CONNECTICUT TECHNICAL EDUCATION AND CAREER SYSTEM

Grade 10

Biology/Honors Biology

SC635/SC636

Connecticut Technical High School System
39 Woodland Street
Hartford, Connecticut 06105

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CTECS - Vision of a Graduate

The Vision of a Graduate (VoG) at the Connecticut Technical Education and Career System (CTECS) embodies our commitment to preparing students for success in Connecticut's workforce.

Developed in collaboration with students, parents, staff, and employers, the VoG ensures that CTECS students are not only job-ready but also equipped to lead, innovate, and adapt in a dynamic world.

As educators, we are dedicated to developing these qualities by providing a comprehensive education that empowers our students to achieve their fullest potential and make meaningful contributions to society.

A Problem Solver

Problem solvers tackle challenges by identifying root causes of issues, brainstorming solutions, implementing effective strategies, and demonstrating adaptability.

- ➔ Engage students with open-ended, creative thinking tasks that require both conventional and innovative solutions.
- ➔ Facilitate group discussions and collaborative projects.
- ➔ Use real-world scenarios and hands-on activities.
- ➔ Highlight the importance of effort, persistence, and continuous learning.
- ➔ Provide regular feedback and encourage reflection.

Work Ready

To be work-ready includes a combination of technical expertise, soft skills, and personal qualities that ensure a graduate can effectively contribute to the workplace from day one.

- ➔ Set high standards for punctuality, responsibility, professionalism, and task completion.
- ➔ Use project-based learning and collaborative assignments.
- ➔ Emphasize clear written and verbal communication.
- ➔ Offer practical exercises like mock interviews and resume workshops.
- ➔ Integrate technology and teach digital literacy.

Respectful

Graduates who embody respectfulness emphasize the importance of treating others with dignity, valuing diversity, and fostering an inclusive and positive environment, both personally and professionally.

- ➔ Demonstrate personal, interpersonal, and professional skills.
- ➔ Show respect for diversity.
- ➔ Model respect through active listening and empathy.
- ➔ Set clear expectations for respectful interactions.
- ➔ Promote collaboration and group discussions.
- ➔ Celebrate respectful behavior.
- ➔ Address disrespect promptly and constructively.

Skilled Socially

Graduates who are skilled socially are equipped to navigate social environments, build relationships, and contribute positively to their communities and workplaces.

- ➔ Show awareness of global responsibility to others and the environment.
- ➔ Participate in community involvement.
- ➔ Design cooperative group projects and team activities
- ➔ Set expectations for respect and give regular feedback.
- ➔ Facilitate discussions on inclusivity, kindness, and respect.
- ➔ Model positive interactions and recognize strong social skills.

A Critical Thinker

Critical thinkers approach problems systematically by analyzing, evaluating, and synthesizing information to make well-informed decisions and contribute to innovative solutions.

- ➔ Encourage critical thinking individually and collaboratively.
- ➔ Design lessons that challenge assumptions and explore diverse viewpoints.
- ➔ Use open-ended questions, rigorous activities, and cross-curricular projects.
- ➔ Integrate project-based learning and real-world problem-solving.
- ➔ Offer reflective opportunities like journaling and discussions.
- ➔ Cultivate an environment that values curiosity and inquiry.

An Effective Communicator

Effective communicators convey ideas, information, and emotions accurately and persuasively, fostering understanding and collaboration.

- ➔ Communicate effectively using oral, written, visual, artistic, and technical modes.
- ➔ Include group discussions, presentations, and peer reviews.
- ➔ Promote active listening and thoughtful responses.
- ➔ Offer clear guidelines and constructive feedback.
- ➔ Stress clear, respectful, and purposeful communication.

CTECS Instructional Model

CTECS uses the Marzano Compendium to guide research-based instructional strategies that differentiate learning and promote access, engagement, and success for all students. Teachers apply these strategies to support diverse learners (including multilingual learners, students with disabilities, and students with varied academic or technical backgrounds) through scaffolds, modeling, guided practice, and multiple ways to participate and show understanding. This approach ensures every student can work toward proficiency in the Priority Standards and the competencies outlined in the CTECS Vision of a Graduate.

Curriculum Introduction

This curriculum document outlines the essential learning for this academic program and provides a clear structure for planning, instruction, and assessment. It includes the components required by NEASC Standard 2.2a, along with elements that reflect the unique nature of CTECS academic programs. The curriculum is organized to show what students learn in each course, how learning progresses across grade levels, and how instruction supports both technical skill development and the CTECS Vision of a Graduate.

Teachers should use this document to:

- Understand the overall structure and expectations of the course sequence
- Reference the Course Map to see the scope and sequence of Priority Standards
- Use the Priority Standards and Units of Study to guide daily, weekly, and cycle-based planning
- Integrate Big Ideas, Essential Questions, Skills/Learning Outcomes, vocabulary, and resources during lesson design
- Plan and implement formative assessments to monitor progress and guide instruction
- Prepare students for the District Summative Assessments, ensuring alignment with the Course Map
- Maintain consistency of instruction across campuses while adapting to student needs

Curriculum Components

Course Map

A Course Map serves as the scope and sequence for this course by outlining the progression of instructional units and the standards that guide teaching and assessment. While each campus will have individual student needs, cycle schedules, and industry-based opportunities, all instructors are expected to teach the standards outlined in the Course Map. Using the Course Map below, teachers will intentionally plan learning experiences that prepare students to meet the identified standards within the designated assessment windows.

Priority Standards (Units of Study)

Priority Standards identify the most essential learning in the trade program. They reflect the core technical competencies, safety practices, and industry-aligned skills that require the greatest instructional focus and appear on program assessments. In CTE programs, each Priority Standard also functions as a Unit of Study, because it includes the required components such as big ideas, essential questions, content topics, and skills/learning outcomes aligned to assessments.

Learning Outcomes

Learning outcomes are what students will know (Concepts) and be able to do (Skills). Concepts identify the major content topics within the Priority Standard (Unit of Study). They appear in the left column of the Learning Outcomes table and follow a similar coding structure as the Priority Standard. Skills are learning objectives that describe the measurable actions students must be able to perform to demonstrate proficiency. They appear in the right column of the Learning Outcomes table and show the progression of learning evidence in the Priority Standard.

Resources

Resources include the tools, equipment, texts, materials, and digital tools that support learning within each unit and reflect industry standards.

Assessment Practices

Teachers use ongoing formative assessments—such as questioning, checks for understanding, performance demonstrations, reflections, and teacher observation—to monitor progress, guide instruction, and support all learners in mastering the Priority Standards.

Vocabulary

Essential vocabulary includes the technical and academic terms students must understand and use accurately to engage in scientific learning and demonstrate proficiency on assessments. Vocabulary is foundational to safety, precision, and communication, and should be a primary initial focus within each unit and taught explicitly through modeling, demonstration, and repeated application.

Biology - Grade 10

Description of the Course

(1 credit) Biology allows students to continue to explore aspects of the life sciences and to apply data collection, analysis, and interpretation skills related to those scientific concepts. Based on the Next Generation Science Standards, the course is made up of two related disciplines: Life Science and Engineering, Technology, and Applications of Science. This framework articulates the standards as well as the science and engineering performances, disciplinary core ideas, and crosscutting concepts. The curriculum describes the specific performances that will be assessed on the Next Generation Science Assessment. Students are expected to complete several inquiry-based projects over the course of the year.

CTECS Science Assessment & Instruction Guidelines

The grade-level **SEP (Science and Engineering Practices) Summative Assessments** for grades 9 through 11 are designed to measure mastery of the *science and engineering practices* identified by the NGSS (Next Generation and Science Standards). The practices describe behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems.

The SEPs are:

- **Asking Questions and Defining Problems**: A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested.
- **Developing and Using Models**: A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations.
- **Planning and Carrying Out Investigations**: Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters.
- **Analyzing and Interpreting Data**: Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing secondary sources for analysis.
- **Using Mathematics and Computational Thinking**: In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; statistically analyzing data; and recognizing, expressing, and applying quantitative relationships.
- **Constructing Explanations and Designing Solutions**: The products of science are explanations and the products of engineering are solutions.

- **Engaging in Argument from Evidence**: Argumentation is the process by which explanations and solutions are reached.
- **Obtaining, and Evaluating, and Communicating Information**: Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity.

Each grade-level SEP Summative Assessment is designed to assess mastery of specific **practices**. The expectation is that students should demonstrate mastery as outlined below in preparation for the NGSS Assessment in 11th grade. Cross-cutting concepts are incorporated across all courses.

Grade Level	**Science Engineering and Practices (SEP) to be Mastered**
9 General Science	Asking Questions and Defining Problems
	Planning and Carrying Out Investigations
	Analyzing and Interpreting Data
10 Biology	Developing and Using Models
	Engaging in Argument from Evidence
	Obtaining, Evaluating, and Communicating Information
11 Chemistry Advanced Topics	Using Mathematics and Computational Thinking
	Constructing Explanations and Designing Solutions

Cross-Cutting Concepts (incorporated into all courses)
Cause and Effect
Structure and Function
Systems and System Models
Scale, Proportion, and Quantity
Stability and Change
Energy and Matter
Patterns

Instruction, Grading and Assessment Considerations

The manner and pedagogy used to teach the Disciplinary Core Ideas (DCIs) is at the discretion of the instructors. They are, however, expected to support their students in demonstrating mastery of the SEPs on the common summative assessments by the end of the course, in unit order.

Instruction:

- Keeping in mind that all DCIs should be covered by the end of the school year for each course, instructors are encouraged to engage students in learning tasks that consider relevance, interest, school trades, and available materials and supplies.
- The instructional focus should be on the SEPs and the Cross-Cutting Concepts (CCCs) as identified by the NGSS.
- Instruction can be linear or spiraling and be designed around anchoring phenomena and/or storylines.
- Interim Based Assessment:
    - 10th Grade: Students will be exposed to NGSS style questions through the NGSS Practice Assessments. Skills of focus include: Test Taking Skills, Navigating Multi Select Questions, Desmos Calculator, Highlighting, Online Graphing
    - Minimum of 4 IAB practice sessions during Sophomore year.

