and considering forces at different scales, including the atomic scale. Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time.	In grades 9-12, students understand much of science deals with constructing explanations of how things change and how they remain stable. They quantify and model changes in systems over very short or very long periods of time. They see some changes are irreversible, and negative feedback can stabilize a system, while positive feedback can destabilize it. They recognize systems can be designed for greater or lesser stability.

Disciplinary Core Ideas (DCIs): LS1.A: Structure and Function

K-2	3-5	6-8	9-12
LS1.A: All organisms have external parts that they use to perform daily functions.	**LS1.A**: Organisms have both internal and external macroscopic structures that allow for growth, survival, behavior, and reproduction.	**LS1.A**: All living things are made up of cells. In organisms, cells work together to form tissues and organs that are specialized for particular body functions.	**LS1.A**: Systems of specialized cells within organisms help perform essential functions of life. Any one system in an organism is made up of numerous parts. Feedback mechanisms maintain an organism's internal conditions within certain limits and mediate behaviors.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- **WHST.9-12.7:** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- **WHST.11-12.8:** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Mathematics Connections:

- [Indicator code]: Indicator description (from the teacher's guide or look in standards documents).

Social Studies Connections:

- [Indicator code]: Indicator description (from the teacher's guide or look in standards documents).

Fine and Performing Arts Connections:

- [Indicator code]: Indicator description (from the teacher's guide or look in standards documents).

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 3 Bundle 3 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
    - SC.HS.6.1.b, SC.HS.6.1.c, SC.HS.8.3.a, SC.HS.8.3.b SC.HS.8.3.c, SC.HS.8.3.d, SC.HS.8.3.f,
- NGSS Conceptual Progressions Bundle Course 2 Bundle 4 (https://nextgenscience.org/high-school-conceptual-progression-model-course-2)
    - SC.HS.6.1.b, SC.HS.6.1.c, SC.HS.6.1.d

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- equilibrium, positive feedback, negative feedback, stimulus, response, input, output, fluctuation, external environment, internal environment

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.6 Structure and Function

Standard Code: SC.HS.6.1 Gather, analyze, and communicate evidence of the relationship between structure and function in living things.

How do the structures of organisms enable life's functions? Students are expected to investigate explanations for the structure and function of cells as the basic units of life, the hierarchical systems of organisms, and the role of specialized cells for maintenance and growth. Students will demonstrate understanding of how systems of cells function together to support the life processes.

Indicator

Indicator Code: SC.HS.6.1.d

Use a <u>model</u> <u>to illustrate the role</u> of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.

NGSS Comparison: HS-LS1-4

Other Indicators in this Standard

SC.HS.6.1.a, SC.HS.6.1.b, SC.HS.6.1.c

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Developing and Using Models: Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world. • Use a model based on evidence to illustrate the relationships between systems or between components of a system	**Systems and System Models:** • 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.

Disciplinary Core Idea (DCI)

[LS1.B](): **Growth and Development of Organisms:**

- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- Immortal Cells of Henrietta Lacks (https://thewonderofscience.com/phenomenon/2018/7/8/the-immortal-cells-of-henrietta-lacks)
- Adult Stem Cells and Body Maintenance
- Axolotls/Anole and Limb Regeneration
- HHMI Structure and function of telomeres: Structure and Function of Telomeres (biointeractive.org)

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.6.1.d **Use a model to illustrate the role** of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.			
1	Components of the model		
	a	From the given model, students identify and describe* the components of the model relevant for illustrating the role of mitosis and differentiation in producing and maintaining complex organisms, including:	
		i.	Genetic material containing two variants of each chromosome pair, one from each parent;
		ii.	Parent and daughter cells (i.e., inputs and outputs of mitosis); and
		iii.	A multi-cellular organism as a collection of differentiated cells.
2	Relationships		
	a	Students identify and describe* the relationships between components of the given model, including:	
		i.	Daughter cells receive identical genetic information from a parent cell or a fertilized egg.

		ii.	Mitotic cell division produces two genetically identical daughter cells from one parent cell.
		iii.	Differences between different cell types within a multicellular organism are due to gene expression — not different genetic material within that organism.
3	Connections		
	a	Students use the given model to illustrate that mitotic cell division results in more cells that:	
		i.	Allow growth of the organism;
		ii.	Can then differentiate to create different cell types; and
		iii.	Can replace dead cells to maintain a complex organism.
	b	Students make a distinction between the accuracy of the model and the actual process of cellular division.	

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Developing and Using Models

K-2	3-5	6-8	9-12
Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. • Distinguish between a model and the actual object, process, and/or events the model represents. • Compare models to identify common features and differences. • Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). • Develop a simple model based on evidence to represent a proposed object or tool.	Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Identify limitations of models. • 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. • Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Evaluate limitations of a model for a proposed object or tool. • Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed. • Use and/or develop a model of simple systems with uncertain and less predictable factors. • 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.	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena and move flexibly between model types based on merits and limitations.

	• Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.	• Develop a model to describe unobservable mechanisms. • Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	• Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Crosscutting Concepts (CCCs): Systems and System Models

K-2	3-5	6-8	9-12
In grades K-2, students understand objects and organisms can be described in terms of their parts; and systems in the natural and designed world have parts that work together.	In grades 3-5, students understand that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. They can also describe a system in terms of its components and their interactions.	In grades 6-8, students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study.	In grades 9-12, students can investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They can use models (e.g., physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales. They can also use models and simulations to predict the behavior of a system and recognize that these predictions have limited precision and reliability due to the assumptions and approximations inherent in the models. They can also design systems to do specific tasks.

Disciplinary Core Ideas (DCIs): LS1.B: Growth and Development of Organisms

K-2	3-5	6-8	9-12
LS1.B: Parents and offspring often engage in behaviors that help the offspring survive.	**LS1.B**: Reproduction is essential to every kind of organism. Organisms have unique and diverse life cycles.	**LS1.B**: Animals engage in behaviors that increase the odds of reproduction. An organism's growth is affected by both genetic and environmental factors.	**LS1.B**: Growth and division of cells in organisms occurs by mitosis and differentiation for specific cell types.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- SL.11-12.5: Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics Connections:

- MP.4: Model with mathematics.
- HSF-IF.C.7: Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
- HSF-BF.A.1: Write a function that describes a relationship between two quantities.

Social Studies Connections:

- [Indicator code]: Indicator description (from the teacher's guide or look in standards documents).

Fine and Performing Arts Connections:

- [Indicator code]: Indicator description (from the teacher's guide or look in standards documents).

Connection to other grade level indicator

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 3 Bundle 3 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
    - SC.HS.6.1.a, SC.HS.6.1.d, SC.HS.9.4.a, SC.HS.9.4.b, SC.HS.9.4.c, SC.HS.10.5.a, SC.HS.10.5.b
- NGSS Conceptual Progressions Bundle Course 2 Bundle 4 (https://nextgenscience.org/high-school-conceptual-progression-model-course-2)
    - SC.HS.6.1.b, SC.HS.6.4.c, SC.HS.6.1.d

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- mitosis, growth, maintenance, systems, cell cycle, DNA replication, chromosomes, multicellular, nucleus, daughter cell, parent cell, DNA, tissue, organ

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- **KSA 1**: Clearly define the components of the model that illustrate the role of mitosis and differentiation in maintaining a complex organism with genetic material that contains two variants of each chromosome pair, one from each parent.
- **KSA 2:** Clearly define the components of the model that illustrate the role of mitosis and differentiation in maintaining a complex organism that has both parent input and daughter output of cells.
- **KSA 3**: Clearly define the components of the model that illustrate the role of mitosis and differentiation in maintaining a multicellular organism as a collection of differentiated cells.
- **KSA 4**: Clearly define the relationships between components of the given model, including daughter cells that receive identical genetic information from a parent cell or a fertilized egg.
- **KSA 5**: Identify and describe the relationships between components of the given model including mitotic cell division produces two genetically identical daughter cells from one parent cell.

- **KSA 6**: Identify and describe the relationships between components of the given model including differences between different cell types within a multicellular organism which are due to gene expression — not different genetic material within that organism.
- **KSA 7**: Students use the given model to illustrate that mitotic cell division results in more cells that allow growth of the organism.
- **KSA 8**: Students use the given model to illustrate that mitotic cell division results in more cells that can then differentiate to create different cell types.
- **KSA 9:** Students use the given model to illustrate that mitotic cell division results in more cells that allow growth of the organism to replace dead cells to maintain a complex organism.
- **KSA 10:** Students make a distinction between the accuracy of the model and the actual process of cellular division.

Standard

Topic Code: SC.HS.7 Interdependent Relationships in Ecosystems

Standard Code: SC.HS.7.2 Gather, analyze, and communicate evidence of interdependent relationships in ecosystems.

How do organisms interact with the living and non-living environment to obtain matter and energy?
Students will be expected to investigate the role of biodiversity in ecosystems and the role of animal behavior on survival of individuals and species. Students will develop increased understanding of interactions among organisms and how those interactions influence the dynamics of ecosystems

Indicator

Indicator Code: SC.HS.7.2.a

Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales**.** 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 does not include deriving mathematical equations to make comparisons.

NGSS Comparison: HS-LS2-1

Other Indicators in this Standard

SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.7.2.e, SC.HS.7.2.f

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Using Mathematics and Computational Thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical and/or computational representations of phenomena or design solutions to support explanations.	**Scale, Proportion, and Quantity:** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

Disciplinary Core Idea (DCI)

LS2.A: **Interdependent Relationships in Ecosystems:**

- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction
• Phet simulation on ecosystem function: https://phet.colorado.edu/en/simulations/natural-selection • HHMI trophic cascade activity: Topic 2: Ecosystems & Ecology | HHMI BioInteractive • HHMI Serengeti tree modeling, ecosystem function: Topic 4: Ecology | HHMI BioInteractive

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.7.2.a Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

1	Representation		
	a	Students identify and describe* the components in the given mathematical and/or computational representations (e.g., trends, averages, histograms, graphs, spreadsheets) that are relevant to supporting given explanations of factors that affect carrying capacities of ecosystems at different scales. The components include:	
		i.	The population changes gathered from historical data or simulations of ecosystems at different scales; and
		ii.	Data on numbers and types of organisms as well as boundaries, resources, and climate.
	b	Students identify the given explanation(s) to be supported, which include the following ideas: Factors (including boundaries, resources, climate, and competition) affect carrying capacity of an ecosystem, and:	
		i.	Some factors have larger effects than do other factors.
		ii.	Factors are interrelated.
		iii.	The significance of a factor is dependent on the scale (e.g., a pond vs. an ocean) at which it occurs.
2	Mathematical and/or computational modeling		
	a	Students use given mathematical and/or computational representations (e.g., trends, averages, histograms, graphs, spreadsheets) of ecosystem factors to identify changes over time in the numbers and types of organisms in ecosystems of different scales.	
3	Analysis		
	a	Students analyze and use the given mathematical and/or computational representations	
		i.	To identify the interdependence of factors (both living and nonliving) and resulting effect on carrying capacity; and
		ii.	As evidence to support the explanation and identify the factors that have the largest effect on the carrying capacity of an ecosystem for a given population.

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Using Mathematics and Computational Thinking

K-2	3-5	6-8	9-12
Mathematical and computational thinking in K–2 builds on prior experience and progresses to recognizing that mathematics can	Mathematical and computational thinking in 3–5 builds on K–2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to	Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets	Mathematical and computational thinking in 9- 12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to

be used to describe the natural and designed world(s). • Decide when to use qualitative vs. quantitative data. • Use counting and numbers to identify and describe patterns in the natural and designed world(s). • Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs. • Use quantitative data to compare two alternatives.	analyze data and compare alternative design solutions. • Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success. • Organize simple data sets to reveal patterns that suggest relationships. • Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems. • Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem.	and using mathematical concepts to support explanations and arguments. • Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. • Use mathematical representations to describe and/or support scientific conclusions and design solutions. • Create algorithms (a series of ordered steps) to solve a problem. • Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems. • Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.	analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3 , acre-feet, etc.).

Crosscutting Concepts (CCCs): Scale, Proportion, and Quantity

K-2	3-5	6-8	9-12
In grades K-2, students use relative scales (e.g., bigger and smaller; hotter and colder; faster and slower) to describe objects.	In grades 3-5, students recognize natural objects, and observable phenomena exist from the very small to the immensely large. They use standard units to measure and describe	In grades 6-8, students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale. They use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information	In grades 9-12, students understand the significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. They recognize patterns observable at one scale may not be observable or exist at other scales, and some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Students use orders of magnitude to understand how a model at one scale relates to a model at another scale. They use algebraic

They use standard units to measure length	physical quantities such as weight, time, temperature, and volume	about the magnitude of properties and processes. They represent scientific relationships through algebraic expressions and equations.	thinking to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

Disciplinary Core Ideas (DCIs): LS2.A: Interdependent Relationships in Ecosystems

K-2	3-5	6-8	9-12
LS2.A: Plants depend on water and light to grow and on animals for pollination or to move their seeds around.	**LS2.A**: The food of almost any 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, while decomposers restore some materials back to the soil.	**LS2.A**: Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors, any of which can limit their growth. Competitive, predatory, and mutually beneficial interactions vary across ecosystems, but the patterns are shared.	**LS2.A**: Ecosystems have carrying capacities resulting from biotic and abiotic factors. The fundamental tension between resource availability and organism populations affects the abundance of species in any given ecosystem.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST.11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- WHST.9-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Mathematics Connections:

- MP.2: Reason abstractly and quantitatively.
- MP.4: Model with mathematics.
- HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 3 Bundle 5 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
    - SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.8.3.e, SC.HS.10.5.c, SC.HS.10.5.e

- NGSS Conceptual Progressions Bundle Course 3 Bundle 2 (https://nextgenscience.org/high-school-conceptual-progression-model-course-3)
    - SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.10.5.a, SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.d, SC.HS.10.5.e

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- Ecosystem, species, predatory/prey interaction, parasitism, commensalism, herbivore, carnivore, omnivore, trophic level, population size, environmental factors
- abiotic, biotic, carrying capacity, stability, biodiversity, population, predation, abundance, disturbance, equilibrium, fluctuation, climate change, generation, limiting resources, limiting factors, competition, feedback, population control, trends, extinction, pollution, deforestation, sustainable, symbiosis, density

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.7 Interdependent Relationships in Ecosystems

Standard Code: SC.HS.7.2 Gather, analyze, and communicate evidence of interdependent relationships in ecosystems.

How do organisms interact with the living and non-living environment to obtain matter and energy?
Students will be expected to investigate the role of biodiversity in ecosystems and the role of animal behavior on survival of individuals and species. Students will develop increased understanding of interactions among organisms and how those interactions influence the dynamics of ecosystems

Indicator

Indicator Code: SC.HS.7.2.b

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

NGSS Comparison: HS-LS2-2

Other Indicators in this Standard

SC.HS.7.2.a, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.7.2.e, SC.HS.7.2.f

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Using Mathematics and Computational Thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena or design solutions to support and revise explanations. ***Connections to the nature of science*** **Scientific Knowledge is Open to Revision in Light of New Evidence:** • Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.	**Scale, Proportion, and Quantity:** • Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

Disciplinary Core Idea (DCI)

LS2.A: Interdependent Relationships in Ecosystems:

- 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:

- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- Phet simulation on ecosystem function: https://phet.colorado.edu/en/simulations/natural-selection
- HHMI trophic cascade activity: Topic 2: Ecosystems & Ecology | HHMI BioInteractive
- HHMI Serengeti tree modeling, ecosystem function: Topic 4: Ecology | HHMI BioInteractive

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.7.2.b	**Use mathematical representations** to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.	
1	Representation	
	a	Students identify and describe* the components in the given mathematical representations (which include trends, averages, and graphs of the number of organisms per unit of area in a stable system) that are relevant to supporting and revising the given explanations about factors affecting biodiversity and ecosystems, including:

		i.	Data on numbers and types of organisms are represented.
		ii.	Interactions between ecosystems at different scales are represented.
	b	Students identify the given explanation(s) to be supported of factors affecting biodiversity and population levels, which include the following ideas:	
		i.	The populations and number of organisms in ecosystems vary as a function of the physical and biological dynamics of the ecosystem.
		ii.	The response of an ecosystem to a small change might not significantly affect populations, whereas the response to a large change can have a large effect on populations that then feeds back to the ecosystem at a range of scales.
		iii.	Ecosystems can exist in the same location on a variety of scales (e.g., plants and animals vs. microbes), and these populations can interact in ways that significantly change these ecosystems (e.g., interactions among microbes, plants, and animals can be an important factor in the resources available to both a microscopic and macroscopic ecosystem).
2	Mathematical Modeling		
	a	Students use the given mathematical representations (including trends, averages, and graphs) of factors affecting biodiversity and ecosystems to identify changes over time in the numbers and types of organisms in ecosystems of different scales.	
3	Analysis		
	a	Students use the analysis of the given mathematical representations of factors affecting biodiversity and ecosystems	
		i.	To identify the most important factors that determine biodiversity and population numbers of an ecosystem.
		ii.	As evidence to support explanation(s) for the effects of both living and nonliving factors on biodiversity and population size, as well as the interactions of ecosystems on different scales.
		iii.	To describe* how, in the model, factors affecting ecosystems at one scale can cause observable changes in ecosystems at a different scale.
	b	Students describe* the given mathematical representations in terms of their ability to support explanation(s) for the effects of modest to extreme disturbances on an ecosystems' capacity to return to original status or become a different ecosystem.	
4	Revision		
	a	Students revise the explanation(s) based on new evidence about any factors that affect biodiversity and populations (e.g., data illustrating the effect of a disturbance within the ecosystem).	

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Using Mathematics and Computational Thinking

K-2	3-5	6-8	9-12
Mathematical and computational thinking in K–2 builds on prior experience and progresses to recognizing that mathematics can be used to describe the natural and designed world(s). • Decide when to use qualitative vs. quantitative data. • Use counting and numbers to identify and	Mathematical and computational thinking in 3–5 builds on K–2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions. • Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success.	Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. • Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. • Use mathematical representations to describe and/or support scientific conclusions and design solutions.	Mathematical and computational thinking in 9- 12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

describe patterns in the natural and designed world(s). • Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs. • Use quantitative data to compare two alternatives.	• Organize simple data sets to reveal patterns that suggest relationships. • Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems. • Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem.	• Create algorithms (a series of ordered steps) to solve a problem. • Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems. • Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.	• Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3 , acre-feet, etc.).

Crosscutting Concepts (CCCs): Scale, Proportion, and Quantity

K-2	3-5	6-8	9-12
In grades K-2, students use relative scales (e.g., bigger and smaller; hotter and colder; faster and slower) to describe objects. They use standard units to measure length	In grades 3-5, students recognize natural objects, and observable phenomena exist from the very small to the immensely large. They use standard units to measure and describe physical quantities such as weight, time, temperature, and volume	In grades 6-8, students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale. They use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes. They represent scientific relationships through algebraic expressions and equations.	In grades 9-12, students understand the significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. They recognize patterns observable at one scale may not be observable or exist at other scales, and some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Students use orders of magnitude to understand how a model at one scale relates to a model at another scale. They use algebraic thinking to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

Disciplinary Core Ideas (DCIs): LS2.A: Interdependent Relationships in Ecosystems, LS2.C: Ecosystem Dynamics, Functioning, and Resilience

K-2	3-5	6-8	9-12
LS2.A: Plants depend on water and light to grow and depend on animals for pollination or to move their seeds around. **LS2.C**: N/A	**LS2.A**: The food of almost any 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, while decomposers restore some materials back to the soil. **LS2.C**: When the environment changes some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die.	LS2.A: **LS2.A**: Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors, any of which can limit their growth. Competitive, predatory, and mutually beneficial interactions vary across ecosystems, but the patterns are shared. **LS2.C**: Ecosystem characteristics vary over time. Disruptions to any part of an ecosystem can lead to shifts in all its populations. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.	**LS2.A**: Ecosystems have carrying capacities resulting from biotic and abiotic factors. The fundamental tension between resource availability and organism populations affects the abundance of species in any given ecosystem. **LS2.C**: If a biological or physical disturbance to an ecosystem occurs, including one induced by human activity, the ecosystem may return to its more or less original state or become a very different ecosystem, depending on the complex set of interactions within the ecosystem.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST.11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- WHST.9-12.2:Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Mathematics Connections:

- MP.2: Reason abstractly and quantitatively.
- MP.4: Model with mathematics.
- HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Social Studies Connections

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 3 Bundle 5 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
  - SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.8.3.e, SC.HS.10.5.c, SC.HS.10.5.e
- NGSS Conceptual Progressions Bundle Course 3 Bundle 2 (https://nextgenscience.org/high-school-conceptual-progression-model-course-3)

- SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.10.5.a, SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.d, SC.HS.10.5.e

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- Scale, proportion, quantity, magnitude, arithmetic growth, geometric growth, ratio, algebra, exponential growth or decline
- Resource limits, population growth rate, death rate, immigration/emigration rate
- Disruption, disturbance, abiotic factor, biotic factor
- Producer, consumer, predator, prey, parasite
- abiotic, biotic, carrying capacity, stability, biodiversity, population, predation, abundance, disturbance, equilibrium, fluctuation, climate change, generation, limiting resources, limiting factors, competition, feedback, population control, trends, extinction, pollution, deforestation, sustainable, symbiosis, density

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- **KSA 1:** Students will identify and describe how ecosystems can exist in the same location on a variety of scales (e.g., plants and animals vs. microbes)
- **KSA 2**: Students will use mathematical representations to identify and describe how various organisms interact with one another, affecting biodiversity and populations.
- **KSA 3:** Students will use mathematical representations to identify and describe how 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.
- **KSA 4:** Students will use mathematical representations to identify and describe how modest biological or physical disturbances to ecosystems may result in very little disruption in the ecosystem, as opposed to becoming a very different ecosystem (i.e. ecosystem resilience).
- **KSA 5:** Students will use mathematical representations to identify and describe how extreme fluctuations in conditions or the size of any population can challenge the functioning of ecosystems in terms of resources and habitat availability.
- **KSA 6**: Students will revise an explanation to show that the response of an ecosystem to changes at different scales with the ecosystem can be directly or indirectly related, depending on the feedback loop.

Standard

Topic Code: SC.HS.7 Interdependent Relationships in Ecosystems

Standard Code: SC.HS.7.2 Gather, analyze, and communicate evidence of interdependent relationships in ecosystems.

How do organisms interact with the living and non-living environment to obtain matter and energy?
Students will be expected to investigate the role of biodiversity in ecosystems and the role of animal behavior on survival of individuals and species. Students will develop increased understanding of interactions among organisms and how those interactions influence the dynamics of ecosystems

Indicator

Indicator Code: SC.HS.7.2.c

Evaluate the claims, evidence, and reasoning that the interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. 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.

NGSS Comparison: HS-LS2-6

Other Indicators in this Standard

SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.d, SC.HS.7.2.e, SC.HS.7.2.f

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)

Engaging in Argument from Evidence:
Engaging in argument from evidence in 9–12 builds from K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

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

Connections to the nature of science

Scientific Knowledge is Open to Revision in Light of New Evidence:

- Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.

Crosscutting Concept (CCC)

Stability and Change:

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

Disciplinary Core Idea (DCI)

LS2.C: **Ecosystem Dynamics, Functioning, and Resilience:**

- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- HHMI population dynamics simulation: Population Dynamics (biointeractive.org)

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.7.2.c Evaluate the claims, evidence, and reasoning that the interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

1	Identifying the given explanation and the supporting claims, evidence, and reasoning.	
	a	Students identify the given explanation that is supported by the claims, evidence, and reasoning to be evaluated, and which includes the following idea: 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.
	b	From the given materials, students identify:
		i. The given claims to be evaluated;
		ii. The given evidence to be evaluated; and
		iii. The given reasoning to be evaluated.
2	Identifying any potential additional evidence that is relevant to the evaluation	
	a	Students identify and describe* additional evidence (in the form of data, information, or other appropriate forms) that was not provided but is relevant to the explanation and to evaluating the given claims, evidence, and reasoning:
		i. The factors that affect biodiversity;
		ii. The relationships between species and the physical environment in an ecosystem; and
		iii. Changes in the numbers of species and organisms in an ecosystem that has been subject to a modest or extreme change in ecosystem conditions.
3	Evaluating and critiquing	
	a	Students describe* the strengths and weaknesses of the given claim in accurately explaining a particular response of biodiversity to a changing condition, based on an understanding of the factors that affect biodiversity and the relationships between species and the physical environment in an ecosystem.
	b	Students use their additional evidence to assess the validity and reliability of the given evidence and its ability to support the argument that resiliency of an ecosystem is subject to the degree of change in the biological and physical environment of an ecosystem.
	c	Students assess the logic of the reasoning, including the relationship between degree of change and stability in ecosystems, and the utility of the reasoning in supporting the explanation of how:
		i. Modest biological or physical disturbances in an ecosystem result in maintenance of relatively consistent numbers and types of organisms.
		ii. Extreme fluctuations in conditions or the size of any population can challenge the functioning of ecosystems in terms of resources and habitat availability and can even result in a new ecosystem.

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Engaging in Argument from Evidence

K-2	3-5	6-8	9-12
Engaging in argument from evidence in K–2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s).	Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).	Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).	Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

• 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. • Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument. • Construct an argument with evidence to support a claim. • Make a claim about the effectiveness of an object, tool, or solution supported by relevant evidence.	• 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. • Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions. • Construct and/or support an argument with evidence, data, and/or a model. • Use data to evaluate claims about cause and effect. • 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.	• Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. • Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. • 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. • 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 the technology meets relevant criteria and constraints. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	• Compare and evaluate competing arguments or design solutions based on accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. • Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions. • Construct, use, and/or present an oral and written argument or counterarguments based on data and evidence. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations)

Crosscutting Concepts (CCCs): Stability and Change

K-2	3-5	6-8	9-12
In grades K-2, students observe some things stay the same while other	In grades 3-5, students measure change in terms of differences over time and observe that change may occur at different rates. Students	In grades 6-8, students explain stability and change in natural or designed systems by examining changes over time, and considering forces at different scales, including the atomic scale. Students learn changes in	In grades 9-12, students understand much of science deals with constructing explanations of how things change and how they remain stable. They quantify and model changes in systems over very short or very

things change, and things may change slowly or rapidly.	learn some systems appear stable, but over long periods of time they will eventually change.	one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time	long periods of time. They see some changes are irreversible, and negative feedback can stabilize a system, while positive feedback can destabilize it. They recognize systems can be designed for greater or lesser stability.

Disciplinary Core Ideas (DCIs): LS2.C: Ecosystem Dynamics, Functioning, and Resilience

K-2	3-5	6-8	9-12
LS2.C: N/A	**LS2.C**: When the environment changes some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die.	**LS2.C**: Ecosystem characteristics vary over time. Disruptions to any part of an ecosystem can lead to shifts in all of its populations. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.	**LS2.C**: If a biological or physical disturbance to an ecosystem occurs, including one induced by human activity, the ecosystem may return to its more or less original state or become a very different ecosystem, depending on the complex set of interactions within the ecosystem.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST.9-10.8: Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
- RST.11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- RST.11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
- RST.11-12.8: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Mathematics Connections:

- MP.2: Reason abstractly and quantitatively.
- HSS-ID.A.1: Represent data with plots on the real number line.
- HSS-IC.A.1: Understand statistics as a process for making inferences about population parameters based on a random sample from that population. HSS-IC.B.6: Evaluate reports based on data.

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 3 Bundle 5 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
  - SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.8.3.e, SC.HS.10.5.c, SC.HS.10.5.e
- NGSS Conceptual Progressions Bundle Course 3 Bundle 2 (https://nextgenscience.org/high-school-conceptual-progression-model-course-3)
  - SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.10.5.a, SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.d, SC.HS.10.5.e

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- Population growth, population decline, fitness, disturbance, positive feedback, negative feedback, stability, dynamic equilibrium
- Argument, claims, evidence, counter-argument, ideas, models, questions, scientific knowledge, experimental data
- solution, human impact, environment, biodiversity, criteria, constraints, iterative, optimize, pollution, deforestation, invasive species, carrying capacity, ecosystems, climate, extinction, conservation

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.7 Interdependent Relationships in Ecosystems
Standard Code: SC.HS.7.2 Gather, analyze, and communicate evidence of interdependent relationships in ecosystems.

How do organisms interact with the living and non-living environment to obtain matter and energy?
Students will be expected to investigate the role of biodiversity in ecosystems and the role of animal behavior on survival of individuals and species. Students will develop increased understanding of interactions among organisms and how those interactions influence the dynamics of ecosystems

Indicator

Indicator Code: SC.HS.7.2.d

Evaluate the evidence for how group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. 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.

NGSS Comparison: HS-LS2-8

Other Indicators in this Standard

SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.e, SC.HS.7.2.f

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Engaging in Argument from Evidence: Engaging in argument from evidence in 9–12 builds from K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. ***Connections to the nature of science*** **Scientific Knowledge is Open to Revision in Light of New Evidence:** • Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.	**Cause and Effect:** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Disciplinary Core Idea (DCI)

LS2.D: Social Interactions and Group Behavior:

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

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- PHET natural selection simulation: Natural Selection - Mutation | Genetics | Selection - PhET Interactive Simulations (colorado.edu)

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.7.2.d	**Evaluate the evidence** for how group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.	
1	Identifying the given explanation and the supporting evidence	
	a	Students identify the given explanation that is supported by the evidence to be evaluated, and which includes the following idea: Group behavior can increase the chances for an individual and a species to survive and reproduce.
	b	Students identify the given evidence to be evaluated.
2	Identifying any potential additional evidence that is relevant to the evaluation	

	a	Students identify additional evidence (in the form of data, information, or other appropriate forms) that was not provided but is relevant to the explanation and to evaluating the given evidence, and which includes evidence for causal relationships between specific group behaviors (e.g., flocking, schooling, herding, cooperative hunting, migrating, swarming) and individual survival and reproduction rates.
3	Evaluating and critiquing	
	a	Students use their additional evidence to assess the validity, reliability, strengths, and weaknesses of the given evidence along with its ability to support logical and reasonable arguments about the outcomes of group behavior.
	b	Students evaluate the given evidence for the degree to which it supports a causal claim that group behavior can have a survival advantage for some species, including how the evidence allows for distinguishing between causal and correlational relationships, and how it supports cause and effect relationships between various kinds of group behavior and individual survival rates (for example, the relationship between moving in a group and individual survival rates, compared to the survival rate of individuals of the same species moving alone or outside of the group).