Grading:

- As mandated by the district, Mandated Grading Categories are:
    - Assessment 40%
    - Labs/Projects 30%
    - Classwork/Activities 30%

Assessment: (Summative and Formative)

- Three dimensional district wide unit assessments will measure mastery of Science and Engineering Practices in Alignment with Cross Cutting Concepts (CCCs) and Disciplinary Core Ideas (DCIs).
- Claim Evidence Reasoning: CERs will measure a student's ability to use data, critical thinking, and scientific reasoning to form and support an argument.

Supporting ELs: For information on how to support English Learners in this unit, refer to the Connecticut English Language Proficiency (CELP) Standards with Correspondences to the K-12 Practices and Connecticut Core Standards. https://portal.ct.gov/-/media/SDE/English-Learners/celp_standards_content_standards_practices.pdf
Use the EL Strategies Desk Cards (Tip Sheets for ALL Classroom Teachers) https://www.crec.org/docs/4339/RESC_Alli-ance_Desk_Cards_Revised_2.pdf for specific questioning techniques and teaching strategies to sup-port students' learning.

Course Map - 10th Grade Biology

Unit	Cycles	Big Ideas	Priority Standards (*Supporting Standards)	Interim Assessments
Unit 1: Molecules to Organisms: Structures and Processes	**1-3**	**Big Idea(s):** Basic organization of organisms and their ability to maintain stability	HS-LS1-2 (Organization of systems in multicellular organisms) HS-LS1-3 (Homeostasis) HS-LS 1-5 (Photosynthesis) HS-LS 1-7 (Cellular respiration) [HONORS] HS-LS1-6 (Macromolecules)	HS-LS1-2 HS-LS1-3 HS-LS1-6
Unit 2: Inheritance and Variation of Traits	**4-5**	**Big Idea(s):** Energy conversion Genetic inheritance	HS-LS 1-4 (Cellular Division) HS-LS 3-1 (Chromosomal inheritance) HS-LS 1-1 (genes, proteins, & tissues) HS-LS 3-2 (Genetic Variation) [HONORS] HS-LS3-3 (Variation and distribution of traits)	HS-LS1-1 HS-LS3-2 HS-LS3-3
Unit 3: Natural Selection and Adaptation	**6-8**	**Big Idea(s):** Biological evolution and how organisms change over time	HS-LS 1-4 (Cellular Division) HS-LS 3-1 (Chromosomal inheritance) HS-LS 1-1 (genes, proteins, & tissues) HS-LS 3-2 (Genetic Variation) [HONORS] HS-LS3-3 (Variation and distribution of traits)	HS-LS4-1 HS-LS4-2 HS-LS4-5
Unit 4: Ecosystems	**9-10**	**Big Idea(s):** Identify and explain relationships within an ecosystem	HS-LS2-1 (Carrying capacities) *HS-LS2-2 (Factors affecting biodiversity) HS-LS2-3 (Cycling of matter - aerobic and anaerobic) [HONORS] HS-LS2-4 (Cycling of matter ecosystems) *HS-LS2-6 (Interactions between ecosystems) *HS-LS2-7* (Reducing impacts on environment and biodiversity) [HONORS] HS-LS2-8 (Group behaviors between species for survival)	HS-LS2-1 HS-LS2-2 HS-LS2-4 HS-LS2-6 HS-LS2-7

Unit 1: Molecules to Organisms: Structures and Processes

Organization of systems in multicellular organisms

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Priority Standard (Performance Expectation): HS-LS1-2
Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.

Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.

Big Idea(s):

- Life is a masterpiece of coordination; no cell or organ functions in isolation, and the failure of even one microscopic component can disrupt the stability of the entire macroscopic organism

Essential Question(s):

- How do trillions of individual cells coordinate their efforts like a professional sports team to keep you alive and functioning?

Examples of Engaging Phenomenon:

- Giant Squid Chromatophores: How the visual system, nervous system, and integumentary (skin) system work together to change the squid's color and texture for camouflage or communication.
- Runner's High: The interaction between the respiratory, circulatory, and nervous systems during intense physical activity.
- Blood Glucose Control: How the digestive system (nutrient intake) and circulatory system (transport) interact with the pancreas to maintain homeostasis.
- The Pupillary Reflex: How the nervous and muscular systems interact to regulate light entering the eye.

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)
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.	• Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. • Assemble or complete an illustration or flow chart that is capable of representing how structures in two (or more) body systems

- Specialized cells within organisms help them perform the essential functions of life, which involve chemical reactions that take place between different types of molecules such as water, proteins, carbohydrates, lipids, and nucleic acids.
- 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.

Feedback mechanisms

- 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. Outside that range (e.g., at a too high or too low external temperature, with too little food or water available), the organism cannot survive.

interact to carry out normal, necessary bodily functions. (This does not include labeling an existing diagram.)

- Identify and describe, using the developed model, the relationships between the structures and their coordinated functions in two (or more) body systems.
- Show, using the developed model, that interacting systems have a hierarchical organization and provide specific functions within the body at those specific levels or organization.
- Make predictions about, or generate explanations for, how additions/substitutions/removal of certain components in the model can interrupt or change the relationships between those components and, thus, the bodily functions carried out by those structures in two (or more) body systems.
- Identify the components and the mechanism in each level of the hierarchy OR identify the properties of the components that allow those functions to occur, given models or diagrams of hierarchical organization of interacting systems.
- Identify missing components, relationships, or other limitations of the model.

Cross-Cutting Concepts: 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.

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
  - Circulatory, respiratory, digestive, excretory, nervous, immune, integumentary, skeletal, muscle, reproductive, external stimuli, cell, tissue, organ, multicellular

- Additional tier 2 words that students should be familiar with: - Models, relationship, evidence, illustrate, data Science vocabulary students are NOT expected to know: Synaptic transmission, neuron, neurotransmitter, biofeedback, hormonal signaling.
Resources: NGSS Phenomenon Master List, HS-LS1-2: Interacting Body Systems

Homeostasis

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Priority Standard (Performance Expectation): HS-LS1-3
Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Clarification Statement: Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels.

Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanism.

Big Idea(s):
- Living systems are expert "balancers," using real-time feedback loops to maintain internal stability even when external conditions become extreme or hostile.

Essential Question(s):
- What internal "sensors" keep your body from crashing during physical stress, and what happens when the balance is broken?

Examples of Engaging Phenomenon:
- Fruit ripeness (positive feedback loop):
  - In nature, a tree or bush will suddenly ripen all of its fruits or vegetables without any visible signal.
- Human blood sugar concentration (negative feedback loop):
  - The liver both stores and produces sugar in response to blood glucose concentration.
  - The pancreas releases either glucagon or insulin in response to blood glucose concentration.
- Sunning lizards (negative feedback loop):
  - Lizards sun on a warm rock to regulate body temperature.
- Thermoregulation in dolphins due to counter-current arrangement of veins around arteries (negative feedback loop):
  - The counter-current system minimizes the loss of heat incurred when blood travels to the different parts of dolphins' bodies.
- HS-LS1-3: Feedback Mechanisms and Homeostasis
- HS-LS1-3: Feedback Mechanisms and Homeostasis: Marathon Runner Collapse

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)
<u>Feedback Mechanisms</u> ● Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and	**Planning and Carrying Out Investigations** ● 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

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<td>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. Outside that range (e.g., at a too high or too low external temperature, with too little food or water available), the organism cannot survive.</td>
<td>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.
● Identify the outcome data that should be collected in an investigation to provide evidence that feedback mechanisms maintain homeostasis. This could include measurements and/or identifications of changes in the external environment, the response of the living system, stabilization/destabilization of the system's internal conditions, and/or the number of systems for which data are collected.
● Record observations about the external factors affecting systems interacting to maintain homeostasis, responses of living systems to external conditions, and/or stabilization/destabilization of the systems' internal conditions.
● Identify or describe the relationships, interactions, and/or processes that contribute to and/or participate in the feedback mechanisms maintaining homeostasis that lead to the observed data.
● Express or complete a causal chain, using the collected data, explaining how the components of (a) mechanism(s) interact in response to a disturbance in equilibrium in order to maintain homeostasis. This may include indicating directions of causality in an incomplete model such as a flow chart or diagram, or completing cause and effect chains.
● Evaluate the sufficiency and limitations of data collected to explain the cause and effect mechanism(s) maintaining homeostasis.</td>
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<tr>
<td colspan="2"><u>Cross-Cutting Concepts</u>: Stability and Change
- Feedback (negative or positive) can stabilize or destabilize a system.</td>
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<tr>
<td colspan="2"><u>Academic Vocabulary:</u>
- Science vocabulary students ARE expected to know:
    - Equilibrium, steady state, stable state, balanced state, stimulus, receptor, biotic factor, abiotic factor, external environment, internal environment, muscle, nerve, hormone, enzyme, chemical regulator, gland, system, metabolism,</td>
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disturbance, fluctuation, maintenance, concentration, hibernation, positive feedback, negative feedback.

- Additional tier 2 words that students should be familiar with:
    - Develop, plan, investigation, data, regulation, thermoregulation

Science vocabulary students are NOT expected to know: Receptor proteins, ligands, signal transduction, phosphorylation cascade, feedback inhibition, Effector, osmoregulation, conformer, set point, sensor, circadian rhythm, acclimatization, thermoregulation, endothermic, ectothermic, integumentary system, countercurrent exchange, bioenergetics, basal metabolic rate, standard metabolic rate, torpor, poikilotherm, homeotherm, countercurrent heat exchange.

Resources: NGSS Phenomenon Master List

Macromolecules [HONORS]

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Priority Standard (Performance Expectation): HS-LS1-6
Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.

Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.