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Engaging in Argument from Evidence

K-2	3-5	6-8	9-12
Engaging in argument from evidence in K–2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s). 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. • Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument. • Construct an argument with evidence to support a claim.	Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • 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. • Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions. • Construct and/or support an argument with evidence, data, and/or a model.	Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. • Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. • Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support	Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Compare and evaluate competing arguments or design solutions based on accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. • Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

• Make a claim about the effectiveness of an object, tool, or solution supported by relevant evidence.	• Use data to evaluate claims about cause and effect. • 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.	or refute an explanation or a model for a phenomenon or a solution to a problem. • 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 the technology meets relevant criteria and constraints. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	• Construct, use, and/or present an oral and written argument or counterarguments based on data and evidence. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations)

Crosscutting Concepts (CCCs): Cause and Effect

K-2	3-5	6-8	9-12
In grades K-2, students learn that events have causes that generate observable patterns. They design simple tests to gather evidence to support or refute their own ideas about causes.	In grades 3-5, students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationship.	In grades 6-8, students classify relationships as causal or correlational and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.	In grades 9-12, students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.

Disciplinary Core Ideas (DCIs): LS2.D: Social Interactions and Group Behavior

K-2	3-5	6-8	9-12

LS2.D: N/A	LS2.D: Being part of a group helps animals obtain food, defend themselves, and cope with changes.	LS2.D: N/A	LS2.D: Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST.9-10.8: Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
- RST.11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- RST.11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
- RST.11-12.8: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Mathematics Connections:

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 3 Bundle 5 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
    - SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.8.3.e, SC.HS.10.5.c, SC.HS.10.5.e
- NGSS Conceptual Progressions Bundle Course 3 Bundle 2 (https://nextgenscience.org/high-school-conceptual-progression-model-course-3)
    - SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.10.5.a, SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.d, SC.HS.10.5.e

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- Group, individual, selection, kin, intraspecific, interspecific, group behavior, survival chance/life table
- Empirical evidence, cause/effect, bias, natural system, designed system, spatial scale, temporal scale

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

Standard

Topic Code: SC.HS.7 Interdependent Relationships in Ecosystems

Standard Code: SC.HS.7.2 Gather, analyze, and communicate evidence of interdependent relationships in ecosystems.

How do organisms interact with the living and non-living environment to obtain matter and energy?
Students will be expected to investigate the role of biodiversity in ecosystems and the role of animal behavior on survival of individuals and species. Students will develop increased understanding of interactions among organisms and how those interactions influence the dynamics of ecosystems

Indicator

Indicator Code: SC.HS.7.2.e

Design, evaluate, and refine a solution for increasing the positive impacts of human activities on the environment and biodiversity. Examples of human activities can include habitat development and restoration, supporting native pollinators, reducing consumption, rotating crops, and using integrated pest management. Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.

NGSS Comparison: HS-LS2-7 (modified)

Other Indicators in this Standard

SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.7.2.f

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Constructing Explanations and Designing Solutions: Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**Stability and Change:** • Much of science deals with constructing explanations of how things change and how they remain stable.

Disciplinary Core Idea (DCI)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience:

- 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:

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary to HS.7.2.E)*

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- Virtual Biology lab Connell's barnacle ecosystem simulation: Barnacle Competition - Virtual Biology Lab

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.7.2.e Design, evaluate, and refine a solution for increasing the positive impacts of human activities on the environment and biodiversity.		
1	Using scientific knowledge to generate the design solution	
	a	Students design a solution that involves reducing the negative effects of human activities on the environment and biodiversity, and that relies on scientific knowledge of the factors affecting changes and stability in biodiversity. Examples of factors include but are not limited to:
		i. Overpopulation;
		ii. Overexploitation;
		iii. Habitat destruction;
		iv. Pollution;
		v. Introduction of invasive species; and
		vi. Changes in climate.
	b	Students describe* the ways the proposed solution decreases the negative effects of human activity on the environment and biodiversity.
2	Describing criteria and constraints, including quantification when appropriate	
	a	Students describe* and quantify (when appropriate) the criteria (amount of reduction of impacts and human activities to be mitigated) and constraints (for example, cost, human needs, and environmental impacts) for the solution to the problem, along with the tradeoffs in the solution.
3	Evaluating potential solutions	
	a	Students evaluate the proposed solution for its impact on overall environmental stability and changes.
	b	Students evaluate the cost, safety, and reliability, as well as social, cultural, and environmental impacts, of the proposed solution for a select human activity that is harmful to an ecosystem.
4	Refining and/or optimizing the design solution	
	a	Students refine the proposed solution by prioritizing the criteria and making tradeoffs as necessary to further reduce environmental impact and loss of biodiversity while addressing human needs.

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Constructing Explanations and Designing Solutions

K-2	3-5	6-8	9-12
Constructing explanations and designing solutions in K–2 builds on prior experiences	Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and	Constructing explanations and designing solutions in 6–8 builds on K– 5 experiences and progresses to include constructing explanations and designing solutions	Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are

and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. • 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.	progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. • Identify the evidence that supports particular points in an explanation. • 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.	supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. • Construct an explanation using models or representations. • 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. • Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. • 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.	supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise 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. • Apply scientific ideas, principles, and/or evidence to explain phenomena and solve design problems, considering possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Crosscutting Concepts (CCCs): Stability and Change

K-2	3-5	6-8	9-12
In grades K-2, students observe some things stay the same while other things change, and things may change slowly or rapidly.	In grades 3-5, students measure change in terms of differences over time and observe that change may occur at different rates. Students learn some systems appear stable, but over long periods of time they will eventually change.	In grades 6-8, students explain stability and change in natural or designed systems by examining changes over time, and considering forces at different scales, including the atomic scale. Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time	In grades 9-12, students understand much of science deals with constructing explanations of how things change and how they remain stable. They quantify and model changes in systems over very short or very long periods of time. They see some changes are irreversible, and negative feedback can stabilize a system, while positive feedback can destabilize it. They recognize systems can be designed for greater or lesser stability.

Disciplinary Core Ideas (DCIs):

K-2	3-5	6-8	9-12
LS2.C: N/A **LS4.D**: A range of different organisms live in different places.	**LS2.C**: When the environment changes some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die **LS4.D**: Populations of organisms live in a variety of habitats. Change in those habitats affects the organisms living there.	**LS2.C**: Ecosystem characteristics vary over time. Disruptions to any part of an ecosystem can lead to shifts in all its populations. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. **LS4.D**: Changes in biodiversity can influence humans' resources and ecosystem services they rely on.	**LS2.C**: If a biological or physical disturbance to an ecosystem occurs, including one induced by human activity, the ecosystem may return to its original state or become a very different ecosystem, depending on the complex set of interactions within the ecosystem. **LS4.D**: Biodiversity is increased by formation of new species and reduced by extinction. Humans depend on biodiversity but also have adverse impacts on it. Sustaining biodiversity is essential to supporting life on Earth.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST.9-10.8: Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
- RST.11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
- RST.11-12.8: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
- WHST.9-12.7: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Mathematics Connections:

- MP.2: Reason abstractly and quantitatively.
- HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
- HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 3 Bundle 6 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
  - SC.HS.7.2.e, SC.HS.7.2.f, SC.HS.15.5.a, SC.HS.15.5.c, SC.HS.15.5.d, SC.HS.10.5.c, SC.HS.10.5.e
- NGSS Conceptual Progressions Bundle Course 3 Bundle 3 (https://nextgenscience.org/high-school-conceptual-progression-model-course-3)
  - SC.HS.7.2.e, SC.HS.7.2.f, SC.HS.14.4.d, SC.HS.15.5.b, SC.HS.15.5.d, SC.HS.15.5.f,
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Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- Stability, long-term, short-term, disturbance, disruption, sensitivity, resilience, anthropogenic
- Quantitative, qualitative, logical explanation, evidence, prediction
- solution, human impact, environment, biodiversity, criteria, constraints, iterative, optimize, pollution, deforestation, invasive species, carrying capacity, ecosystems, climate, extinction, conservation

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.7 Interdependent Relationships in Ecosystems

Standard Code: SC.HS.7.2 Gather, analyze, and communicate evidence of interdependent relationships in ecosystems.

How do organisms interact with the living and non-living environment to obtain matter and energy?
Students will be expected to investigate the role of biodiversity in ecosystems and the role of animal behavior on survival of individuals and species. Students will develop increased understanding of interactions among organisms and how those interactions influence the dynamics of ecosystems

Indicator

Indicator Code: SC.HS.7.2.f

Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. Assessment is limited to testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.

NGSS Comparison: HS-LS4-6, HS-ETS1-4

Other Indicators in this Standard

SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.7.2.e

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Using Mathematics and Computational Thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create or revise a simulation of a phenomenon, designed device, process, or system. • Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.	**Cause and Effect:** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Systems and System Models:** • 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.

Disciplinary Core Idea (DCI)
LS4.C: Adaptation: • 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:

- 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.

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 to HS.7.2.F)*
- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- HHMI Biome viewer including endangered species in all places: BiomeViewer (biointeractive.org)
- Quantifying biodiversity with Simpon's index: Quantifying_Biodiversity.docx (live.com)

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.7.2.f	**Use a computer simulation** to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.		
1	Representation		
	a	Students create or revise a simulation that:	
		i.	Models effects of human activity (e.g., overpopulation, overexploitation, adverse habitat alterations, pollution, invasive species, changes in climate) on a threatened or endangered species or to the genetic variation within a species; and
		ii.	Provides quantitative information about the effect of the solutions on threatened or endangered species.
	b	Students describe* the components that are modeled by the computational simulation, including human activity (e.g., overpopulation, overexploitation, adverse habitat alterations, pollution, invasive species, changes in climate) and the factors that affect biodiversity.	
	c	Students describe* the variables that can be changed by the user to evaluate the proposed solutions, tradeoffs, or other decisions.	
2	Computational modeling		
	a	Students use logical and realistic inputs for the simulation that show an understanding of the reliance of ecosystem function and productivity on biodiversity, and that take into account the constraints of cost, safety, and reliability as well as cultural, and environmental impacts.	
	b	Students use the simulation to identify possible negative consequences of solutions that would outweigh their benefits.	
3	Analysis		
	a	Students compare the simulation results to expected results.	
	b	Students analyze the simulation results to determine whether the simulation provides sufficient information to evaluate the solution.	
	c	Students identify the simulation's limitations.	
	d	Students interpret the simulation results and predict the effects of the specific design solutions on biodiversity based on the interpretation.	
4	Revision		
	a	Students revise the simulation as needed to provide sufficient information to evaluate the solution.	

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Using Mathematics and Computational Thinking

K-2	3-5	6-8	9-12
Mathematical and computational thinking in K–2 builds on prior experience and progresses to recognizing that mathematics can be used to describe the natural and designed world(s). • Decide when to use qualitative vs. quantitative data. • Use counting and numbers to identify and describe patterns in the natural and designed world(s). • Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs. • Use quantitative data to compare two alternatives	Mathematical and computational thinking in 3–5 builds on K–2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions. • Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success. • Organize simple data sets to reveal patterns that suggest relationships. • Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems. • Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem.	Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. • Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. • Use mathematical representations to describe and/or support scientific conclusions and design solutions. • Create algorithms (a series of ordered steps) to solve a problem. • Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems. • Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.	Mathematical and computational thinking in 9- 12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Crosscutting Concepts (CCCs): Cause and Effect, Systems and System Models

K-2	3-5	6-8	9-12
In grades K-2, students learn that events have causes that generate observable patterns. They design simple tests to gather evidence to support or refute their own ideas about causes. In grades K-2, students understand objects and organisms can be described in terms of their parts; and systems in the natural and designed world have parts that work together.	In grades 3-5, students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationship. In grades 3-5, students understand that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. They can also describe a system in terms of its components and their interactions.	In grades 6-8, students classify relationships as causal or correlational and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. In grades 6-8, students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study.	In grades 9-12, students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects. In grades 9-12, students can investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They can use models (e.g., physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales. They can also use models and simulations to predict the behavior of a system and recognize that these predictions have limited precision and reliability due to the assumptions and approximations inherent in the models. They can also design systems to do specific tasks.

Disciplinary Core Ideas (DCIs): LS4.C: Adaptation, LS4.D: Biodiversity and Humans, ETS1.B: Developing Possible Solutions

K-2	3-5	6-8	9-12
LS4.C: N/A	**LS4.C**: Particular organisms can only survive in particular environments.	**LS4.C**: Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common.	**LS4.C**: Evolution results primarily from genetic variation of individuals in a species, competition for resources, and proliferation of organisms better able to survive and reproduce. Adaptation means that the distribution of traits in a population, as well as species

LS4.D: A range of different organisms live in different places. **ETS1.B**: Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.	**LS4.D**: Populations of organisms live in a variety of habitats. Change in those habitats affects the organisms living there. **ETS1.B**: Support an argument that the alignment of an object's shape to the function it is supposed to fulfill can be used to predict its function and evaluate its effectiveness.	**LS4.D**: Changes in biodiversity can influence humans' resources and ecosystem services they rely on. **ETS1.B**: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.	expansion, emergence or extinction, can change when conditions change. **LS4.D**: Biodiversity is increased by formation of new species and reduced by extinction. Humans depend on biodiversity but also have adverse impacts on it. Sustaining biodiversity is essential to supporting life on Earth. **ETS1.B**: Design a Solution - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- WHST.9-12.5: Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS4-6)
- WHST.9-12.7: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS4-6)

Mathematics Connections:

- MP.2: Reason abstractly and quantitatively. (HS-ETS1-4)
- MP.4: Model with mathematics. (HS-ETS1-4)

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 3 Bundle 6 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
  - SC.HS.7.2.e, SC.HS.7.2.f, SC.HS.15.5.a, SC.HS.15.5.c, SC.HS.15.5.d, SC.HS.10.5.c, SC.HS.10.5.e
- NGSS Conceptual Progressions Bundle Course 3 Bundle 3 (https://nextgenscience.org/high-school-conceptual-progression-model-course-3)
  - SC.HS.7.2.e, SC.HS.7.2.f, SC.HS.14.4.d, SC.HS.15.5.b, SC.HS.15.5.d, SC.HS.15.5.f,

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- Cause and effect, assumption (mathematical), approximation, spatial scale, temporal scale
- Exponential growth and reduction, subsystems, algorithms, algebra

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.8 Matter and Energy in Organisms and Ecosystems

Standard Code: SC.HS.8.3 Gather, analyze, and communicate evidence of the flow of energy and cycling of matter in organisms and ecosystems.