Big Idea(s):

- Sugar molecules are more than just fuel; they are the atomic "LEGO set" of life, providing the raw material backbones needed to build proteins, lipids, and DNA.
- Scientific explanations require evidence-based modeling: Understanding complex biological synthesis requires constructing and revising explanations based on valid evidence from models, simulations, and investigations.

Essential Question(s):

- How can your body take simple atoms from a snack and rearrange them into the complex molecular machinery required for survival?

Examples of Engaging Phenomenon:

- Hagfish produce and are covered in a thick layer of protective slime.
- The black widow spider's silk is several times as strong as any other known spider silk, making it about as durable as Kevlar.
- The female silk moth releases a pheromone that is sensed by the male's feather-like antennae, inducing his excited fluttering behavior.
- The bombardier beetle releases a boiling, noxious, pungent spray that can repel potential predators.
- HS-LS1-6: Formation of Carbon-Based Molecules

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)
<u>Organization for Matter and Energy Flow in Organisms</u> ● Chemical elements are recombined in different ways to form different products as matter and energy flow through different organizational levels of living systems	**Constructing Explanations and Designing Solutions** ● 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

- Energy is transferred from one system of interacting molecules to another as a result of these chemical reactions
- Photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.

Sugar molecules formed contain carbon, hydrogen, and oxygen

- 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)
- Aerobic (in the presence of oxygen) 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.
- Anaerobic (without oxygen) cellular respiration follows a different and less efficient chemical pathway to provide energy in cells.
- Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy loss to the surrounding environment.
- Matter and energy are conserved in each change. This is true of all biological systems, from individual cells to ecosystems.

continue to do so in the future.

- Describe, identify, or select evidence supporting or contradicting a claim that sugar molecules containing organic elements (e.g., carbon, hydrogen, and oxygen) that are ingested by an organism are broken down and rearranged via chemical reactions to form proteins, lipids, and nucleic acids.
- Identify and justify additional pieces of evidence that would help distinguish between competing hypotheses.
- Express or complete a description of the flow of energy and/or matter within and between living systems. This may include indicating directions of causality in an incomplete model such as a flow chart or diagram, or completing cause and effect chains.
- Articulate, describe, or select the relationships, interactions, reactions and/or processes to be explained. This may entail sorting relevant from irrelevant information or features of the reactants and products.
- Predict the effects of subsequent changes in the amount and types of organic molecules ingested and the amount and type of products formed within a living system, given an appropriate explanation for a phenomenon

Cross-Cutting Concepts: 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.

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
  - Hydrocarbon, protein, polypeptide, carbohydrate, amino acid, nucleic acid, DNA, ATP, lipid, fatty acid, ingestion, rearrangement, stable, open system, polymer, monomer, organic, inorganic, enzyme.
- Additional tier 2 words that students should be familiar with:

- Construct, explain, design, evidence, reasoning Science vocabulary students are NOT expected to know: Hydroxyl, carboxyl, amine, phosphate, isomer, functional group, hydrolysis, dehydration synthesis, Endothermic reaction, exothermic reaction, aerobic respiration, oxidation, reduction, oxidation-reduction reaction, glycolysis, citric acid cycle, electron transport chain.
Resources: NGSS Phenomenon Master List

Photosynthesis

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Priority Standard (Performance Expectation): HS-LS1-5
Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

Clarification Statement: 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 Boundary: Assessment does not include specific biochemical steps.

Big Idea(s):

- Plants are the planet's primary "energy harvesters," performing the incredible feat of trapping the energy of a star 93 million miles away and using it to build complex living structures out of thin air and water.

Essential Question(s):

- How does a plant transform light energy into a "solid" chemical battery that powers almost all life on Earth?

Examples of Engaging Phenomenon:

- A maple tree in Washington state survives in the winter after losing all of its leaves.
- The waters of the Laguna Grande lagoon in Puerto Rico give off a bluish-green glow at night when disturbed.
- On the sill of a stained glass window, a soy plant behind the red glass panel grew taller than a soy plant behind the green glass panel.
- In a parking lot in the city of Bordeaux, France a tank filled with algae produces a green light.
- HS-LS1-5: Photosynthesis and Energy Transformation

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)
<u>Photosynthesis</u> • Photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. • Sugar molecules thus formed contain carbon, hydrogen, and oxygen; their hydrocarbon backbones are used to make amino acids and	**Developing and Using Models** • Illustrate the relationships between systems or between components of a system. • Assemble or complete, from a collection of potential model components and distractors, an illustration or flow chart that is capable of representing the transformation of light energy into stored chemical energy.

other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. ● Chemical elements are recombined in different ways to form different products as matter and energy flow through different organizational levels of living systems. ● Energy is transferred from one system of interacting molecules to another, as a result of these chemical reactions.	● Identify and describe, using a model, the relationships in terms of matter and/or energy between the reactants and the products of photosynthesis ● Show the transfer of matter and flow of energy between an organism and its environment during photosynthesis.

Cross-Cutting Concepts: 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.

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
    - Organic, hydrocarbon, net transfer, chloroplast, chlorophyll, cytoplasm, mitochondria, vacuole, nucleus, protein, ATP, amino acid, autotroph(s), heterotroph(s), algae
- Additional tier 2 words that students should be familiar with:
    - Model, illustrate, relationship, component

Science vocabulary students are NOT expected to know: Thylakoid, NADP(H/+), Calvin cycle, carbon fixation, redox reactions, electron transport chain, oxidative phosphorylation, photoautotroph(s), mesophyll, stomata, stroma, thylakoids, thylakoid membrane, light reactions, carotenoids, cytochrome complex, C3 plants, C4 plants

Resources: NGSS Phenomenon Master List

Cellular Respiration

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Priority Standard (Performance Expectation): HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy.
Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration. Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.
Big Idea(s): ● Cellular respiration is the universal "molecular engine" that unlocks the energy stored in food, breaking down chemical bonds to provide the power needed for every heartbeat, thought, and muscle movement.
Essential Question(s): ● How do your cells "break" the energy out of your food, and what determines how efficiently you can use that energy to survive?
Examples of Engaging Phenomenon: ● A young plant is grown in a bowl of sugar water. As it grows, the amount of sugar in the water decreases. ● A bacterial colony in a petri dish is continually provided with sugar water. Over the course of a few days, the bacteria grow larger. When sugar water is no longer provided, the colonies shrink and some disappear. ● A person feels tired and weak before eating lunch. After eating some fruit, the person feels more energetic and awake. ● An athlete completing difficult training feels that her muscles recover and repair faster when she eats more food in a day, compared to when she ate less food in a day. ● HS-LS1-7: Cellular Respiration and Energy Transfer

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)
<u>Cellular Respiration</u> ● Chemical elements are recombined in different ways to form different products as matter and energy flow through different organizational levels of living systems. ● Energy is transferred from one system of	**Developing and Using Models** ● Illustrate the relationships between systems or between components of a system, using a model. ● Assemble or complete an illustration or flow chart that is capable of representing the transformation of food plus oxygen into energy and/or new compounds. This does not include labeling an existing

<table>
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interacting molecules to another as a result of these chemical reactions.

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.

</td>
<td>
diagram.

Identify and describe, using the developed model, the relationships between the reactants of the transformation and the products of the transformation.
Show that matter and energy are only rearranged during cellular respiration, but never created or destroyed, using the developed model.
Make predictions about howadditions/substitutions/removals of certain components can maintain/destroy the balance of the food plus oxygen → energy/new compounds reaction.
Identify the components and the mechanism in each scenario OR identify the properties of the components that allow cellular respiration to occur, given models or diagrams of cellular respiration.
Identify missing components, relationships, or other limitations of the model.
Describe, select, or identify the relationships among components of a model that describe or explain cellular respiration.

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<td colspan="2">
<u>Cross-Cutting Concepts</u>: 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.

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<tr>
<td colspan="2">
<u>Academic Vocabulary:</u>

Science vocabulary students ARE expected to know:

ATP, chemical bonds, energy transfer, glycolysis, enzymes, mitochondria, cytosol, cytoplasm, nitrogen, adenine, phosphate, amino acid.

</td>
</tr>
</table>

- Additional tier 2 words that students should be familiar with:
  - Model, evidence, illustrate, relationship, components, system

Science vocabulary students are NOT expected to know: Biochemical, fatty acids, oxidizing agent, electron acceptor, biosynthesis, locomotion, phosphorylation, electron transport chain, chemiosmosis, pyruvate,NADH, pentose.

Resources: NGSS Phenomenon Master List, HS-LS1-7: Cellular Respiration and Energy Transfer

Unit 2: Inheritance and Variation of Traits

Cellular Division

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<table>
<tr><td colspan="2">Priority Standard (Performance Expectation): HS-LS1-4
Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.</td></tr>
<tr><td colspan="2">Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.</td></tr>
<tr><td colspan="2">Big Idea(s):
● Every complex organism is the result of a precise biological "expansion plan" where a single cell must divide and specialize perfectly to build a functioning body.</td></tr>
<tr><td colspan="2">Essential Question(s):
● If every cell in your body has the exact same DNA, how does one become a brain cell while another becomes a bone cell?</td></tr>
<tr><td colspan="2">Examples of Engaging Phenomenon:
● Plant cells in a root tip longitudinal cross section are different sizes and shapes.
● HS-LS1-4: Cellular Division and Differentiation</td></tr>
<tr><td>Students will know: (Disciplinary Core Ideas)</td><td>As evidenced by: (Science & Engineering Practices)</td></tr>
<tr><td><u>Cell Division: Mitosis</u>
● Cells grow and then divide via a process called mitosis, thereby allowing the organism to grow.
● Organisms begin 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</td><td>Developing and Using Models
● Illustrate, using a model based on evidence, the relationships between systems or between components of a system together to meet the needs of the whole organism.</td></tr>
</table>

complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. ● Successive subdivisions of an embryo's cells occur, programmed genetic instructions and small differences in their immediate environments activate or inactivate different genes, which cause the cells to develop differently—a process called differentiation. **Cell Division: Meiosis** ● In sexual reproduction, a specialized type of cell division called meiosis occurs that results in the production of sex cells, such as gametes in animals (sperm and eggs), which contain only one member from each chromosome pair in the parent cell.	

Cross-Cutting Concepts: 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.

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
  - Nucleus, chromosome, sister chromatids, sperm cell, egg cell, fertilize, genome, gene, differential gene expression, cellular differentiation, cellular division, cytoplasm, daughter cell, parent cell, somatic cell, cell cycle, homologous, haploid, diploid, DNA.
- Additional tier 2 words that students should be familiar with:
  - Model, evidence, illustrate, relationship, component, system, scales

Science vocabulary students are NOT expected to know: Spindle, metaphase plate, cleavage furrow, chromatin modification, transcription regulation initiation, enhancers, transcription factors, post-transcriptional regulation; noncoding RNAs, cytoplasmic determinants, inductive signals, chiasmata, kinetochore, microtubule, Epigenetics, interphase, prophase, metaphase, anaphase, telophase, cytokinesis, epistasis.

Resources: NGSS Phenomenon Master List

Chromosomal Inheritance

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Priority Standard (Performance Expectation): HS-LS3-1
Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

Big Idea(s):

- Chromosomes are the physical "instruction manuals" for life; they serve as the structural vehicles that ensure your parents' traits are accurately packaged and transmitted to you through a long molecule called DNA.

Essential Question(s):

- How can a single microscopic molecule carry the specific "code" for an entire organism, and how is that code handed down from one generation to the next?

Examples of Engaging Phenomenon:

- DNA sequencing shows that all people have the gene for lactase production, but only about 30% of adults can digest milk.
- Polydactyl tabby cat Jake holds the world record for most toes, with seven toes on each paw.
- E. coli bacteria are healthful in mammalian intestines but make mammals sick when ingested.
- E. coli bacteria are used to produce human insulin.
- HS-LS3-1: Chromosomal Inheritance

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)
<u>Structure and Function</u> ● 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. **<u>Inheritance of Traits</u>** ● Genetic instructions for forming species' characteristics are carried in the chromosomes. ● Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. ● Instructions for forming species' characteristics are carried in DNA. **<u>Gene expression</u>** ● 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.	**Asking Questions and Defining Problems** ● Ask questions that arise from examining models or a theory to clarify relationships. ● Identify or construct an empirically testable question based on the phenomenon that could lead to design of an experiment or model to define the relationships between the role of DNA and/or chromosomes in the inheritance of traits. ● Assemble or complete, from a collection of potential model components, an illustration, or pedigree that is capable of representing the role of genetic material in coding the instructions for inheritance. ● Construct a question that arises from examining a model or theory to clarify the connections between DNA/chromosomes and inheritance of traits. ● Make predictions about the pattern of inheritance based on a model derived from the empirically testable question. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors. ● Assemble or complete a flow chart describing the cause and effect relationships between genetic material and the characteristic traits passed from parents to offspring.
<u>Cross-Cutting Concepts</u>: Cause and Effect - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

Academic Vocabulary:
- Science vocabulary students ARE expected to know:
    - Genome, zygote, fertilization, dominant, recessive, codominance, incomplete dominance, sex-linked, allele, sequencing, pedigree, parent generation, F1, F2, haploid, diploid, replication.
 	
- Additional tier 2 words that students should be familiar with:
    - Question, define, examine, model, clarify, evidence, correlation, cause (causation), claim
 	
Science vocabulary students are NOT expected to know: Epigenetics, interphase, prophase, metaphase, anaphase, telophase, cytokinesis, epistasis.

Resources: NGSS Phenomenon Master List, Why Do Humans Have Different Colored Skin?, Hemingway's Polydactyl Cats, The Inner Life of the Cell, Malaria and Sickle Cell Anemia, Hox Genes, The Potential and Ethics of CRISPR, Shrew Caravan

Genes, proteins & tissues

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Priority Standard (Performance Expectation): HS-LS1-1
Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.

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

Big Idea(s):

- DNA is the "master architect," but proteins are the "builders." The specific sequence of your DNA dictates the shape of your proteins, which in turn determines every physical characteristic you possess.

Essential Question(s):

- How does the "invisible" language of your DNA determine the physical structure and essential functions of your specialized cells?

Examples of Engaging Phenomenon:

- Sweat glands cool the body by releasing sweat onto the skin's surface. A protein transports salt to help carry the water to the skin's surface. In some individuals, the salt is not reabsorbed and is left on the skin.
- When a blood vessel is cut, several proteins act to form a blood clot. This blood clot helps to stop the loss of blood from the body. In some individuals, when a blood vessel is cut, a blood clot does not form.
- During cell division, a copy of DNA in the cell is made. Sometimes mistakes are made in the DNA copy that are corrected by specific proteins. In some cells, when those mistakes in the DNA are not corrected, uncontrolled cellular division results.
- After a person eats, sugars from food are absorbed from the bloodstream into the body's cells. Insulin—a polypeptide hormone—allows those cells to absorb glucose from the bloodstream. In some individuals, sugars are not absorbed into the body's cells and are left in the bloodstream.
- HS-LS1-1: Genes, Proteins, and Tissues

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)
Structure and Function ● Systems of specialized cells within organisms help them perform the essential functions of life, which involves chemical reactions that take place between different types of molecules, such as	**Constructing Explanations and Designing Solutions** ● 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

water, proteins, carbohydrates, lipids, and nucleic acids. ● 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	world operate today as they did in the past and will continue to do so in the future. ● Describe the cause and effect relationship between a DNA sequence and the structure/function of a protein. This may include indicating the directions of causality in a model or completing a cause and effect chain. ● Describe, identify, or select evidence that supports or contradicts a claim about the role of DNA in causing the phenomenon. The evidence may be obtained from valid source(s) or might be generated by students using a simulation. ● Predict, given an appropriate explanation for a phenomenon, the effects of subsequent changes to a DNA sequence in protein structure and function. Predictions may be selected from a collection of possibilities, including distractors, or they might be illustrated or described in writing. ● Construct, using evidence, an explanation of how protein structure and subsequent function depend on a DNA sequence. ● Identify and justify additional pieces of evidence that would help distinguish between competing hypotheses.

Cross-Cutting Concepts: 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.

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
  - Nucleus, chromosome, DNA, nucleated cell, transcription, double helix, adenine, guanine, cytosine, thymine, deoxyribose, phosphate, hydrogen bond, nucleotide base, mRNA, amino acid, translation

- Additional tier 2 words that students should be familiar with:
  - Construct, explain/explanation, design, solution, evidence, model, system, component

Science vocabulary students are NOT expected to know: primary, secondary, tertiary protein structure, tRNA, ribosome.

Resources: NGSS Phenomenon Master List

Genetic variation

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Priority Standard (Performance Expectation): HS-LS3-2
Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.

Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

Big Idea(s):
- Diversity is a survival strategy; nature uses chromosomal "shuffling" and occasional replication "typos" to ensure a population is prepared for an unpredictable future.

Essential Question(s):
- Why is being "different" a biological necessity, and how does nature create that variety without breaking the system?

Examples of Engaging Phenomenon:
- Due to pesticide residue, frogs have extra, non-functioning, limbs.
- Most chickens have feathers that lay flat against their bodies. In one family of chickens, 50% of offspring have feathers that curl away from their bodies.
- A single gene mutation accounts for the blue color of irises in over 99.5% of people with blue eyes.
- One sunflower growing in a field has a wide, flat stem and an unusual number of leaves. The next year, several sunflowers in the field shared these traits.
- HHS-LS3-2: Inheritable Genetic Variation

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)
<u>Variation of Traits: Sexual Reproduction</u> ● Chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. ● DNA replication is tightly regulated and remarkably accurate, but errors do occur and	**Engaging in Argument from Evidence** ● Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence. ● Make or construct a claim, based on the provided data, regarding inheritable genetic variations that may result from: 1) new genetic combinations through meiosis, 2) viable errors occurring

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.	during replication, and/or 3) mutations caused by environmental factors. This does not include selecting a claim from a list. ● Sort inferences about inheritable genetic variation into those that are supported by the data, contradicted by the data, outliers in the data, or none of these—or some similar classification. ● Identify patterns of information/evidence in the data that support correlative/causative inferences about inheritable genetic variation. ● Construct an argument using scientific reasoning that draws on credible evidence to explain how 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. ● Identify additional evidence that would help clarify, support, or contradict a claim or causal argument. ● Identify, describe, and/or construct alternate explanations or claims, and cite the data needed to distinguish among them. ● Predict outcomes of genetic variations, given the cause-and-effect relationships of inheritance.

Cross-Cutting Concepts: Cause and Effect

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

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
    - Amino acid, DNA, enzyme, protein synthesis, chromosome, egg, egg cell, sperm, sperm cell, dominant trait, recessive trait, recombination, sex cell, sex chromosome, sex-linked trait, meiosis, mutation, advantageous, expression, base pairs, genome, UV radiation, triplet codon, insertion, deletion, frameshift, substitution, somatic, epigenetic.

- Additional tier 2 words that students should be familiar with:
  - Argument, evidence, defend, claim, cause and effect, correlation, causation

Science vocabulary students are NOT expected to know: Polyploidy, single nucleotide polymorphisms (SNPs), conjugation, DNA polymerase, mutagenic, chromosomal translocation, missense, nonsense, non-genic region, tautomerism, depurination, deamination, slipped-strand mispairing, Sheik disorder, prion, epidemiology.