How do organisms obtain and use energy they need to live and grow? How do matter and energy move through ecosystems? Students will be expected to develop understanding of organisms' interactions with each other and their physical environment, how organisms obtain resources, change the environment, and how these changes affect both organisms and ecosystems. Students will use mathematical concepts to construct explanations for the role of energy in the cycling of matter in organisms and ecosystems.

Indicator

Indicator Code: SC.HS.8.3.a

Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models. Assessment does not include specific biochemical steps.

NGSS Comparison: HS-LS1-5

Other Indicators in this Standard

SC.HS.8.3.b, SC.HS.8.3.c, SC.HS.8.3.d, SC.HS.8.3.e, SC.HS.8.3.f

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Developing and Using Models: Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Use a model based on evidence to illustrate the relationships between systems or between components of a system.	**Energy and Matter:** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Disciplinary Core Idea (DCI)

LS1.C: Organization for Matter and Energy Flow in Organisms:

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- HHMI photosynthesis simulation: Photosynthesis (biointeractive.org)
- Algae fuel and food

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.8.3.a Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.			
1	Components of the model		
	a	From the given model, students identify and describe* the components of the model relevant for illustrating that photosynthesis transforms light energy into stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen, including:	
		i.	Energy in the form of light;
		ii.	Breaking of chemical bonds to absorb energy;
		iii.	Formation of chemical bonds to release energy; and
		iv.	Matter in the form of carbon dioxide, water, sugar, and oxygen.
2	Relationships		
	a	Students identify the following relationship between components of the given model: Sugar and oxygen are produced by carbon dioxide and water by the process of photosynthesis.	
3	Connections		
	c	Students use the given model to illustrate:	
		i.	The transfer of matter and flow of energy between the organism and its environment during photosynthesis; and
		ii.	Photosynthesis as resulting in the storage of energy in the difference between the energies of the chemical bonds of the inputs (carbon dioxide and water) and outputs (sugar and oxygen).

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Developing and Using Models

K-2	3-5	6-8	9-12
Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. Distinguish between a model and the actual object, process, and/or events the model represents. • Compare models to identify common features and differences. • Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller),	Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Identify limitations of models. • Develop and/or use models to describe and/or predict phenomena. • Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Evaluate limitations of a model for a proposed object or tool. • Develop or modify a model— based on evidence – to match what happens if a variable or component of a system is changed. • Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena

and/or patterns in the natural and designed world(s).		• Develop and/or use a model to predict and/or describe phenomena. • Develop a model to describe unobservable mechanisms.	and move flexibly between model types based on merits and limitations. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Crosscutting Concepts (CCCs): Energy and Matter

K-2	3-5	6-8	9-12
In grades K-2, students observe objects may break into smaller pieces, be put together into larger pieces, or change shapes.	In grades 3-5, students learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change.	In grades 6-8, students learn matter is conserved because atoms are conserved in physical and chemical processes. They also learn 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.	In grades 9-12, students learn that the total amount of energy and matter in closed systems is conserved. They can describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Disciplinary Core Ideas (DCIs): LS1.C: Organization for Matter and Energy Flow in Organisms

K-2	3-5	6-8	9-12
LS1.C: Animals obtain food they need from plants or other animals.	**LS1.C**: Food provides animals with the materials and energy they need for body repair, growth, warmth, and motion. Plants acquire material for growth chiefly from air, water, and process matter and obtain	**LS1.C**: Plants use the energy from light to make sugars through photosynthesis. Within individual organisms, food is broken down	**LS1.C**: The hydrocarbon backbones of sugars produced through photosynthesis are used to make amino acids and other molecules that can be assembled into proteins or DNA. Through cellular respiration, matter and energy flow through different organizational levels of an

Plants need water and light.	energy from sunlight, which is used to maintain conditions necessary for survival.	through a series of chemical reactions that rearrange molecules and release energy.	organism as elements are recombined to form different products and transfer energy.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- SL.11-12.5: Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics Connections:

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 1 Bundle 4 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
  - SC.HS.6.1.b, SC.HS.6.1.c, SC.HS.8.3.a, SC.HS.8.3.b SC.HS.8.3.c, SC.HS.8.3.d, SC.HS.8.3.f,
- NGSS Conceptual Progressions Bundle Course 1 Bundle 4 (https://nextgenscience.org/high-school-conceptual-progression-model-course-1)
  - SC.HS.5.5.b, SC.HS.5.5.c, SC.HS.5.5.f, SC.HS.4.4.e, SC.HS.8.3.a

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- Matter, hydrocarbon, energy, energy flow, chemical reactions, cellular respiration, photosynthesis, carbohydrate, protein, DNA, lipid

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.8 Matter and Energy in Organisms and Ecosystems
Standard Code: SC.HS.8.3 Gather, analyze, and communicate evidence of the flow of energy and cycling of matter in organisms and ecosystems.

How do organisms obtain and use energy they need to live and grow? How do matter and energy move through ecosystems? Students will be expected to develop understanding of organisms' interactions with each other and their physical environment, how organisms obtain resources, change the environment, and how these changes affect both organisms and ecosystems. Students will use mathematical concepts to construct explanations for the role of energy in the cycling of matter in organisms and ecosystems.

Indicator

Indicator Code: SC.HS.8.3.b

Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other molecules to form the four basic macromolecules. Emphasis is on using evidence from models and simulations to support explanations. Assessment does not include the details of the specific chemical reactions or identification of macromolecules.

NGSS Comparison: HS-LS1-6 (modified)

Other Indicators in this Standard

SC.HS.8.3.a, SC.HS.8.3.c, SC.HS.8.3.d, SC.HS.8.3.e, SC.HS.8.3.f

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Constructing Explanations and Designing Solutions: Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise 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.	**Energy and Matter:** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Disciplinary Core Idea (DCI)

LS1.C: **Organization for Matter and Energy Flow in Organisms:**

- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.

- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- HHMI energy flow simulation: Energy Flow through Ecosystems
- If We Are What We Eat, Americans Are Corn and Soy

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.8.3.b Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other molecules to form the four basic macromolecules.			
1	Articulating the explanation of phenomena		
	a	Students construct an explanation that includes:	
		iii.	The relationship between the carbon, hydrogen, and oxygen atoms from sugar molecules formed in or ingested by an organism and those same atoms found in amino acids and other large carbon-based molecules; and
		iv.	That larger carbon-based molecules and amino acids can be a result of chemical reactions between sugar molecules (or their component atoms) and other atoms.
2	Evidence		
	a	Students identify and describe* the evidence to construct the explanation, including:	
		iv.	All organisms take in matter (allowing growth and maintenance) and rearrange the atoms in chemical reactions.
		v.	Cellular respiration involves chemical reactions between sugar molecules and other molecules in which energy is released that can be used to drive other chemical reactions.
		vi.	Sugar molecules are composed of carbon, oxygen, and hydrogen atoms.
		vii.	Amino acids and other complex carbon-based molecules are composed largely of carbon, oxygen, and hydrogen atoms.
		viii.	Chemical reactions can create products that are more complex than the reactants.
		ix.	Chemical reactions involve changes in the energies of the molecules involved in the reaction.
	b	Students use a variety of valid and reliable sources for the evidence (e.g., theories, simulations, students' own investigations).	
3	Reasoning		
	a	Students use reasoning to connect the evidence, along with 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, to construct the explanation that atoms from sugar molecules may combine with other elements via chemical reactions to form other large carbon-based molecules. Students describe* the following chain of reasoning for their explanation:	
		iii.	The atoms in sugar molecules can provide most of the atoms that comprise amino acids and other complex carbon-based molecules.
		iv.	The energy released in respiration can be used to drive chemical reactions between sugars and other substances, and the products of those reactions can include amino acids and other complex carbon-based molecules.
		v.	The matter flows in cellular processes are the result of the rearrangement of primarily the atoms in sugar molecules because those are the molecules whose reactions release the energy needed for cell processes.
4	Revising the explanation		
	a	Given new evidence or context, students revise or expand their explanation about the relationships between atoms in sugar molecules and atoms in large carbon-based molecules and justify their revision.	

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Constructing Explanations and Designing Solutions

K-2	3-5	6-8	9-12
Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. • 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.	Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. • Identify the evidence that supports particular points in an explanation. • 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.	Constructing explanations and designing solutions in 6–8 builds on K– 5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. • Construct an explanation using models or representations. • 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. • Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. • 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.	Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise 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. • Apply scientific ideas, principles, and/or evidence to explain phenomena and solve design problems, considering possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Crosscutting Concepts (CCCs): Energy and Matter

K-2	3-5	6-8	9-12
In grades K-2, students observe objects may break into smaller pieces, be put together into larger pieces, or change shapes.	In grades 3-5, students learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change.	In grades 6-8, students learn matter is conserved because atoms are conserved in physical and chemical processes. They also learn 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.	In grades 9-12, students learn that the total amount of energy and matter in closed systems is conserved. They can describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Disciplinary Core Ideas (DCIs): LS1.C: Organization for Matter and Energy Flow in Organisms

K-2	3-5	6-8	9-12
LS1.C: Animals obtain food they need from plants or other animals. Plants need water and light.	**LS1.C**: Food provides animals with the materials and energy they need for body repair, growth, warmth, and motion. Plants acquire material for growth chiefly from air, water, and process matter and obtain energy from sunlight, which is used to maintain conditions necessary for survival.	**LS1.C**: Plants use the energy from light to make sugars through photosynthesis. Within individual organisms, food is broken down through a series of chemical reactions that rearrange molecules and release energy.	**LS1.C**: The hydrocarbon backbones of sugars produced through photosynthesis are used to make amino acids and other molecules that can be assembled into proteins or DNA. Through cellular respiration, matter and energy flow through different organizational levels of an organism as elements are recombined to form different products and transfer energy.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST.11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- WHST.9-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-12.5: Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

- WHST.9-12.9: Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics Connections:

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 1 Bundle 4 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
  - SC.HS.6.1.b, SC.HS.6.1.c, SC.HS.8.3.a, SC.HS.8.3.b SC.HS.8.3.c, SC.HS.8.3.d, SC.HS.8.3.f,
- NGSS Conceptual Progressions Bundle Course 2 Bundle 3 (https://nextgenscience.org/high-school-conceptual-progression-model-course-2)
  - SC.HS.2.2.d, SC.HS.8.3.b, SC.HS.8.3.c, SC.HS.SC.HS.4.4.a, SC.HS.4.4.c,

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- Energy, hydrocarbon, sugar, energy storage, energy transfer, metabolism, anabolism, catabolism, cellular respiration, organizational levels

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.8 Matter and Energy in Organisms and Ecosystems

Standard Code: SC.HS.8.3 Gather, analyze, and communicate evidence of the flow of energy and cycling of matter in organisms and ecosystems.

How do organisms obtain and use energy they need to live and grow? How do matter and energy move through ecosystems? Students will be expected to develop understanding of organisms' interactions with each other and their physical environment, how organisms obtain resources, change the environment, and how these changes affect both organisms and ecosystems. Students will use mathematical concepts to construct explanations for the role of energy in the cycling of matter in organisms and ecosystems.

Indicator

Indicator Code: SC.HS.8.3.c

Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules are broken and bonds in new compounds are formed resulting in a net transfer of energy. Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration. Assessment should not include identification of the steps or specific processes involved in cellular respiration.

NGSS Comparison: HS-LS1-7

Other Indicators in this Standard

SC.HS.8.3.a, SC.HS.8.3.b, SC.HS.8.3.d, SC.HS.8.3.e, SC.HS.8.3.f

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Developing and Using Models: Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Use a model based on evidence to illustrate the relationships between systems or between components of a system.	**Energy and Matter:** • Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.

Disciplinary Core Idea (DCI)

LS1.C: Organization for Matter and Energy Flow in Organisms:

- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken, and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- 12 Years in a Sealed Ecosphere
- Farming Fish with Vegetables
- Algae Fuel and Food
- Vegetable Oil as Fuel
- Biosphere 2
- Reconstructing Ancient Diets with Isotopes

- If We Are What We Eat, Americans Are Corn and Soy

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.8.3.c Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules are broken and bonds in new compounds are formed resulting in a net transfer of energy.

1	Components of the model		
	a	From a given model, students identify and describe* the components of the model relevant for their illustration of cellular respiration, including:	
		i.	Matter in the form of food molecules, oxygen, and the products of their reaction (e.g., water and CO_2);
		ii.	The breaking and formation of chemical bonds; and
		iii.	Energy from chemical reactions.
2	Relationships		
	a	From the given model, students describe* the relationships between components, including:	
		i.	Carbon dioxide and water are produced from sugar and oxygen by the process of cellular respiration; and
		ii.	The process of cellular respiration releases energy because the energy released when the bonds that are formed in CO_2 and water is greater than the energy required to break the bonds of sugar and oxygen.
3	Connections		
	a	Students use the given model to illustrate that:	
		i.	The chemical reaction of oxygen and food molecules releases energy as the matter is rearranged, existing chemical bonds are broken, and new chemical bonds are formed, but matter and energy are neither created nor destroyed.
		ii.	Food molecules and oxygen transfer energy to the cell to sustain life's processes, including the maintenance of body temperature despite ongoing energy transfer to the surrounding environment.

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Developing and Using Models

K-2	3-5	6-8	9-12
Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. Distinguish between a model and the actual object, process, and/or events the model represents.	Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Identify limitations of models. • Develop and/or use models to describe and/or predict phenomena.	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Evaluate limitations of a model for a proposed object or tool. • Develop or modify a model— based on evidence – to match what happens if a variable or component of a system is changed.	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or

• Compare models to identify common features and differences. • Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).	• Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.	• 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.	predict phenomena and move flexibly between model types based on merits and limitations. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Crosscutting Concepts (CCCs): Energy and Matter

K-2	3-5	6-8	9-12
In grades K-2, students observe objects may break into smaller pieces, be put together into larger pieces, or change shapes.	In grades 3-5, students learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change.	In grades 6-8, students learn matter is conserved because atoms are conserved in physical and chemical processes. They also learn 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.	In grades 9-12, students learn that the total amount of energy and matter in closed systems is conserved. They can describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Disciplinary Core Ideas (DCIs): LS1.C: Organization for Matter and Energy Flow in Organisms

K-2	3-5	6-8	9-12
LS1.C: Animals obtain food they need from plants or other animals.	LS1.C: Food provides animals with the materials and energy they need for body repair, growth, warmth, and motion. Plants acquire material for growth chiefly from air, water, and process matter and obtain energy	LS1.C: Plants use the energy from light to make sugars through photosynthesis. Within individual organisms, food is broken down through a series of chemical	LS1.C: The hydrocarbon backbones of sugars produced through photosynthesis are used to make amino acids and other molecules that can be assembled into proteins or DNA. Through cellular respiration, matter and energy flow through different organizational levels of an organism as

Plants need water and light.	from sunlight, which is used to maintain conditions necessary for survival.	reactions that rearrange molecules and release energy.	elements are recombined to form different products and transfer energy.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics Connections:

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 1 Bundle 4 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
  - SC.HS.6.1.b, SC.HS.6.1.c, SC.HS.8.3.a, SC.HS.8.3.b SC.HS.8.3.c, SC.HS.8.3.d, SC.HS.8.3.f,
- NGSS Conceptual Progressions Bundle Course 2 Bundle 3 (https://nextgenscience.org/high-school-conceptual-progression-model-course-2)
  - SC.HS.2.2.d, SC.HS.8.3.b, SC.HS.8.3.c, SC.HS.8.3.d, SC.HS.8.3.f

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- Photosynthesis, energy, energy transfer, carbon backbone, metabolism, cellular metabolism, protein, DNA

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.8 Matter and Energy in Organisms and Ecosystems
Standard Code: SC.HS.8.3 Gather, analyze, and communicate evidence of the flow of energy and cycling of matter in organisms and ecosystems.