Resources: NGSS Phenomenon Master List

Variation and distribution of traits [HONORS]

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Priority Standard (Performance Expectation): HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits. Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.
Big Idea(s): ● Inherent Variation in Populations: Populations are characterized by a range of expressed traits, meaning that individuals within a group will naturally show differences rather than being identical ● Probability as a Predictive Tool: Probability is used to explain the likelihood and frequency with which specific traits will appear across different individuals in a population ● Data-Driven Biological Explanations: Using math and statistics provides a rigorous framework for explaining the complex patterns of inheritance and physical expression seen in nature
Essential Question(s): ● How can concepts of statistics and probability be used to explain the variation and distribution of expressed traits in a population?
Examples of Engaging Phenomenon: ● O Positive is the most common blood type. Not all ethnic groups have the same mix of these blood types. Hispanic people, for example, have a relatively high number of O's, while Asian people have a relatively high number of B's. ● Hydrangea flowers of the same genetic variety range in color from blue-violet to pink, with the shade and intensity of color depending on the acidity and aluminum content of the soil. ● Most humans were born with five fingers on each hand, yet the polydactyl trait (having more than five fingers on each hand) is the dominant trait. ● When a red rose is crossed with a white rose, all pink roses are produced. ● HS-LS3-3: Variation and Distribution of Traits

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)

<table>
<tr>
<td><u>Variation of Traits: Environmental Factors</u>
● 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.</td>
<td>Analyzing and Interpreting 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.
● Describe data or patterns/relationships in given data that support (or refute) an explanation for the change in trait frequency or magnitude in a population, due to both genetic and environmental factors.
● Make predictions about the trait frequency or distribution in a population due to the presence/absence or addition/removal of both genetic and environmental factors.
● Organize and/or arrange (e.g., using illustrations and/or labels) data, or summarize data to provide evidence for an explanation of the relationship between a trait's occurrence in a population and genetic and environmental factors.
● Analyze, evaluate, estimate, calculate, and/or construct an equation for the statistical mean and/or the standard deviation, to describe the change in the distribution of a trait in a population over time, due to genetic and environmental factors.
● Identify statistical anomalies or outliers for a trait or a population that are outside the expected range (norm reaction), which may or may not be quickly removed due to genetic and environmental factors.</td>
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<tr>
<td colspan="2"><u>Cross-Cutting Concepts:</u> 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).</td>
</tr>
</table>

Academic Vocabulary:
- Science vocabulary students ARE expected to know:
    - Gene, allele, dominant, recessive, homozygous, heterozygous, phenotype, genotype, P generation, F1 generation, F2 generation, complete dominance, incomplete dominance, codominance, pedigree, carrier, fertilization, sex linked traits, gamete, Mendelian genetics, zygote, haploid, diploid, epistasis.
- Additional tier 2 words that students should be familiar with:
    - Analyze, interpret, data, statistics (determining function fits to data, slope, intercept, and correlation to coefficient for linear fits), predict, variable, linear growth vs exponential growth, probability
 	
Science vocabulary students are NOT expected to know: Test-cross, monohybrid, dihybrid, law of independent assortment, law of segregation, pleiotropy, norm of reaction, multifactorial, Barr Body, genetic recombination, latent allele.

Resources: NGSS Phenomenon Master List, Galapagos Finch Evolution, Corn Cob Sprouting in WaterMalaria and Sickle Cell Anemia ,

Unit 3: Natural Selection and Adaptation

Evolution Inheritance Factors

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Priority Standard (Performance Expectation): HS-LS4-2
Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on the number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.
Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.

Big Idea(s):
- Evolution is not a random occurrence but the predictable result of four interacting factors: population growth, genetic variety, limited resources, and the survival of those with the best traits.

Essential Question(s):
- Why is the "survival of the fittest" an inevitable mathematical outcome when life meets the limitations of its environment?

Examples of Engaging Phenomenon:
- Cane toads introduced to Australia in the 1930s have evolved to be bigger, more active, and have longer legs.
- In the late 1990s, a resurgence of bed bug outbreaks began. Bed Bugs are now much harder to kill with thick, waxy exoskeletons, faster metabolism, and mutations to block certain insecticides.
- Skinks living in cooler regions give live birth, while those living in warm coastal areas lay eggs.
- A butterfly parasite found on the Samoan Islands destroyed the male embryos of blue moon butterflies, decreasing the male population to only 1%. After a year, males had rebounded to 40% of the population.
- Hox genes control the body plan of organisms with each hox gene coding for a specific body part. Hox gene mutations can lead to investigations on development. Similarities in hox genes across various animals can show phylogeny. https://youtu.be/voQQ1dhCqZg
- HS-LS4-2: Four Factors of Natural Selection

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)

<u>Natural Selection</u>
● Natural Selection occurs only if there is both
    ● variation in the genetic information between organisms in a population and
    ● variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals.
<u>Evidence of Common Ancestry and Diversity</u>
● Evolution is a consequence of the interaction of four factors:
    ● the potential for a species to increase in number
    ● the genetic variation of individuals in a species due to mutation and sexual reproduction
    ● competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce
    ● the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.
	Constructing Explanations and Designing Solutions
	● 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.
	● Describe the cause-and-effect relationship between: (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, and change in species over time. This may include indicating directions of causality in a model or completing cause-and-effect chains.
	● Describe, identify, or select evidence supporting or contradicting a claim about the role of (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 in causing the phenomenon. The evidence may be evidence generated by the students in the simulation or selected from provided data.
	● Predict, given an appropriate explanation for a phenomenon, the effects of subsequent changes in environmental conditions on the population.
	● Construct an explanation, using evidence, of the changes in species over time as a result of (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.
	● Identify and justify additional pieces of evidence that would help distinguish between competing hypotheses for the changes in species over time.

<u>Cross-Cutting Concepts</u>: Cause and Effect - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
    - Beneficial change, detrimental change, distribution, emergence, gene frequency, biotic, abiotic, advantageous, diverge, proliferation, bottleneck effect, island effect, geographic isolation, founder effect, recombination.
- Additional tier 2 words that students should be familiar with:
    - Construct, explanation, design, solution, evidence, cause and effect, claim, correlation

Science vocabulary students are NOT expected to know: Hardy-Weinberg equilibrium, biotechnology, relative fitness, directional selection, disruptive selection, stabilizing selection, heterozygote advantage, frequency-dependent selection, prezygotic barriers, postzygotic barriers.

Resources: NGSS Phenomenon Master List,

Evidence of ancestry and evolution [HONORS]

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Priority Standard (Performance Expectation): HS-LS4-1
Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence

Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.

Big Idea(s):

- Evolution is the fundamental process responsible for the diversity of life on Earth, involving changes in the inherited traits of populations across generations
- The scientific community's understanding of evolution is built upon empirical evidence—information acquired by observation or experimentation—rather than theoretical speculation
- Support for common ancestry does not come from a single source; instead, it is reinforced by multiple lines of evidence from various scientific disciplines

Essential Question(s):

- How can scientific information be effectively communicated to support the concepts of common ancestry and biological evolution?
- How can evidence be used to support the theory of evolution?

Examples of Engaging Phenomenon:

- Red pandas look a bit like bears and a bit like raccoons. Task Statement: Provide evidence about whether red pandas are better classified as raccoons or bears. Stimulus material might include pictures, DNA information, embryological information, and homologous structures.
- Hermit crabs live in shells, like oysters, but look like crabs. Provide evidence classifying hermit crabs either as mollusks (like oysters) or arachnids (like crabs).
- Crawfish look just like lobster, but smaller. Which came first, the lobster or the crawfish?
- Fossil records of an extinct hooved animal show a thickened knob of bone in its middle ear. This structure is also found in modern whales and helps them hear underwater.
- Megafauna Extinction: Did Humans or Climate Kill Off the Mammoths?: https://youtu.be/x_Nx6C5cSHU
- HS-LS4-1: Evidence of Common Ancestry and Diversity

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)

Evidence of Common Ancestry and Diversity	Obtaining, Evaluating, and Communicating Information
● Genetic information, like the fossil record, provides evidence of evolution. ● DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. ● Genetic information is derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.	● 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). ● Analyze and interpret scientific evidence from multiple scientific/technical sources including text, diagrams, charts, symbols, mathematical representations that support common ancestry among organisms and/or biological evolution. ● Evaluate the validity/relevance/reliability of scientific evidence about biological evolution. ● Identify relationships or patterns in scientific evidence at macroscopic and/or microscopic scales. ● Describe the specific evidence needed to support an explanation about how organisms share a common ancestor. ● Synthesize an explanation with evidence from multiple sources.

Cross-Cutting Concepts: 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

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
    - Amino acids, cladogram, comparative anatomy, DNA sequencing, electrophoresis, embryology, evolution, fossil record, gene flow, genetic drift, mutation, natural selection, nucleotides, sedimentary layers, species, descent with modification, homologous structures, evolutionary tree, analogous structures.
- Additional tier 2 words that students should be familiar with:
    - Evaluate, communicate, pattern(s), scale(s), scientific information, evidence, explain

Science vocabulary students are NOT expected to know: Phylogenetic, phylogeny, phylogenetic tree, taxonomy, cladistics, vestigial structures, convergent evolution, analogous, endemic, phylocode, sister taxa, basal taxon, polytomy, homoplasy, molecular systematics, monophyletic, paraphyletic, polyphyletic, maximum parsimony, orthologous genes, paralogous genes, horizontal gene transfer.

Resources: NGSS Phenomenon Master List

Statistics of inheritable traits

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Priority Standard (Performance Expectation): HS-LS4-3
Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

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

Big Idea(s):

- The increase in frequency of a trait within a population is dependent on it being heritable, meaning it can be passed down from one generation to the next.
- Scientists use concepts of statistics and probability to provide rigorous support and explanations for how trait distributions change within a population
- Over time, there is a measurable trend where organisms with advantageous traits increase in proportion relative to those that lack such trait

Essential Question(s):

- How does evidence support the claim that organisms with advantageous heritable traits increase in proportion over time?
- How can we apply concepts of statistics and probability to analyze and explain changes in the prevalence of advantageous heritable traits within populations?