How do organisms obtain and use energy they need to live and grow? How do matter and energy move through ecosystems? Students will be expected to develop understanding of organisms' interactions with each other and their physical environment, how organisms obtain resources, change the environment, and how these changes affect both organisms and ecosystems. Students will use mathematical concepts to construct explanations for the role of energy in the cycling of matter in organisms and ecosystems.

Indicator

Indicator Code: SC.HS.8.3.d

Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments. Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.

NGSS Comparison: HS-LS2-3

Other Indicators in this Standard

SC.HS.8.3.a, SC.HS.8.3.b, SC.HS.8.3.c, SC.HS.8.3.e, SC.HS.8.3.f

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Constructing Explanations and Designing Solutions: Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise 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. ***Connections to the nature of science*** **Scientific Knowledge is Open to Revision in Light of New Evidence:** • Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.	**Energy and Matter:** • Energy drives the cycling of matter within and between systems.

Disciplinary Core Idea (DCI)
LS2.B: Cycles of Matter and Energy Transfer in Ecosystems: • Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
Possible Science and/or Engineering Phenomena to Support 3D Instruction
• 50 Year old sealed ecosphere • 12 Years in a Sealed Ecosphere • Farming Fish with Vegetables • Attack of the Killer Fungi • Biosphere 2 • Reconstructing Ancient Diets with Isotopes • If We Are What We Eat, Americans Are Corn and Soy

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.8.3.d	**Construct and revise an explanation** based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.		
1	Articulating the explanation of phenomena		
	a	Students construct an explanation that includes that:	
		i.	Energy from photosynthesis and respiration drives the cycling of matter and flow of energy under aerobic or anaerobic conditions within an ecosystem.
		ii.	Anaerobic respiration occurs primarily in conditions where oxygen is not available.
2	Evidence		
	a	Students identify and describe* the evidence to construct the explanation, including:	
		i.	All organisms take in matter and rearrange the atoms in chemical reactions.
		ii.	Photosynthesis captures energy in sunlight to create chemical products that can be used as food in cellular respiration.
		iii.	Cellular respiration is the process by which the matter in food (sugars, fats) reacts chemically with other compounds, rearranging the matter to release energy that is used by the cell for essential life processes.
	b	Students use a variety of valid and reliable sources for the evidence, which may include theories, simulations, peer review, and students' own investigations.	
3	Reasoning		
	a	Students use reasoning to connect evidence, along with 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, to construct their explanation. Students describe* the following chain of reasoning used to construct their explanation:	
		i.	Energy inputs to cells occur either by photosynthesis or by taking in food.
		ii.	Since all cells engage in cellular respiration, they must all produce products of respiration.
		iii.	The flow of matter into and out of cells must therefore be driven by the energy captured by photosynthesis or obtained by taking in food and released by respiration.
		iv.	The flow of matter and energy must occur whether respiration is aerobic or anaerobic.
4	Revising the explanation		
	a	Given new data or information, students revise their explanation and justify the revision (e.g., recent discoveries of life surrounding deep sea ocean vents have shown that photosynthesis is not the only driver for cycling matter and energy in ecosystems).	

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Constructing Explanations and Designing Solutions

K-2	3-5	6-8	9-12
Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. • 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.	Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. • Identify the evidence that supports particular points in an explanation. • 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.	Constructing explanations and designing solutions in 6–8 builds on K– 5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. • Construct an explanation using models or representations. • 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. • Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. • 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.	Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise 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. • Apply scientific ideas, principles, and/or evidence to explain phenomena and solve design problems, considering possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Crosscutting Concepts (CCCs): Energy and Matter

K-2	3-5	6-8	9-12
In grades K-2, students observe objects may break into smaller pieces, be put together into larger pieces, or change shapes.	In grades 3-5, students learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change.	In grades 6-8, students learn matter is conserved because atoms are conserved in physical and chemical processes. They also learn 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.	In grades 9-12, students learn that the total amount of energy and matter in closed systems is conserved. They can describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Disciplinary Core Ideas (DCIs): LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

K-2	3-5	6-8	9-12
LS2.B: [Content found in LS1.C and ESS3.A]: - LS1.C: Animals obtain food they need from plants or other animals. Plants need water and light. - ESS3.A: 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.	**LS2.B:** Matter cycles between the air and soil and among organisms as they live and die.	**LS2.B:** The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. Food webs model how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem.	**LS2.B:** Photosynthesis and cellular respiration provide most of the energy for life processes. Only a fraction of matter consumed at the lower level of a food web is transferred up, resulting in fewer organisms at higher levels. At each link in ecosystem elements are combined in different ways and matter and energy are conserved. Photosynthesis and cellular respiration are key components of the global carbon cycle.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Mathematics Connections:

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 1 Bundle 4 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
  - SC.HS.6.1.b, SC.HS.6.1.c, SC.HS.8.3.a, SC.HS.8.3.b SC.HS.8.3.c, SC.HS.8.3.d, SC.HS.8.3.f,
- NGSS Conceptual Progressions Bundle Course 2 Bundle 3 (https://nextgenscience.org/high-school-conceptual-progression-model-course-2)
  - SC.HS.2.2.d, SC.HS.8.3.b, SC.HS.8.3.c, SC.HS.8.3.d, SC.HS.8.3.f

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- Matter cycling, food chain, food web, producer, consumer, decomposers, trophic level, conservation of energy, conservation of matter, carbon cycle

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- **KSA1**: Students construct an explanation that includes that energy from photosynthesis and respiration drives the cycling of matter and flow of energy under aerobic or anaerobic conditions within an ecosystem.
- **KSA2:** Students identify and describe the evidence to construct the explanation, including: i. All organisms take in matter and rearrange the atoms in chemical reactions. ii. Photosynthesis captures energy in sunlight to create chemical products that can be used as food in cellular respiration. iii. Cellular respiration is the process by which energy is released from food to provide the energy that is used by the cell for essential life processes.
- **KSA3**: Students use reasoning to connect evidence, along with 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, to construct their explanation.
- **KSA4:** Students describe how the flow of energy and matter in and out of a system leads to the following chain of reasoning and use it to construct their explanation:

- Energy inputs to cells occur either by photosynthesis or by taking in food.
    - Since all cells engage in cellular respiration, they must all produce products of respiration.
    - The flow of matter into and out of cells must therefore be driven by the energy captured by photosynthesis or obtained by taking in food and released by respiration.
    - The flow of matter and energy must occur whether respiration is aerobic or anaerobic.
- **KSA5:** Given new data or information, students revise their explanation and justify the revision (e.g., recent discoveries of life surrounding deep sea ocean vents have shown that photosynthesis is not the only driver for cycling matter and energy in ecosystems).

Standard

Topic Code: SC.HS.8 Matter and Energy in Organisms and Ecosystems
Standard Code: SC.HS.8.3 Gather, analyze, and communicate evidence of the flow of energy and cycling of matter in organisms and ecosystems.

How do organisms obtain and use energy they need to live and grow? How do matter and energy move through ecosystems? Students will be expected to develop understanding of organisms' interactions with each other and their physical environment, how organisms obtain resources, change the environment, and how these changes affect both organisms and ecosystems. Students will use mathematical concepts to construct explanations for the role of energy in the cycling of matter in organisms and ecosystems.

Indicator

Indicator Code: SC.HS.8.3.e

Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. 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 is limited to proportional reasoning to describe the cycling of matter and flow of energy.

NGSS Comparison: HS-LS2-4

Other Indicators in this Standard

SC.HS.8.3.a, SC.HS.8.3.b, SC.HS.8.3.c, SC.HS.8.3.d, SC.HS.8.3.f

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Using Mathematics and Computational Thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials	**Energy and Matter:** • Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.

and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

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

Disciplinary Core Idea (DCI)

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

- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- 50 Year old sealed ecosphere
- 12 Years in a Sealed Ecosphere
- Farming Fish with Vegetables
- Attack of the Killer Fungi
- Biosphere 2
- Reconstructing Ancient Diets with Isotopes
- If We Are What We Eat, Americans Are Corn and Soy

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.8.3.e	**Use mathematical representations** to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.		
1	Representation		
	a	Students identify and describe* the components in the mathematical representations that are relevant to supporting the claims. The components could include relative quantities related to organisms, matter, energy, and the food web in an ecosystem.	
	b	Students identify the claims about the cycling of matter and energy flow among organisms in an ecosystem.	
2	Mathematical modeling		
	a	Students describe* how the claims can be expressed as a mathematical relationship in the mathematical representations of the components of an ecosystem	
	b	Students use the mathematical representation(s) of the food web to:	
		i.	Describe* the transfer of matter (as atoms and molecules) and flow of energy upward between organisms and their environment;
		ii.	Identify the transfer of energy and matter between tropic levels; and
		iii.	Identify the relative proportion of organisms at each trophic level by correctly identifying producers as the lowest trophic level having the greatest biomass and energy and consumers decreasing in numbers at higher trophic levels.
3	Analysis		
	a	Students use the mathematical representation(s) to support the claims that include the idea that matter flows between organisms and their environment.	
	b	Students use the mathematical representation(s) to support the claims that include the idea that energy flows from one trophic level to another as well as through the environment.	
	c	Students analyze and use the mathematical representation(s) to account for the energy not transferred to higher trophic levels, but which is instead used for growth, maintenance, or repair, and/or transferred to the environment, and the inefficiencies in transfer of matter and energy.	

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Using Mathematics and Computational Thinking

K-2	3-5	6-8	9-12
Mathematical and computational thinking in K–2 builds on prior experience and progresses to recognizing that mathematics can be used to describe the natural and designed world(s). • Decide when to use qualitative vs. quantitative data. • Use counting and numbers to identify and describe patterns in the natural and designed world(s). • Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs. • Use quantitative data to compare two alternatives.	Mathematical and computational thinking in 3–5 builds on K–2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions. • Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success. • Organize simple data sets to reveal patterns that suggest relationships. • Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems. • Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem.	Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. • Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. • Use mathematical representations to describe and/or support scientific conclusions and design solutions. • Create algorithms (a series of ordered steps) to solve a problem. • Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems. • Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.	Mathematical and computational thinking in 9- 12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3 , acre-feet, etc.).

Crosscutting Concepts (CCCs): Energy and Matter

K-2	3-5	6-8	9-12
In grades K-2, students observe objects may break into smaller pieces, be put together into larger pieces, or change shapes.	In grades 3-5, students learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change.	In grades 6-8, students learn matter is conserved because atoms are conserved in physical and chemical processes. They also learn 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.	In grades 9-12, students learn that the total amount of energy and matter in closed systems is conserved. They can describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Disciplinary Core Ideas (DCIs): LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

K-2	3-5	6-8	9-12
LS2.B: [Content found in LS1.C and ESS3.A]: - LS1.C: Animals obtain food they need from plants or other animals. Plants need water and light. - ESS3.A: 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.	**LS2.B**: Matter cycles between the air and soil and among organisms as they live and die.	**LS2.B**: The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. Food webs model how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem.	**LS2.B**: Photosynthesis and cellular respiration provide most of the energy for life processes. Only a fraction of matter consumed at the lower level of a food web is transferred up, resulting in fewer organisms at higher levels. At each link in ecosystem elements are combined in different ways and matter and energy are conserved. Photosynthesis and cellular respiration are key components of the global carbon cycle.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

Mathematics Connections:

- MP.2 Reason abstractly and quantitatively. (HS-LS2-4)
- MP.4 Model with mathematics. (HS-LS2-4)
- HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-4)
- HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-LS2-4)
- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-4)

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 1 Bundle 4 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
  - SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d SC.HS.8.3.e, SC.HS.10.5.c, SC.HS.10.5.e,
- NGSS Conceptual Progressions Bundle Course 2 Bundle 2 (https://nextgenscience.org/high-school-conceptual-progression-model-course-2)
  - SC.HS.8.3.e, SC.HS.14.4.c, SC.HS.13.3.a, SC.HS.13.3.d, SC.HS.13.3.e, SC.HS.12.2.b,
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Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- model, cycling of matter, energy flow, food chain, food web, energy pyramid, pyramid of biomass, autotroph, heterotroph, producer, consumer, decomposer, solar energy, predatory-prey relationship, trophic level, biomass

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.8 Matter and Energy in Organisms and Ecosystems
Standard Code: SC.HS.8.3 Gather, analyze, and communicate evidence of the flow of energy and cycling of matter in organisms and ecosystems.

How do organisms obtain and use energy they need to live and grow? How do matter and energy move through ecosystems? Students will be expected to develop understanding of organisms' interactions with each other and their physical environment, how organisms obtain resources, change the environment, and how these changes affect both organisms and ecosystems. Students will use mathematical concepts to construct explanations for the role of energy in the cycling of matter in organisms and ecosystems.

Indicator

Indicator Code: SC.HS.8.3.f

Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. Examples of models could include simulations and mathematical models. Assessment does not include the specific chemical steps of photosynthesis and respiration.

NGSS Comparison: HS-LS2-5

Other Indicators in this Standard

SC.HS.8.3.a, SC.HS.8.3.b, SC.HS.8.3.c, SC.HS.8.3.d, SC.HS.8.3.e

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Developing and Using Models: Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or components of a system.	**Systems and System Models:** • 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.

Disciplinary Core Idea (DCI)

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

- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

PS3.D: Energy in Chemical Processes:

- The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. *(secondary to HS.8.3.f)*

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- Air Plants - No Soil Needed

- Algae Fuel and Food
- Vegetable Oil as Fuel
- Biosphere 2
- Reconstructing Ancient Diets with Isotopes
- If We Are What We Eat, Americans Are Corn and Soy

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.8.3.f Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

1	Components of the model		
	a	Students use evidence to develop a model in which they identify and describe* the relevant components, including:	
		i.	The inputs and outputs of photosynthesis;
		ii.	The inputs and outputs of cellular respiration; and
		iii.	The biosphere, atmosphere, hydrosphere, and geosphere.
2	Relationships		
	a	Students describe* relationships between components of their model, including:	
		i.	The exchange of carbon (through carbon-containing compounds) between organisms and the environment; and
		ii.	The role of storing carbon in organisms (in the form of carbon-containing compounds) as part of the carbon cycle.
3	Connections		
	a	Students describe* the contribution of photosynthesis and cellular respiration to the exchange of carbon within and among the biosphere, atmosphere, hydrosphere, and geosphere in their model.	
	b	Students make a distinction between the model's simulation and the actual cycling of carbon via photosynthesis and cellular respiration.	

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Developing and Using Models

K-2	3-5	6-8	9-12
Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or	Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Identify limitations of models.	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

design solutions. Distinguish between a model and the actual object, process, and/or events the model represents. • Compare models to identify common features and differences. • Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). • Develop a simple model based on evidence to represent a proposed object or tool.	• 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. • Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. • Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.	• Evaluate limitations of a model for a proposed object or tool. • Develop or modify a model— based on evidence – to match what happens if a variable or component of a system is changed. • Use and/or develop a model of simple systems with uncertain and less predictable factors. • 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. • Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	• Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena and move flexibly between model types based on merits and limitations. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Crosscutting Concepts (CCCs): Systems and System Models

K-2	3-5	6-8	9-12
In grades K-2, students understand objects and organisms can be described in terms of their parts; and systems in the natural and designed world have parts that work together.	In grades 3-5, students understand that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. They can also describe a system in terms of its components and their interactions.	In grades 6-8, students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flow within systems. They can also learn that models are limited in that they	In grades 9-12, students can investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They can use models (e.g., physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales. They can also use models and simulations to predict the behavior of a system and recognize that these predictions have limited precision and reliability due to the

		only represent certain aspects of the system under study.	assumptions and approximations inherent in the models. They can also design systems to do specific tasks.

Disciplinary Core Ideas (DCIs): LS2.B: Cycles of Matter and Energy Transfer in Ecosystems, PS3.D: Energy in Chemical Processes

K-2	3-5	6-8	9-12
LS2.B: [Content found in LS1.C and ESS3.A]: • LS1.C: Animals obtain food they need from plants or other animals. Plants need water and light. • ESS3.A: 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. **PS3.D**: Sunlight warms Earth's surface.	**LS2.B**: Matter cycles between the air and soil and among organisms as they live and die. **PS3.D**: Energy can be "produced," "used," or "released" by converting stored energy. Plants capture energy from sunlight, which can later be used as fuel or food.	**LS2.B**: The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. Food webs model how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem. **PS3.D**: Sunlight is captured by plants and used in a reaction to produce sugar molecules, which can be reversed by burning those molecules to release energy.	**LS2.B**: Photosynthesis and cellular respiration provide most of the energy for life processes. Only a fraction of matter consumed at the lower level of a food web is transferred up, resulting in fewer organisms at higher levels. At each link in ecosystem elements are combined in different ways and matter and energy are conserved. Photosynthesis and cellular respiration are key components of the global carbon cycle. **PS3.D**: Photosynthesis is the primary biological means of capturing radiation from the sun; energy cannot be destroyed; it can be converted to less useful forms.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

Mathematics Connections:

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 1 Bundle 4 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
    - SC.HS.6.1.b, SC.HS.6.1.c, SC.HS.8.3.a, SC.HS.8.3.b SC.HS.8.3.c, SC.HS.8.3.d, SC.HS.8.3.f,
- NGSS Conceptual Progressions Bundle Course 2 Bundle 3 (https://nextgenscience.org/high-school-conceptual-progression-model-course-2)
    - SC.HS.2.2.d, SC.HS.8.3.b, SC.HS.8.3.c, SC.HS.8.3.d, SC.HS.8.3.f

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- Sun, sugar, energy, burning, biogeochemical cycle, food web, producer, consumer, decomposer, conservation of energy

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.9 Heredity: Inheritance and Variation of Traits

Standard Code: SC.HS.9.4 Gather, analyze, and communicate evidence of the inheritance and variation of traits.

How are the characteristics from one generation related to the previous generation? High school students demonstrate understanding of the relationship of DNA and chromosomes in the processes of cellular division that pass traits from one generation to the next. Students can determine why individuals of the same species vary in how they look, function, and behave. Ethical issues related to genetic modification of organisms and the nature of science can be described.

Indicator

Indicator Code: SC.HS.9.4.a

Develop and use a model to explain the relationships between the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. Assessment does not include the phases of meiosis or the molecular mechanism of specific steps in the process.

NGSS Comparison: HS-LS3-1 (modified)

Other Indicators in this Standard

SC.HS.9.4.b, SC.HS.9.4.c

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Developing and Using Models: Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Use a model to provide mechanistic accounts of phenomena.	**Cause and Effect:** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Disciplinary Core Idea (DCI)

LS1.A: **Structure and Function**

- 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 to HS.9.4.A) (Note: This Disciplinary Core Idea is also addressed by HS.6.1.A.)*

LS3.A: **Inheritance of Traits**

- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- Why do some people think cilantro tastes like soap?
- Color blindness and hemophilia are more likely to show up in males
- Sickle cell disease and sickle cell carriers
- Why do humans have different skin colors?
- Polydactyl Cats

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.9.4.a		**Develop and use a model** to explain the relationships between the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
1	Components of the model:	
	a	From the given model, students identify and describe* the components of the model relevant for their mechanistic descriptions.
	b	From the given model, students identify the relevant different scales on which the factors operate.
2	Relationships	
	a	Students identify and describe* the relationships between components of the given model.
	b	Students describe* the relationships between components of the model as either causal or correlational.
3	Connections	
	a	Students use the given model to provide a mechanistic account of the relationship between factors represented in the model.

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Developing and Using Models

K-2	3-5	6-8	9-12
Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. Distinguish between a model and the actual object, process, and/or events the model represents.	Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Identify limitations of models. • 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	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Evaluate limitations of a model for a proposed object or tool. • Develop or modify a model— based on evidence – to match what happens if a variable or component of a system is changed.	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability.

• Compare models to identify common features and differences. • Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). • Develop a simple model based on evidence to represent a proposed object or tool.	to describe a scientific principle or design solution. • Develop and/or use models to describe and/or predict phenomena. • Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. • Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.	• Use and/or develop a model of simple systems with uncertain and less predictable factors. • 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. • Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	• Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena and move flexibly between model types based on merits and limitations. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Crosscutting Concepts (CCCs): Cause and Effect

K-2	3-5	6-8	9-12
In grades K-2, students learn that events have causes that generate observable patterns. They design simple tests to gather evidence to support or refute their own ideas about causes.	In grades 3-5, students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationship.	In grades 6-8, students classify relationships as causal or correlational and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.	In grades 9-12, students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.

Disciplinary Core Ideas (DCIs): LS1.A: Structure and Function, LS3.A: Inheritance of Traits

K-2	3-5	6-8	9-12
LS1.A: All organisms have external parts that they use to perform daily functions. **LS3.A:** Young organisms are very much, but not exactly, like their parents and also resemble other organisms of the same kind.	**LS1.A:** Organisms have both internal and external macroscopic structures that allow for growth, survival, behavior, and reproduction. **LS3.A:** Different organisms vary in how they look and function because they have different inherited information; the environment also affects the traits that an organism develops.	**LS1.A:** All living things are made up of cells. In organisms, cells work together to form tissues and organs that are specialized for particular body functions. **LS3.A**: Genes chiefly regulate a specific protein, which affects an individual's traits.	**LS1.A:** Systems of specialized cells within organisms help perform essential functions of life. Any one system in an organism is made up of numerous parts. Feedback mechanisms maintain an organism's internal conditions within certain limits and mediate behaviors. **LS3.A**: DNA carries instructions for forming species' characteristics. Each cell in an organism has the same genetic content, but genes expressed by cells can differ.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Mathematics Connections:

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 3 Bundle 3 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
  - SC.HS.6.1.a, SC.HS.6.1.d, SC.HS.9.4.a, SC.HS.9.4.b, SC.HS.9.4.c, SC.HS.10.5.a, SC.HS.10.5.b
- NGSS Conceptual Progressions Bundle Course 2 Bundle 5 (https://nextgenscience.org/high-school-conceptual-progression-model-course-2)
  - SC.HS.6.1.a, SC.HS.9.4.a, SC.HS.9.4.b, SC.HS.9.4.c

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- structure, DNA, DNA replication, RNA, protein, nucleotide, amino acid, transcription, translation, protein synthesis, cell, nucleus, chromosome, gene, double helix, adenine, guanine, cytosine, thymine, deoxyribose, phosphate, hydrogen bond, base, ribosome, mRNA (messenger RNA)

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.9 Heredity: Inheritance and Variation of Traits
Standard Code: SC.HS.9.4 Gather, analyze, and communicate evidence of the inheritance and variation of traits.

How are the characteristics from one generation related to the previous generation? High school students demonstrate understanding of the relationship of DNA and chromosomes in the processes of cellular division that pass traits from one generation to the next. Students can determine why individuals of the same species vary in how they look, function, and behave. Ethical issues related to genetic modification of organisms and the nature of science can be described.

Indicator

Indicator Code: SC.HS.9.4.b

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. Emphasis is on using data to support arguments for the way variation occurs. Assessment does not include the phases of meiosis or the molecular mechanism of specific steps in the process.

NGSS Comparison: HS-LS3-2

Other Indicators in this Standard

SC.HS.9.4.a, SC.HS.9.4.c

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Engaging in Argument from Evidence: • Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.	**Cause and Effect:** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Disciplinary Core Idea (DCI)

LS3.B: Variation of Traits:

- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- Why Do Humans Have Different Colored Skin?
- Hemingway's Polydactyl Cats
- Corn Cob Sprouting in Water
- Malaria and Sickle Cell Anemia
- The Potential and Ethics of CRISPR
- Darius Goes West - (video, Darius Goes West - Watch the Movie and Join the Movement, Duchenne Muscular Dystrophy, Darius Goes West - Wikipedia,

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.9.4.b 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.

1	Developing a claim		
	a	Students make a claim that includes the idea that inheritable genetic variations may result from:	
		i.	New genetic combinations through meiosis;
		ii.	Viable errors occurring during replication; and
		iii.	Mutations caused by environmental factors.
2	Identifying scientific evidence		
	a	Students identify and describe* evidence that supports the claim, including:	
		i.	Variations in genetic material naturally result during meiosis when corresponding sections of chromosome pairs exchange places.
		ii.	Genetic mutations can occur due to:
			a) errors during replication; and/or
			b) environmental factors.

		iii.	Genetic material is inheritable.
	b	Students use scientific knowledge, literature, student-generated data, simulations and/or other sources for evidence.	
3	Evaluating and critiquing evidence		
	a	Students identify the following strengths and weaknesses of the evidence used to support the claim:	
		i.	Types and numbers of sources;
		ii.	Sufficiency to make and defend the claim, and to distinguish between causal and correlational relationships; and
		iii.	Validity and reliability of the evidence.
4	Reasoning and synthesis		
	a	Students use reasoning to describe* links between the evidence and claim, such as:	
		i.	Genetic mutations produce genetic variations between cells or organisms.
		ii.	Genetic variations produced by mutation and meiosis can be inherited.
	b	Students use reasoning and valid evidence to describe* that new combinations of DNA can arise from several sources, including meiosis, errors during replication, and mutations caused by environmental factors.	
	c	Students defend a claim against counterclaims and critique by evaluating counterclaims and by describing* the connections between the relevant and appropriate evidence and the strongest claim.	

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Engaging in Argument from Evidence

K-2	3-5	6-8	9-12
Engaging in argument from evidence in K–2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s). 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.	Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • 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. • Respectfully provide and receive critiques from peers about a	Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. • Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions	Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Compare and evaluate competing arguments or design solutions based on accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

• Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument. • Construct an argument with evidence to support a claim. • Make a claim about the effectiveness of an object, tool, or solution supported by relevant evidence.	proposed procedure, explanation, or model by citing relevant evidence and posing specific questions. • Construct and/or support an argument with evidence, data, and/or a model. • Use data to evaluate claims about cause and effect. 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.	that elicit pertinent elaboration and detail. • 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. • 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 the technology meets relevant criteria and constraints. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	• Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions. Construct, use, and/or present an oral and written argument or counterarguments based on data and evidence. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Crosscutting Concepts (CCCs): Cause and Effect

K-2	3-5	6-8	9-12
In grades K-2, students learn that events have causes that generate observable patterns. They design simple tests to gather evidence to support or refute their own ideas about causes.	In grades 3-5, students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationship.	In grades 6-8, students classify relationships as causal or correlational and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.	In grades 9-12, students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.

Disciplinary Core Ideas (DCIs): LS3.B: Variation of Traits

K-2	3-5	6-8	9-12
LS3.B: Young organisms are very much, but not exactly, like their parents and resemble other organisms of the same kind.	**LS3.B:** Different organisms vary in how they look and function because they have different inherited information; the environment also affects the traits that an organism develops.	**LS3.B:** In sexual reproduction, each parent contributes half of the genes acquired by the offspring resulting in variation between parent and offspring. Genetic information can be altered because of mutations, which may result in beneficial, negative, or no change to proteins in or traits of an organism.	**LS3.B:** The variation and distribution of traits in a population depend on genetic and environmental factors. Genetic variation can result from mutations caused by environmental factors or errors in DNA replication, or from chromosomes swapping sections during meiosis.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- WHST.9-12.1 Write arguments focused on discipline-specific content.

Mathematics Connections:

- MP.2 Reason abstractly and quantitatively.

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 3 Bundle 3 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
    - SC.HS.6.1.a, SC.HS.6.1.d, SC.HS.9.4.a, SC.HS.9.4.b, SC.HS.9.4.c, SC.HS.10.5.a, SC.HS.10.5.b
- NGSS Conceptual Progressions Bundle Course 2 Bundle 5 (https://nextgenscience.org/high-school-conceptual-progression-model-course-2)
    - SC.HS.6.1.a, SC.HS.9.4.a, SC.HS.9.4.b, SC.HS.9.4.c

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- inherited, genetic variation, gamete, epigenetics, meiosis, mutation, viable, multicellular, sperm cell, egg cell, fertilization, genome, gene, parent cell, daughter cell, DNA, cellular division

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- **KSA1**: Make a claim that inheritable genetic variations will occur and may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors.
- **KSA2**: Examine data that shows that inheritable genetic variations will affect the probability of occurrences of traits in a population in order to identify the strengths and weaknesses of a claim.
- **KSA3**: Using the examined data, develop a claim that inheritable genetic variations are caused by, rather than correlated with, (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

Standard

Topic Code: SC.HS.9 Heredity: Inheritance and Variation of Traits
Standard Code: SC.HS.9.4 Gather, analyze, and communicate evidence of the inheritance and variation of traits.

How are the characteristics from one generation related to the previous generation? High school students demonstrate understanding of the relationship of DNA and chromosomes in the processes of cellular division that pass traits from one generation to the next. Students can determine why individuals of the same species vary in how they look, function, and behave. Ethical issues related to genetic modification of organisms and the nature of science can be described.

Indicator

Indicator Code: SC.HS.9.4.c

Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. 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 does not include Hardy-Weinberg calculations.

NGSS Comparison: HS-LS3-3

Other Indicators in this Standard

SC.HS.9.4.a, SC.HS.9.4.b

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Analyzing and Interpreting Data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.	**Scale, Proportion, and Quantity:** • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

- Apply concepts of statistics and probability (including 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.