Examples of Engaging Phenomenon:

- Green Treefrogs (Hyla versicolor) are abundant in the wetlands of Florida where no Gray Treefrogs (Hyla cinerea) are observed. In the wooded areas of New York, only Gray Treefrogs are observed.
- In the Amazon rainforest, a kapok tree (Ceiba pentandra) measures 200 feet in height, approximately 30 feet above the rest of the canopy.
- A school of mummichog fish (Fundulus heteroclitus) is found in the 6°C waters of the Chesapeake Bay. These fish are normally found in warmer climates, like the 21°C waters of Kings Bay, Georgia.
- A population of the fish Poecilia mexicana lives in the murky hydrogen-sulfide (H2S)-rich waters in southern Mexico that would kill the same species of fish living in clear freshwaters only 10 km away.
- https://youtu.be/TmyfqjXOf7M
    - Certain species of darkling beetles that live in the Namib Desert are able to harvest water vapor using an ingenious series of tips and bumps on their wing scales.
- HS-LS4-3: Adaptation of Populations

<table>
<tr><th>Students will know: (Disciplinary Core Ideas)</th><th>As evidenced by: (Science & Engineering Practices)</th></tr>
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<u>Natural Selection</u>

Natural selection occurs only if there is both

variation in the genetic information between organisms in a population
variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals.

Traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.

<u>Adaptation</u>

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

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Analyzing and Interpreting 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.
Describe or identify patterns or relationships in given data that support (or refute) an explanation for the change in trait frequency or magnitude in a population due to natural selection/selection pressure(s).
Make predictions about the trait frequency or distribution in a population due to the presence/absence or addition/removal of selection pressure(s) in the environment (including Hardy-Weinberg-based predictions about changes in allele/trait frequency/magnitude NOT based on calculations).
Organize and/or arrange (e.g., using illustrations and/or labels) data, or summarize data to provide evidence for an explanation of the effect of selection on a population.
Analyze, evaluate, estimate, calculate, and/or construct an equation to describe the change in the distribution of a trait in a population over time due to selection pressure(s).
Identify statistical anomalies or outliers for a trait or a population that are outside the expected range (for example, Joe DiMaggio’s hitting streak, tossing 10 consecutive heads on a fair coin, etc.) which may or may not be quickly removed due to selection pressure.
Calculate, using statistical analysis, changes in traits in a population over time to provide evidence for an explanation of the relationship between a trait’s occurrence and its prevalence in the population at different points in time.
Identify explanations for a change in a traits frequency and/or distribution in a population over time that can be supported by patterns or relationships in data.

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<u>Cross-Cutting Concepts</u>: Patterns

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

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in explanations of phenomena.

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
    - Fitness, gene, allele, directional selection, diversifying (disruption selection), stabilizing selection, standard deviation, vestigial structure
- Additional tier 2 words that students should be familiar with:
    - Statistics, probability, slope, intercept, correlation coefficient, linear, fit

Science vocabulary students are NOT expected to know: Hemizygous, aneuploidy, intragenomic conflict, sexual dimorphism, balanced polymorphism, apostatic selection.

Resources: NGSS Phenomenon Master List

Adaptations

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Priority Standard (Performance Expectation): HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations	
Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.	
Big Idea(s): ● Adaptation is the ultimate success story in nature; it is the process where a population becomes perfectly "tuned" to its environment through the constant filtering of natural selection.	
Essential Question(s): ● How does nature "select" for the best traits, and what happens to a population when its environment changes faster than it can adapt?	
Examples of Engaging Phenomenon: ● Following a four-year drought in California, field mustard plants are found to flower earlier in the season. ● A new antibiotic is discovered. Within ten years, many bacterial diseases that were previously treated by the antibiotic no longer respond to treatment (e.g., MRSA). ● A small population of Italian wall lizards that feed mainly on insects is introduced to a neighboring island. After several decades, the lizards are found to have thrived and heavily populated the island, and their diet is now mostly vegetation. ● Following climatic changes, the European Great Tit bird begins laying eggs earlier in the spring. ● https://youtu.be/mcM23M-CCog ○ When Darwin visited the Galapagos Island he collected a number of bird species that he brought back to England. He presented them to ornithologist John Gould thinking they were a variety of birds and he was told that they were all different varieties of finches. This led Darwin to speculate that a population of finches had arrived on the islands and had adapted to different climates through natural selection. However Darwin was never able to observe evolution taking place. Researchers Peter and Rosemary Grant have been observing evolution of Galapagos finches for the last 40 years. One of the most famous studies involved the change in beak depth of medium ground finches during times of drought. Birds that had small beaks were unable to open the dry seeds causing microevolution in the surviving birds. ● HS-LS4-4: Natural Selection Leads to Adaptation	
Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)

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. ● 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.	**Constructing Explanations and Designing Solutions** ● 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. ● Organize or summarize the given data or evidence of population characteristics, environmental characteristics, and/or the relationships between them. ● Generate or construct graphs or tables of data to highlight patterns within the given data. ● Describe the cause and effect relationship between natural selection and adaptation using evidence. This may include assembling descriptions from illustrations or lists of options and distractors, or indicating directions of causality in a model or completing cause and effect chains. ● Describe, identify, or select evidence supporting or contradicting a claim about the role of adaptation in causing the phenomenon. The evidence may be generated by the students in a simulation. ● Predict, given an appropriate explanation for a phenomenon, the effects of subsequent changes in environmental conditions on the population. ● Construct an explanation, using evidence, of the adaptation of a species through natural selection. Evidence can be described, identified, or selected/assembled from lists with distractors. Explanations can be written, assembled by manipulating the components of a flow chart or model, or assembled from lists of options that include distractors. Options and distractors should not be single words or short phrases; rather, they should be complete thoughts. ● Identify and justify additional pieces of evidence that would help distinguish among competing hypotheses.
Cross-Cutting Concepts: Cause and Effect - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
    - Beneficial change, detrimental change, distribution, emergence, gene frequency, gene, biotic, abiotic, advantageous, diverge, proliferation, sexual reproduction, bottleneck effect, island effect, geographic isolation, gene flow, genetic drift, founder effect.
- Additional tier 2 words that students should be familiar with:
    - Empirical, differentiate, valid, reliable, investigations, models, theories, simulations, peer review, theories, laws, the natural world

Science vocabulary students are NOT expected to know: Hardy Weinberg Equilibrium, biotechnology, relative fitness, directional selection, disruptive selection, stabilizing selection, heterozygote advantage, frequency-dependent selection, prezygotic barriers, postzygotic barriers.

Resources: NGSS Phenomenon Master List

Evidence for environmental changes

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Priority Standard (Performance Expectation): HS-LS4-5
Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.

Big Idea(s):
- Adaptation is a race against the clock; when environments shift—whether by nature or human activity—a species must evolve, migrate, or face the permanent silence of extinction.

Essential Question(s):
- When the world changes "overnight," what determines which species survive and which are left behind?

Examples of Engaging Phenomenon:
- PCB pollution in the Hudson River wiped out many fish species, but the Atlantic tomcod thrives there (results 1 and 3).
- The population of Greater Prairie Chickens in Illinois decreased from millions of birds in the 1800s to fewer than 50 birds in 1993 (result 3).
- In 1681, the dodo bird went extinct due to hunting and introduction of invasive species (result 3).
- In 1988, the Orange-Spotted Filefish went extinct in response to warmer ocean temperatures (result 3).
- https://youtu.be/qERdL8uHSgI
  - the Great Oxygenation Event occurred when cyanobacteria living in the oceans started producing oxygen through photosynthesis. As oxygen built up in the atmosphere anaerobic bacteria were killed leading to the Earth's first mass extinction. The change in diversity and the arrival of appreciable atmospheric oxygen (as evidenced by the red bands in the rocks) can be analyzed to see what happens when a resource that was scarce becomes very abundant.
- HS-LS4-5: Environmental Change - Speciation and Extinction

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)
<u>**Adaptation**</u> ● Changes in the physical environment, whether naturally occurring or human-induced, have thus contributed to the expansion of some species, the	**Engaging in Argument from Evidence** ● Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. ● Identify, describe, or construct, a claim, based on the provided

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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.
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data, regarding the effect of changes to the environment on the (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.
● Sort inferences about the effect of changes to the environment on (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 into those that are supported by the data, contradicted by the data, outliers in the data, or neither, or some similar classification.
● Identify patterns of information/evidence in the data that support correlative/causative inferences about the effect of changes to the environment on the (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.
● Construct an argument and/or explanation using scientific reasoning drawing on credible evidence to explain the effect of changes to the environment on the (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.
● Identify additional evidence that would help clarify, support, or contradict a claim or causal argument regarding the effect of changes to the environment on the (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.
● Identify, summarize, or organize given data or other information to support or refute a claim regarding the effect of changes to the environment on (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.
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<u>Cross-Cutting Concepts</u>: Cause and Effect
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
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<tr>
<td colspan="2">
<u>Academic Vocabulary:</u>
- Science vocabulary students ARE expected to know:
</td>
</tr>
</table>

- Beneficial change, detrimental change, distribution, emergence, gene frequency, biotic, abiotic, advantageous, diverge, mutation, proliferation, bottleneck effect, island effect, geographic isolation, founder effect, recombination, microevolution, gene flow, speciation, hybrid - Additional tier 2 words that students should be familiar with: - Evidence, merits, accepted explanations Science vocabulary students are NOT expected to know: Biotechnology, relative fitness, directional selection, disruptive selection, stabilizing selection, heterozygote advantage, frequency dependent selection, prezygotic barriers, postzygotic barriers, average heterozygosity, cline, sexual selection, sexual dimorphism, intrasexual selection, intersexual selection, neutral variation, balancing selection
Resources: NGSS Phenomenon Master List

Human impact on biodiversity [HONORS] (back to top)

Priority Standard (Performance Expectation): HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity
Clarification Statement: Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.
Big Idea(s): ● As "Architects of the Anthropocene," humans have the power to destroy biodiversity, but we also have the technical tools to simulate and engineer solutions for its recovery.
Essential Question(s): ● How can we use technology to predict the consequences of our actions before we push a species past the point of no return?
Examples of Engaging Phenomenon: ● The habitat of the Florida Panther is only 5% of its former range, causing the species to become endangered. ● The café marron plant is critically endangered due to massive habitat destruction on the Island of Rodrigues in the Indian Ocean, as a result of deforestation for agricultural use. ● The population of Atlantic Bluefin Tuna has declined by more than 80% since 1970 due to overfishing. ● In the past 120 years, about eighty percent of suitable orangutan habitat in Indonesia has been lost from expansion of oil plantations. At the same time, the estimated number of orangutans in Borneo, an island in Indonesia, has declined from about 230,000 to about 54,000. ● Easter Island Deforestation (Rethinking Easter Island's Historic 'Collapse' | Scientific American) ● HS-LS4-6: Human Impact on Biodiversity Solution

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)

Adaptation
● Natural selection is the result of four factors:
  ● Potential for a species to increase in number
  ● Genetic variation of individuals in a
	Using Mathematics and Computational Thinking
	● Create or revise a simulation of a phenomenon, designed device, process, or system.
	● Calculate or estimate, using data, the effect of a solution on mitigating the adverse impacts of human activity on biodiversity.
	● Illustrate, graph, or identify features or data that can be used to

species due to mutation and sexual reproduction ● Competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce ● Ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. ● Natural selection leads to adaptation ● Adaptive changes due to natural selection, as well as the net result of speciation minus extinction, have strongly contributed to the planet's biodiversity. ● Reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. ● Adaptation also means that the distribution of traits in a population can change when conditions change. **<u>Changes in the physical environment</u>** ● Changes in the physical environment, whether naturally occurring or human induced, have contributed to the expansion of some species. ● Changes in the physical environment lead to 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. **<u>Biodiversity and Humans</u>** ● Human activity (e.g., overpopulation,	determine how effective a solution is for mitigating the adverse impacts of human activity on biodiversity. ● Estimate or infer the properties or relationships that lead to mitigation of the adverse impacts of human activity on biodiversity, based on data. ● Compile the data needed for an inference about the impacts of human activity on biodiversity. This can include sorting out the relevant data from the given information. ● Select or identify, using given information, the criteria against which the solution should be judged. ● Test, using a simulator, a proposed solution and evaluate the outcomes; may include proposing modifications to the solution. ● Identify possible negative consequences of solutions that would outweigh their benefits.

overexploitation, adverse habitat alterations, pollution, invasive species, changes in climate) and the factors that affect biodiversity. ● 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.	

<u>Cross-Cutting Concepts</u>: Cause and Effect

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

<u>Academic Vocabulary:</u>

- Science vocabulary students ARE expected to know:
    - Anthropogenic, efficient, overexploitation, urbanization, acidification, deforestation, concentration, radiation, greenhouse gas, surface runoff, civilization, consumption, mass wasting, urban, development, per-capita, degradation, pollutant, best practice, cost-benefit, extract, regulation
- Additional tier 2 words that students should be familiar with:
    - simulation, designed device, process, or system

Science vocabulary students are NOT expected to know: Oligotrophic and eutrophic lakes/eutrophication, littoral zone, exponential population growth, logistic population growth, ecological footprint, ecosystem services, extinction vortex, minimum viable population, effective population size, critical load.

<u>Resources</u>: NGSS Phenomenon Master List

Unit 4: Ecosystem

Carrying Capacities

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Priority Standard (Performance Expectation): HS-LS2-1
Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales

Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.

Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.

Big Idea(s):
- No environment has infinite resources; every habitat has an "invisible ceiling" called carrying capacity that strictly regulates the abundance of life.

Essential Question(s):
- At what point does a population become a threat to its own "life support system"?

Examples of Engaging Phenomenon:
- On Ngorongoro Crater in Tanzania in 1963, a scientist sees that there are much fewer lions than there were on previous visits.
- On St. Matthew Island reindeer were introduced in 1944, but today no reindeer can be found on the island.
- In Washington State, more harbor seals are present today than in the past.
- In Alaska, you can see many more brown bears in Lake Clark National Park than in Denali National Park.
- Zebra mussels invasive species:https://youtu.be/abImqGDzXBo
- HS-LS2-1: Carrying Capacity of Ecosystems

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)
<u>Interdependent Relationships In Ecosystems</u> • Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. • Carrying capacities are limits to the numbers of	**Using Mathematics and Computational Thinking** • Support explanations using mathematical and/or computational representations of phenomena or design solutions • Calculate or estimate factors affecting the carrying capacity of an ecosystem, using given data.

organisms and populations they can support. ● 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. ● Limiting factors result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease.	● Illustrate, graph, or identify relevant features or data that can be used to calculate or estimate factors affecting the carrying capacity of ecosystems of different scales. ● Calculate or estimate properties of or relationships between factors affecting the carrying capacity of an ecosystem based on data from one or more sources. ● Compile, from given information, the data needed for a particular inference about factors affecting the carrying capacity of an ecosystem. This can include sorting out the relevant data from the given information and representing the data through graphs, charts, and/or histograms. ● Make a claim about the factors that affect the carrying capacity of an ecosystem, using quantitative or abstract reasoning.

Cross-Cutting Concepts: Scale, Proportion and Quantity

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

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
  - Predation, interdependent, disturbance, equilibrium of ecosystems, fluctuation, stable, biotic, abiotic, sustain, anthropogenic, overexploitation, urbanization, population, emigrants, immigrants, exponential, generation, rebounding, limiting resources, logistic, competition, negative feedback, population control.
- Additional tier 2 words that students should be familiar with:
  - mathematical and/or computational representations of phenomena, design solutions, explanations

Science vocabulary students are NOT expected to know: Dispersion, demography, survivorship curve (J or S), reproductive table, semelparity, iteroparity, metapopulation, demographic transition, resource partitioning, Shannon diversity, biomanipulation, density dependent selection (K-selection), density independent selection (r selection), intrinsic factors.
Resources: NGSS Phenomenon Master List

Factors affecting biodiversity

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Supporting Standard (Performance Expectation): HS-LS2-2
Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales

Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.
Assessment Boundary: Assessment is limited to provided data.

Big Idea(s):

- Ecosystems have inherent limits called carrying capacities that restrict the number of organisms and populations they can sustain. This limit exists because while species have the capacity for great reproductive growth, the resources and environments they rely on are finite, creating a fundamental tension that affects species abundance.
- Carrying capacity is shaped by the interaction of biotic and abiotic factors across various scales. These limiting factors include the availability of nonliving resources (abiotic) and living challenges such as predation, competition, and disease (biotic).
- Understanding the dynamics of an ecosystem requires analyzing factors across different scales and effectively communicating evidence-based explanations, particularly regarding human-driven (anthropogenic) impacts like urbanization and overexploitation.

Essential Question(s):

- What biotic and abiotic factors influence biodiversity and population dynamics in ecosystems of varying scales?
- How can mathematical models and representations be used to analyze, explain, and predict changes in biodiversity and population trends?
- How do human activities interact with natural factors to impact biodiversity and population stability in ecosystems?

Examples of Engaging Phenomenon:

- After brown tree snakes were accidentally introduced to Guam in the 1950s, 11 native bird species went extinct.
- When European settlers decreased the wolf population for safety, deer populations thrived and over consumed native plant species.
- California's Central Valley can support fewer waterfowl in the winter during drought.
- The cones of Lodgepole pines do not release their seeds until a fire melts the resin that keeps them sealed.
- Video Clip- "Silent Invaders" *Stop at 1 min 33 seconds and allow students to "Wonder" and Ask Questions about what they saw. https://www.youtube.com/watch?v=abImqGDzXBo
- *How will these changes impact the stability and diversity of the ecosystem?
- Zebra Mussel Fact Sheet- https://www.caryinstitute.org/sites/default/files/public/downloads/curriculum-project/zebra_mussel_fact_sheet.
- HS-LS2-2: Biodiversity and Populations in Ecosystems

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)
<u>Interdependent Relationships In Ecosystems</u> ● Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. ● Carrying capacities are limits to the numbers of organisms and populations they can support. ● 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. ● Limiting factors result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. **<u>Ecosystem Dynamics, Functioning, And Resilience</u>** ● 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. ● Calculating rate change of populations over time ● Biological/physical disturbances ● Population pyramids ● Population fluctuations ● Resources ● Habitat availability ● Anthropogenic changes can disrupt an ecosystem and threaten the survival of some species. ● Human activity in environment including, habitat destruction, pollution, invasive species, overexploitation, and climate change.	**Using Mathematics and Computational Thinking** ● Support and revise explanations using mathematical representations of phenomena or design solutions. ● Calculate or estimate factors affecting biodiversity and populations in ecosystems, using given data. ● Illustrate, graph, or identify relevant features or data that can be used to calculate or estimate factors affecting biodiversity and populations in ecosystems of different scales. ● Calculate or estimate properties of or relationships between factors affecting biodiversity and populations in ecosystems based on data from one or more sources. ● Compile, from given information, the data needed for a particular inference about factors affecting biodiversity and populations in ecosystems. This can include sorting out the relevant data from given information. ● Construct an explanation regarding the relationship between biodiversity and populations in ecosystems of different scales using the given, calculated, or compiled information. ● Revise or evaluate a given explanation of the relationship between biodiversity and populations in ecosystems of different scales based on the given, calculated, or compiled information.
<u>Cross-Cutting Concepts</u>: 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.

Academic Vocabulary:
- Science vocabulary students ARE expected to know:
    - Carrying capacity, anthropogenic changes, overexploitation, extinction, demographic, population, pyramid, deforestation, habitat fragmentation, sustainable, abiotic factor, biotic factor, species, richness, symbiosis, niche, fragile ecosystem, biodiversity index, zero population growth, density, dispersion, immigration, emigration, limiting factor
- Additional tier 2 words that students should be familiar with:
    - Mathematical representations, design solution
 	
Science vocabulary students are NOT expected to know: Water regime, direct driver, eutrophication, species evenness, range of tolerance, realized niche, niche generalist, niche specialist, edge habitat, endemic species, logistic growth model, exponential population growth, mark-recapture method, territoriality, demography, cohort, survivorship curve, reproductive table, life history, semelparity, iteroparity, K-selection, r-selection, dieback.