Connections to Engineering, Technology, and Applications of Science

Science is a Human Endeavor:

- Technological advances have influenced the progress of science and science has influenced advances in technology.
- Science and engineering are influenced by society and society is influenced by science and engineering.

Disciplinary Core Idea (DCI)

LS3.B: Variation of Traits:

- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- Galapagos Finch Evolution
- Corn Cob Sprouting in Water
- Malaria and Sickle Cell Anemia

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.9.4.c **Apply concepts of statistics and probability** to explain the variation and distribution of expressed traits in a population.			
1	Organizing data		
	a	Students organize the given data by the frequency, distribution, and variation of expressed traits in the population.	
2	Identifying relationships		
	a	Students perform and use appropriate statistical analyses of data, including probability measures, to determine the relationship between a trait's occurrence within a population and environmental factors.	
3	Interpreting data		
	a	Students analyze and interpret data to explain the distribution of expressed traits, including:	
		i.	Recognition and use of patterns in the statistical analysis to predict changes in trait distribution within a population if environmental variables change; and
		ii.	Description* of the expression of a chosen trait and its variations as causative or correlational to some environmental factor based on reliable evidence.

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Analyzing and Interpreting Data

K-2	3-5	6-8	9-12

Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations. 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) to answer scientific questions and solve problems. • Compare predictions (based on prior experiences) to what occurred (observable events). • Analyze data from tests of an object or tool to determine if	Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. • Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. • Compare data collected by different groups to discuss similarities and differences in their findings. • Analyze data to refine a problem statement or the design of a proposed object, tool, or process.	Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • 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. • Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible. • Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials). • Analyze and interpret data to determine similarities and differences in findings. • Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success.	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) to make valid and reliable scientific claims or determine an optimal design solution. • Apply concepts of statistics and probability (including 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. • Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data. • Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. • Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Crosscutting Concepts (CCCs): Scale, Proportion, and Quantity

K-2	3-5	6-8	9-12

In grades K-2, students use relative scales (e.g., bigger and smaller; hotter and colder; faster and slower) to describe objects. They use standard units to measure length.	In grades 3-5, students recognize natural objects, and observable phenomena exist from the very small to the immensely large. They use standard units to measure and describe physical quantities such as weight, time, temperature, and volume.	In grades 6-8, students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale. They use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes. They represent scientific relationships through algebraic expressions and equations.	In grades 9-12, students understand the significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. They recognize patterns observable at one scale may not be observable or exist at other scales, and some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Students use orders of magnitude to understand how a model at one scale relates to a model at another scale. They use algebraic thinking to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

Disciplinary Core Ideas (DCIs): LS3.B: Variation of Traits

K-2	3-5	6-8	9-12
LS3.B: Young organisms are very much, but not exactly, like their parents and resemble other organisms of the same kind.	**LS3.B**: Different organisms vary in how they look and function because they have different inherited information; the environment also affects the traits that an organism develops.	**LS3.B**: In sexual reproduction, each parent contributes half of the genes acquired by the offspring resulting in variation between parent and offspring. Genetic information can be altered because of mutations, which may result in beneficial, negative, or no change to proteins in or traits of an organism.	**LS3.B**: The variation and distribution of traits in a population depend on genetic and environmental factors. Genetic variation can result from mutations caused by environmental factors or errors in DNA replication, or from chromosomes swapping sections during meiosis.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

Mathematics Connections:

- MP.2 Reason abstractly and quantitatively.

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Modified Domains Bundle Course 3 Bundle 3 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
    - SC.HS.6.1.a, SC.HS.6.1.d, SC.HS.9.4.a, SC.HS.9.4.b, SC.HS.9.4.c, SC.HS.10.5.a, SC.HS.10.5.b
- NGSS Conceptual Progressions Bundle Course 2 Bundle 5 (https://nextgenscience.org/high-school-conceptual-progression-model-course-2)
    - SC.HS.6.1.a, SC.HS.9.4.a, SC.HS.9.4.b, SC.HS.9.4.c

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- variation, distribution, population, traits, genetic, environmental, gene expression, sickle-cell anemia, malaria, hemoglobin, antibiotic resistance, gene, allele, dominant, recessive, homozygous, heterozygous, phenotype, genotype, probability

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.10 Biological Evolution

Standard Code: SC.HS.10.5 Gather, analyze, and communicate evidence of biological evolution.

How can there be so many similarities among organisms yet so many different plants, animals, and microorganisms? How does biodiversity affect humans? Students will be expected to demonstrate understanding of the factors causing natural selection and the process of evolution of species over time. They demonstrate understanding of how multiple lines of evidence contribute to the strength of scientific theories of natural selection and evolution.

Indicator

Indicator Code: SC.HS.10.5.a

Communicate scientific information that common ancestry and biological evolution are supported by <u>multiple lines of empirical evidence</u>. 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.

NGSS Comparison: HS-LS4-1

Other Indicators in this Standard

SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.d, SC.HS.10.5.e

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Obtaining, Evaluating, and Communicating Information: Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • 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). ***Connections to the nature of science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena:** • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted.	**Patterns:** • 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. ***Connections to Engineering, Technology, and Applications of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	

Disciplinary Core Idea (DCI)

LS4.A: Evidence of Common Ancestry and Diversity:

- Genetic information 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- Galapagos Finch Evolution
- Hox Genes

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.10.5.a		**Communicate scientific** information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
1		Communication style and format
	a	Students use at least two different formats (e.g., oral, graphical, textual and mathematical), to communicate scientific information, including that common ancestry and biological evolution are supported by multiple lines of empirical evidence. Students cite the origin of the information as appropriate.
2		Connecting the DCIs and the CCCs
	a	Students identify and communicate evidence for common ancestry and biological evolution, including:
		i. Information derived from DNA sequences, which vary among species but have many similarities between species;
		ii. Similarities of the patterns of amino acid sequences, even when DNA sequences are slightly different, including the fact that multiple patterns of DNA sequences can code for the same amino acid;
		iii. Patterns in the fossil record (e.g., presence, location, and inferences possible in lines of evolutionary descent for multiple specimens); and
		iv. The pattern of anatomical and embryological similarities.
	b	Students identify and communicate connections between each line of evidence and the claim of common ancestry and biological evolution.
	c	Students communicate that together, the patterns observed at multiple spatial and temporal scales (e.g., DNA sequences, embryological development, fossil records) provide evidence for causal relationships relating to biological evolution and common ancestry.

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Obtaining, Evaluating, and Communicating Information

K-2	3-5	6-8	9-12
Obtaining, evaluating, and communicating information in K–2 builds on prior experiences and uses	Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to	Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to	Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and

observations and texts to communicate new information. • Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s). • Describe how specific images (e.g., a diagram showing how a machine works) support a scientific or engineering idea. • Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question and/or supporting a scientific claim. • 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.	evaluating the merit and accuracy of ideas and methods. • Read and comprehend grade appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence. • Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices. • Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices. • Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. • Communicate scientific and/or technical information orally and/or in written formats, including various media forms, tables, diagrams, and charts.	evaluating the merit and validity of ideas and methods. • Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s). • Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings. • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. • Evaluate data, hypotheses, and/or conclusions in scientific and technical texts based on competing information or accounts. • Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.	reliability of the claims, methods, and designs. • Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. • Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) and in words to address a scientific question or solve a problem. • Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. • Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Crosscutting Concepts (CCCs): Patterns

K-2	3-5	6-8	9-12
In grades K-2, children recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.	In grades 3-5, students identify similarities and differences to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and use these patterns to make predictions.	In grades 6-8, students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships and use graphs and charts to identify patterns in data.	In grades 9-12, students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They recognize classifications or explanations used at one scale may not be useful or need revision using a different scale; thus, requiring improved investigations and experiments. They use mathematical representations to identify certain patterns and analyze performance patterns to reengineer and improve a designed system.

Disciplinary Core Ideas (DCIs): LS4.A: Evidence of Common Ancestry and Diversity

K-2	3-5	6-8	9-12
LS4.A: N/A	**LS4.A**: Some living organisms resemble organisms that once lived on Earth. Fossils provide evidence about the types of organisms and environments that existed long ago.	**LS4.A**: The fossil record documents the existence, diversity, extinction, and change of many life forms and their environments through Earth's history. The fossil record and comparisons of anatomical similarities between organisms enables the inference of lines of evolutionary descent.	**LS4.A**: The ongoing branching that produces multiple lines of descent can be inferred by comparing DNA sequences, amino acid sequences, and anatomical and embryological evidence of different organisms.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST-11.12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
- SL.11-12.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

Mathematics Connections:

- MP.2 Reason abstractly and quantitatively.

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Conceptual Bundle Course 3, #3 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
  - SC.HS.6.1.a, SC.HS.6.1.d, SC.HS.9.4.a, SC.HS.9.4.b, SC.HS.9.4.c, SC.HS.10.5.a, SC.HS.10.5.b,
- NGSS Progressions Bundle Course 3, #3 (https://nextgenscience.org/high-school-conceptual-progression-model-course-3)
  - SC.HS. 7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.10.5.a, SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.d, SC.HS.10.5.e

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- evolution, DNA sequences, amino acid sequences, anatomical structures, fossil record, embryological development, common ancestry, comparative anatomy, heritable traits, natural selection, species, descent with modification, homologous structures, vestigial structures, analogous structures, evolutionary tree

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

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Standard

Topic Code: SC.HS.10 Biological Evolution

Standard Code: SC.HS.10.5 Gather, analyze, and communicate evidence of biological evolution.

How can there be so many similarities among organisms yet so many different plants, animals, and microorganisms? How does biodiversity affect humans? Students will be expected to demonstrate understanding of the factors causing natural selection and the process of evolution of species over time. They demonstrate understanding of how multiple lines of evidence contribute to the strength of scientific theories of natural selection and evolution

Indicator

Indicator Code: SC.HS.10.5.b

Construct an explanation based on evidence that natural selection 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 reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. Emphasis is on using evidence to explain the influence each of the four factors has on 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 does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.

NGSS Comparison: HS-LS4-2 (modified)

Other Indicators in this Standard

SC.HS.10.5.a, SC.HS.10.5.c, SC.HS.10.5.d, SC.HS.10.5.e

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Constructing Explanations and Designing Solutions: Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • 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.	**Cause and Effect:** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Disciplinary Core Idea (DCI)

LS4.B: **Natural Selection:**

- 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:**

- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- Why Do Humans Have Different Colored Skin?
- Galapagos Finch Evolution
- Malaria and Sickle Cell Anemia

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.10.5.b Construct an explanation based on evidence that natural selection 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 reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

1	Articulating the explanation of phenomena		
	a	Students construct an explanation that includes a description* that evolution is caused primarily by one or more of the 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.	
2	Evidence		
	a	Students identify and describe* evidence to construct their explanation, including that:	
		iv.	As a species grows in number, competition for limited resources can arise.
		v.	Individuals in a species have genetic variation (through mutations and sexual reproduction) that is passed on to their offspring.
		vi.	Individuals can have specific traits that give them a competitive advantage relative to other individuals in the species.
	b	Students use a variety of valid and reliable sources for the evidence (e.g., data from investigations, theories, simulations, peer review).	
3	Reasoning		
	a	Students use reasoning to connect the evidence, along with 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, to construct the explanation. Students describe* the following chain of reasoning for their explanation:	
		iv.	Genetic variation can lead to variation of expressed traits in individuals in a population.
		v.	Individuals with traits that give competitive advantages can survive and reproduce at higher rates than individuals without the traits because of the competition for limited resources.
		vi.	Individuals that survive and reproduce at a higher rate will provide their specific genetic variations to a greater proportion of individuals in the next generation.
		vii.	Over many generations, groups of individuals with particular traits that enable them to survive and reproduce in distinct environments using distinct resources can evolve into a different species.
	b	Students use the evidence to describe* the following in their explanation:	
		i.	The difference between natural selection and biological evolution (natural selection is a process, and biological evolution can result from that process); and
		ii.	The cause and effect relationship between genetic variation, the selection of traits that provide comparative advantages, and the evolution of populations that all express the trait.

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Constructing Explanations and Designing Solutions

K-2	3-5	6-8	9-12
Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. • 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.	Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. • Identify the evidence that supports particular points in an explanation. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	Constructing explanations and designing solutions in 6–8 builds on K– 5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. • Construct an explanation using models or representations. • 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. • Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.	Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise 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. • Apply scientific ideas, principles, and/or evidence to explain phenomena and solve design problems, considering possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Crosscutting Concepts (CCCs): Cause and Effect

K-2	3-5	6-8	9-12
In grades K-2, students learn that events have causes that generate observable patterns. They design simple tests to gather evidence to support or refute their own ideas about causes.	In grades 3-5, students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationship.	In grades 6-8, students classify relationships as causal or correlational and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.	In grades 9-12, students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.

Disciplinary Core Ideas (DCIs): LS4.B: Natural Selection, LS4.C: Adaptation

K-2	3-5	6-8	9-12
LS4.B: N/A	**LS4.B:** Differences in characteristics between individuals of the same species provide advantages in surviving and reproducing	**LS4.B:** Both natural and artificial selection result from certain traits giving some individuals an advantage in surviving and reproducing, leading to predominance of certain traits in a population.	**LS4.B:** Natural selection occurs only if there is variation in the genes and traits between organisms in a population. Traits that positively affect survival can become more common in a population.
LS4.C: N/A	**LS4.C:** Particular organisms can only survive in particular environments.	**LS4.C:** Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common.	**LS4.C:** Evolution results primarily from genetic variation of individuals in a species, competition for resources, and proliferation of organisms better able to survive and reproduce. Adaptation means that the distribution of traits in a population, as well as species expansion, emergence or extinction, can change when conditions change.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST-11.12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
- SL.11-12.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

Mathematics Connections:

- MP.2 Reason abstractly and quantitatively. (HS-LS4-2)
- MP.4 Model with mathematics. (HS-LS4-2)

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Conceptual Bundle Course 3, #3 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
  - SC.HS.6.1.a, SC.HS.6.1.d, SC.HS.9.4.a, SC.HS.9.4.b, SC.HS.9.4.c, SC.HS.10.5.a, SC.HS.10.5.b,
- NGSS Progressions Bundle Course 3, #3 (https://nextgenscience.org/high-school-conceptual-progression-model-course-3)
  - SC.HS. 7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.10.5.a, SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.d, SC.HS.10.5.e

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- natural selection, evolution, species, heritable, genetic variation, mutation, sexual reproduction, competition, limited resources, proliferation, adaptation, beneficial, selective pressure

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

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Standard

Topic Code: SC.HS.10 Biological Evolution
Standard Code: SC.HS.10.5 Gather, analyze, and communicate evidence of biological evolution.

How can there be so many similarities among organisms yet so many different plants, animals, and microorganisms? How does biodiversity affect humans? Students will be expected to demonstrate understanding of the factors causing natural selection and the process of evolution of species over time. They demonstrate understanding of how multiple lines of evidence contribute to the strength of scientific theories of natural selection and evolution

Indicator

Indicator Code: SC.HS.10.5.c

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. Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations. Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.

NGSS Comparison: HS-LS4-3

Other Indicators in this Standard

SC.HS.10.5.a, SC.HS.10.5.b, SC.HS.10.5.d, SC.HS.10.5.e

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Analyzing and Interpreting Data: Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Apply concepts of statistics and probability (including 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.	**Patterns:** • 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.

Disciplinary Core Idea (DCI)

LS4.B: Natural Selection:
- 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:

- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- Natural Fish Lure | Lampsilis Mussel and Bass
- A Peacock's Tail
- Why Do Humans Have Different Colored Skin?
- Galapagos Finch Evolution
- Inflation of Moth Coremata

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.10.5.c 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.		
1	Organizing data	
	a	Students organize data (e.g., using tables, graphs and charts) by the distribution of genetic traits over time.
	b	Students describe* what each dataset represents
2	Identifying relationships	
	a	Students perform and use appropriate statistical analyses of data, including probability measures, to determine patterns of change in numerical distribution of traits over various time and population scales.
3	Interpreting data	
	a	Students use the data analyses as evidence to support explanations about the following:
		i. Positive or negative effects on survival and reproduction of individuals as relating to their expression of a variable trait in a population;
		ii. Natural selection as the cause of increases and decreases in heritable traits over time in a population, but only if it affects reproductive success; and
		iii. The changes in distribution of adaptations of anatomical, behavioral, and physiological traits in a population.

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Analyzing and Interpreting Data

K-2	3-5	6-8	9-12
Analyzing data in K–2 builds on prior experiences and progresses to	Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data	Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations,	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the

collecting, recording, and sharing observations. • 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) to answer scientific questions and solve problems. • Compare predictions (based on prior experiences) to what occurred (observable events). • Analyze data from tests of an object or tool to determine if	and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. • Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. • Compare data collected by different groups to discuss similarities and differences in their findings. • Analyze data to refine a problem statement or the design of a proposed object, tool, or process. • Use data to evaluate and refine design solutions.	distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • 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. • Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible. • Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials). • Analyze and interpret data to determine similarities and differences in findings. • Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success.	comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) to make valid and reliable scientific claims or determine an optimal design solution. • Apply concepts of statistics and probability (including 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. • Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data. • Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. • Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Crosscutting Concepts (CCCs): Patterns

K-2	3-5	6-8	9-12
In grades K-2, children recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.	In grades 3-5, students identify similarities and differences to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and use these patterns to make predictions.	In grades 6-8, students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships and use graphs and charts to identify patterns in data.	In grades 9-12, students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They recognize classifications or explanations used at one scale may not be useful or need revision using a different scale; thus, requiring improved investigations and experiments. They use mathematical representations to identify certain patterns and analyze performance patterns to reengineer and improve a designed system.

Disciplinary Core Ideas (DCIs): LS4.B: Natural Selection, LS4.C: Adaptation

K-2	3-5	6-8	9-12
LS4.B: N/A **LS4.C: N/A**	**LS4.B**: Differences in characteristics between individuals of the same species provide advantages in surviving and reproducing **LS4.C**: Particular organisms can only survive in particular environments.	**LS4.B**: Both natural and artificial selection result from certain traits giving some individuals an advantage in surviving and reproducing, leading to predominance of certain traits in a population. **LS4.C**: Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common.	**LS4.B**: Natural selection occurs only if there is variation in the genes and traits between organisms in a population. Traits that positively affect survival can become more common in a population. **LS4.C**: Evolution results primarily from genetic variation of individuals in a species, competition for resources, and proliferation of organisms better able to survive and reproduce. Adaptation means that the distribution of traits in a population, as well as species expansion, emergence or extinction, can change when conditions change.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST-11.12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics Connections:

- MP.2 Reason abstractly and quantitatively.

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Conceptual Bundle Course 3, #4 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
    - SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.d, SC.HS.10.5.e
- NGSS Progressions Bundle Course 3, #3 (https://nextgenscience.org/high-school-conceptual-progression-model-course-3)
    - SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.10.5.a, SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.d, SC.HS.10.5.e

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- advantageous, heritable trait, increase, proportion, distribution, fitness, gene, allele, variation, adaptation, natural selection

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- **KSA #1** Organize data of increases and decreases in heritable traits over time in a population
- **KSA #2** Use data analysis as evidence to support an explanation that individuals that survive and reproduce at a higher rate will provide their specific genetic variations to a greater proportion of individuals in the next generation
- **KSA #3** Observe patterns in data to provide evidence of causation or correlation of specific traits and competitive advantage of individuals relative to other individuals in a species

- **KSA #4** Perform and use appropriate statistical analysis of data to identify evidence that biotic and abiotic differences in ecosystems contribute to changes in gene frequency over time through natural selection

Standard

Topic Code: SC.HS.10 Biological Evolution
Standard Code: SC.HS.10.5 Gather, analyze, and communicate evidence of biological evolution.

How can there be so many similarities among organisms yet so many different plants, animals, and microorganisms? How does biodiversity affect humans? Students will be expected to demonstrate understanding of the factors causing natural selection and the process of evolution of species over time. They demonstrate understanding of how multiple lines of evidence contribute to the strength of scientific theories of natural selection and evolution

Indicator

Indicator Code: SC.HS.10.5.d

Construct an explanation based on evidence for how natural selection leads to adaptation of populations. 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) and sexual selection contribute to a change in gene frequency over time, leading to adaptation of populations.

NGSS Comparison: HS-LS4-4

Other Indicators in this Standard

SC.HS.10.5.a, SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.e

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Constructing Explanations and Designing Solutions: Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • 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.	**Cause and Effect:** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Connections to Engineering, Technology, and Applications of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems:** • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.
Disciplinary Core Idea (DCI)	

LS4.C: Adaptation

- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- Natural Fish Lure | Lampsilis Mussel and Bass
- Why Do Humans Have Different Colored Skin?
- Galapagos Finch Evolution
- Malaria and Sickle Cell Anemia

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.10.5.d Construct an explanation based on evidence for how natural selection leads to adaptation of populations.			
1	Articulating the explanation of phenomena		
	a	Students construct an explanation that identifies the cause and effect relationship between natural selection and adaptation.	
2	Evidence		
	a	Students identify and describe* the evidence to construct their explanation, including:	
		i.	Changes in a population when some feature of the environment changes;
		ii.	Relative survival rates of organisms with different traits in a specific environment;
		iii.	The fact that individuals in a species have genetic variation (through mutations and sexual reproduction) that is passed on to their offspring; and
		iv.	The fact that individuals can have specific traits that give them a competitive advantage relative to other individuals in the species.
	b	Students use a variety of valid and reliable sources for the evidence (e.g., theories, simulations, peer review, students' own investigations)	
3	Reasoning		
	a	Students use reasoning to synthesize the valid and reliable evidence to distinguish between cause and correlation to construct the explanation about how natural selection provides a mechanism for species to adapt to changes in their environment, including the following elements:	
		i.	Biotic and abiotic differences in ecosystems contribute to changes in gene frequency over time through natural selection.
		ii.	Increasing gene frequency in a population results in an increasing fraction of the population in each successive generation that carries a particular gene and expresses a particular trait.
		iii.	Over time, this process leads to a population that is adapted to a particular environment by the widespread expression of a trait that confers a competitive advantage in that environment.

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Constructing Explanations and Designing Solutions

K-2	3-5	6-8	9-12

Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence based accounts of natural phenomena and designing solutions. • Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. • Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem.	Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. • Identify the evidence that supports particular points in an explanation.	Constructing explanations and designing solutions in 6–8 builds on K– 5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. • 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 reasoning to show why the data or evidence is adequate for the explanation or conclusion.	Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise 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. • Apply scientific ideas, principles, and/or evidence to explain phenomena and solve design problems, considering possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Crosscutting Concepts (CCCs): Cause and Effect

K-2	3-5	6-8	9-12
In grades K-2, students learn that events have causes that generate observable patterns. They design simple tests to gather evidence to	In grades 3-5, students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur	In grades 6-8, students classify relationships as causal or correlational and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They	In grades 9-12, students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain

support or refute their own ideas about causes.	together with regularity might or might not signify a cause and effect relationship.	also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.	and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.

Disciplinary Core Ideas (DCIs): LS4.C: Adaptation

K-2	3-5	6-8	9-12
LS4.C: N/A	**LS4.C:** Particular organisms can only survive in particular environments.	**LS4.C:** Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common.	**LS4.C:** Evolution results primarily from genetic variation of individuals in a species, competition for resources, and proliferation of organisms better able to survive and reproduce. Adaptation means that the distribution of traits in a population, as well as species expansion, emergence or extinction, can change when conditions change.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST-11.12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics Connections:

- MP.2 Reason abstractly and quantitatively.

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Conceptual Bundle Course 3, #4 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
  - SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.d, SC.HS.10.5.e
- NGSS Progressions Bundle Course 3, #3 (https://nextgenscience.org/high-school-conceptual-progression-model-course-3)
  - SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.10.5.a, SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.d, SC.HS.10.5.e

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- design solution, natural selection, adaptation, populations, criteria, constraints, optimal, bacterial resistance, antibiotics, herbicides, climate change, pollinators, adaptation, beneficial, detrimental, distribution, frequency, genetic variation, mutation

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

Stackable, Instructionally-Embedded, Portable Science (SIPS) Assessments:

- https://sipsassessments.org/

Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.

Standard

Topic Code: SC.HS.10 Biological Evolution

Standard Code: SC.HS.10.5 Gather, analyze, and communicate evidence of biological evolution.

How can there be so many similarities among organisms yet so many different plants, animals, and microorganisms? How does biodiversity affect humans? Students will be expected to demonstrate understanding of the factors causing natural selection and the process of evolution of species over time. They demonstrate understanding of how multiple lines of evidence contribute to the strength of scientific theories of natural selection and evolution

Indicator

Indicator Code: SC.HS.10.5.e

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. 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.

NGSS Comparison: HS-LS4-5

Other Indicators in this Standard

SC.HS.10.5.a, SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.d

Concepts and Skills to Master

Foundation Boxes:

Science and Engineering Practice (SEP)	Crosscutting Concept (CCC)
Engaging in Argument from Evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current or historical episodes in science. • Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.	**Cause and Effect:** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Disciplinary Core Idea (DCI)

LS4.C: Adaptation:

- 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.

Possible Science and/or Engineering Phenomena to Support 3D Instruction

- The Asteroid That Killed the Dinosaurs
- Galapagos Finch Evolution
- The Great Oxygenation Event
- Bacteria and antibiotic resistance

Evidence Statements

What does it look like to demonstrate proficiency on this indicator?

HS.10.5.e	**Evaluate the evidence** supporting claims that <u>changes</u> in environmental conditions <u>may result in</u>: (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.		
1	Identifying the given claims and evidence to be evaluated		
	a	Students identify the given claims, which include the idea that changes in environmental conditions may result in:	
		i.	Increases in the number of individuals of some species;
		ii.	The emergence of new species over time; and
		iii.	The extinction of other species.
	b	Students identify the given evidence to be evaluated.	
2	Identifying any potential additional evidence that is relevant to the evaluation		
	a	Students identify and describe* additional evidence (in the form of data, information, models, or other appropriate forms) that was not provided but is relevant to the claims and to evaluating the given evidence, including:	
		i.	Data indicating the change over time in:
			a) The number of individuals in each species;
			b) The number of species in an environment; and
			c) The environmental conditions.
		ii.	Environmental factors that can determine the ability of individuals in a species to survive and reproduce.

3	Evaluating and critiquing	
	a	Students use their additional evidence to assess the validity, reliability, strengths, and weaknesses of the given evidence, along with its ability to support logical and reasonable arguments about the outcomes of group behavior.
	b	Students assess the ability of the given evidence to be used to determine causal or correlational effects between environmental changes, the changes in the number of individuals in each species, the number of species in an environment, and/or the emergence or extinction of species.
4	Reasoning and synthesis	
	a	Students evaluate the degree to which the given empirical evidence can be used to construct logical arguments that identify causal links between environmental changes and changes in the number of individuals or species based on environmental factors that can determine the ability of individuals in a species to survive and reproduce

Critical Background Knowledge

Grade Band Progressions:

Science and Engineering Practices (SEPs): Engaging in Argument from Evidence

K-2	3-5	6-8	9-12
Engaging in argument from evidence in K–2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s). • Distinguish between explanations that account for all gathered evidence and those that do not. • Construct an argument with evidence to support a claim.	Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • 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. • Construct and/or support an argument with evidence, data, and/or a model. Use data to evaluate claims about cause and effect.	Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. • 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.	Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Compare and evaluate competing arguments or design solutions based on accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Crosscutting Concepts (CCCs): Cause and Effect

K-2	3-5	6-8	9-12
In grades K-2, students learn that events have causes that generate observable patterns. They design simple tests to gather evidence to support or refute their own ideas about causes.	In grades 3-5, students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationship.	In grades 6-8, students classify relationships as causal or correlational and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.	In grades 9-12, students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.

Disciplinary Core Ideas (DCIs): LS4.C: Adaptation

K-2	3-5	6-8	9-12
LS4.C: N/A	**LS4.C:** Particular organisms can only survive in particular environments.	**LS4.C:** Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common.	**LS4.C:** Evolution results primarily from genetic variation of individuals in a species, competition for resources, and proliferation of organisms better able to survive and reproduce. Adaptation means that the distribution of traits in a population, as well as species expansion, emergence or extinction, can change when conditions change.

Related Cross-Curricular Standards: Current Grade Level

ELA Connections:

- RST-11.12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics Connections:

- MP.2 Reason abstractly and quantitatively.

Social Studies Connections:

Fine and Performing Arts Connections:

Connection to other grade level indicators

Authentic Connections to Other Content Standards:

- NGSS Conceptual Bundle Course 3, #4 (https://nextgenscience.org/high-school-domains-model-course-3-life-sciences)
  - SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.d, SC.HS.10.5.e
- NGSS Progressions Bundle Course 3, #3 (https://nextgenscience.org/high-school-conceptual-progression-model-course-3)
  - SC.HS.7.2.a, SC.HS.7.2.b, SC.HS.7.2.c, SC.HS.7.2.d, SC.HS.10.5.a, SC.HS.10.5.b, SC.HS.10.5.c, SC.HS.10.5.d, SC.HS.10.5.e.

Academic Language Development

Words to support student discourse related to the Disciplinary Core Ideas (DCIs):

- environmental, stability, disturbance, extinction, speciation, distribution, deforestation, fertilizers, drought, flood, adaptation, evolution, frequency, gene, advantageous, detrimental, population, genetic variation, selective pressure

Assessment Considerations

Formative Assessment:

- https://www.education.ne.gov/assessment/science-classroom-formative-task-repository-for-grades-5-8/

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Knowledge, Skills, and Abilities:

- Copy and paste in the KSA's from the formative task repository "Task Specifications Tools".
- Or if not written yet, write KSA statements from the evidence statements above. Those that have written tasks for NSCAS and the repository, please train your group.