Resources: NGSS Phenomenon Master List

Cycling of matter - aerobic and anaerobic

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Priority Standard (Performance Expectation): HS-LS2-3
Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.

Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.

Big Idea(s):

- Energy drives the cycling of matter, which in turn determines the stability, functioning, and interconnectedness of ecosystems. This continuous process involves chemical elements being combined and recombined as they pass through food webs, the atmosphere, and the soil.
- Life processes rely on photosynthesis and cellular respiration, including anaerobic processes, to provide the necessary energy for survival.
- Within an ecosystem, matter and energy are always conserved, even as they change forms.

Essential Question(s):

- How does the cycling of matter and flow of energy shape [the stability, functioning, and interconnectedness of] ecosystems?
- In what ways do aerobic and anaerobic conditions influence how matter and energy move through ecological systems?
- How can evidence be used to construct, evaluate, and refine explanations of matter cycling and energy flow in response to changes or disruptions in ecosystems?

Examples of Engaging Phenomenon:

- After running for a long period of time, human muscles develop soreness and a burning sensation, and breathing rate increases.
- Bread baked with yeast looks and tastes differently than bread that is baked without yeast.
- A plant that is watered too much will have soft, brown patches on their leaves and will fail to grow.
- Cyanobacteria differ from other bacteria in that cyanobacteria appear blue-green in color and also lack flagella.
- HS-LS2-3: Aerobic and Anaerobic Cycling of Matter

<table>
<tr><th>Students will know: (Disciplinary Core Ideas)</th><th>As evidenced by: (Science & Engineering Practices)</th></tr>
<tr><td>
<u>Aerobic and Anaerobic conditions</u>

Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
Food webs

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.
There are generally fewer organisms at higher levels of a food web, and there is a limit to the number of organisms that an ecosystem can sustain.

The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil and are combined and recombined in different ways.
Matter and energy are conserved at each link upward in a food web; some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. Competition among species is ultimately competition for the matter and energy.

</td><td>
Constructing Explanations and Designing Solutions

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.

</td></tr>
<tr><td colspan="2">
<u>Cross-Cutting Concepts</u>: Energy and Matter

Energy drives the cycling of matter within and between systems.

</td></tr>
</table>

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
    - Cyanobacteria differ from other bacteria in that cyanobacteria appear blue-green in color and also lack flagella.
- Additional tier 2 words that students should be familiar with:
    - Explanation, design, solution, evidence, reasoning, system, construct, revise

Science vocabulary students are NOT expected to know: Lactic acid fermentation, alcoholic fermentation, glycolysis, Kreb's cycle, electron transport chain.

Resources: NGSS Phenomenon Master List

- 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

Cycling of matter - Ecosystems [HONORS]

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Priority Standard (Performance Expectation): HS-LS2-4
Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.

Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.

Big Idea(s):

- Matter and energy are fundamentally conserved as they cycle and flow through an ecosystem.
- Energy transfer between trophic levels is highly inefficient, which limits the structure of food webs. Because only a small fraction of the matter consumed at one level is transferred upward for growth and cellular respiration, there are generally fewer organisms and less biomass at higher trophic levels compared to the producers at the base
- Mathematical and computational models are critical tools for visualizing and analyzing ecosystem dynamics. By using proportional reasoning and quantitative data, such as biomass measurements or organism counts, researchers can support claims and predict how energy and matter will move through a specific system.

Essential Question(s):

- How do matter and energy move through ecosystems?
- How can mathematical representations help us visualize, analyze, and support claims about the cycling of matter and flow of energy among organisms?
- How can modeling and data be used to understand, predict, and communicate changes in the flow of energy and matter in ecosystems?

Examples of Engaging Phenomenon:

- In the 6,000-hectare rainforest of San Lorenzo, Panama, there are 312 arthropods for every mammal, including humans.
- In Silver Springs, Florida, the biomass of plants is 809 g/m2, while the biomass of large fish is 5 g/m2
- A herd of grazing caribou in the Seward Peninsula of Alaska are seen eating the leaves of birch trees in July. In December, they are seen eating tree lichen.
- A pine tree growing in a forest remains in one location throughout its lifetime. A fox in the same forest moves around every day of its life.
- https://youtu.be/qERdL8uHSgI
  - The Great Oxygenation Event occurred when cyanobacteria living in the oceans started producing oxygen through photosynthesis. As oxygen built up in the atmosphere anaerobic bacteria were killed leading to the Earth's first mass extinction..
- [HS-LS2-4: Biomass and Trophic Levels](#)

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)
Cycles of Matter and Energy Transfer in Ecosystems ● Plants or algae form the lowest level of the 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. ● 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. ● Matter and energy are conserved at each link in an ecosystem	**Using Mathematics and Computational Thinking** ● Support claims using mathematical representations of phenomena or design solutions. ● Calculate or estimate changes or differences in matter and energy between trophic levels of an ecosystem. ● Illustrate, graph, or identify a mathematical model describing changes in stored energy through trophic levels of an ecosystem. ● Compile and interpret data from given information to establish the relationship between organisms at different trophic levels. ● Make a claim, using quantitative or abstract reasoning, about the cycling of matter and flow of energy through the trophic levels of an ecosystem. This may include sorting relevant information from irrelevant information. ● Identify and describe the components of a mathematical representation of an ecosystem that could include relative quantities related to organisms, matter, energy, and the food web of that ecosystem.
<u>Cross-Cutting Concepts</u>: 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.	

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
    - Interdependent, nutrient, hydrocarbon, transfer system, equilibrium of ecosystems, decomposer, producer, ATP, solar energy, predator-prey relationship, trophic level
- Additional tier 2 words that students should be familiar with:
    - Claims, phenomena, representation, systems

Science vocabulary students are NOT expected to know: Detritivore, denitrification, thermodynamics, nitrogen fixation, biogeochemical cycle, anaerobic process.

Resources: NGSS Phenomenon Master List

- 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

Interactions between ecosystems

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Supporting Standard (Performance Expectation): HS-LS2-6
Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable condition, but changing conditions may result in a new ecosystem.

Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.

Big Idea(s):

- Dynamic Equilibrium and Ecosystem Stability: Under stable conditions, complex interactions between biotic and abiotic factors work to maintain relatively consistent numbers and types of organisms within an ecosystem. This state of balance allows ecosystems to function predictably over long periods of time.
- Transformation through Extreme Fluctuations: When faced with extreme disturbances—such as volcanic eruptions, rapid sea-level rise, or the introduction of invasive species like the Burmese python—an ecosystem's functioning may be challenged beyond its limit. These extreme shifts can result in the emergence of a new ecosystem with entirely different structures and functions.
- Human Impact on Biodiversity and Stability: Human activities—including habitat destruction, pollution, overexploitation, and climate change—serve as significant drivers of environmental change. These activities can disrupt the complex interactions that maintain stability, often leading to a decrease in biodiversity or the permanent transformation of the landscape.

Essential Question(s):

- How do complex interactions among biotic and abiotic factors influence the stability of ecosystems and the consistency of organism populations over time?
- How can claims and evidence be used to evaluate the causes and consequences of ecosystem stability, disruption, or transformation?
- How do ecological changes of environmental conditions lead to the emergence of new ecosystems with different structures and functions?

Examples of Engaging Phenomenon:

- The populations of rabbits and deer in the Florida Everglades significantly decreased with the introduction of the Burmese python.
- Biodiversity of an area of the Amazon rainforest is affected differently in sustainable and non-sustainable lumber farms.
- After a fire, the biodiversity of a forest immediately decreases but eventually increases.
- An increase in mouse populations are observed the year after a flood but return to pre-flood numbers the following year.
- Finch evolution - https://youtu.be/mcM23M-CCog
- HS-LS2-6: Ecosystem Dynamics, Functioning, and Resilience

<table>
<tr><th>Students will know: (Disciplinary Core Ideas)</th><th>As evidenced by: (Science & Engineering Practices)</th></tr>
<tr><td><u>Ecosystem Dynamics, Functioning, and Resilience</u>
● 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.threaten the survival of some species.
    ● Human activity in environment
    ● Habitat destruction
    ● Pollution
    ● Invasive species
    ● Overexploitation
    ● Climate change</td><td>Engaging in Argument from Evidence
● Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
● Identify, based on the provided data or information, the explanation that complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
● Identify and/or explain the claims, evidence, and reasoning supporting the explanation that complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
● Identify and/or describe additional relevant evidence not provided that would support or clarify the explanation of the complex interactions in ecosystems, factors that affect biodiversity, relationships between species and the environment, and changes in numbers of species and organisms in a stable or changing ecosystem.
● Evaluate the strengths and weaknesses of a claim to explain the relationship of biodiversity and the environment in an ecosystem based on the evidence or data provided.
● Analyze and/or interpret evidence and its ability to support the explanation of the resiliency of an ecosystem in response to different levels of change.
● Provide and/or evaluate reasoning to support the explanation that an ecosystem remains relatively consistent when faced with modest disturbances, but it may experience extreme changes or fluctuations in biodiversity when faced with extreme disturbances.</td></tr>
</table>

Cross-Cutting Concepts: Stability and Change

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

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
    - Biosphere, biodiversity, carbon cycle, water cycle, nitrogen cycle, fluctuation, consistent, stable, equilibrium, species, emergence, extinction, niche, native, non-native, invasive, overgrazing, human, impact, succession, primary succession, secondary succession.
- Additional tier 2 words that students should be familiar with:
    - Evaluate, claim, evidence, reasoning, explanations, stability, change

Science vocabulary students are NOT expected to know: Genetic drift, founder effect, Hardy-Weinberg, intermediate disturbance hypothesis, species-area curve.

Resources: NGSS Phenomenon Master List

- Galapagos Finch Evolution - HS-LS2-6

Reducing impacts on environment and biodiversity

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Priority Standard (Performance Expectation): HS-LS2-7 Design, Evaluate and refine a solution for reducing the impacts of human activity on the environment and biodiversity.
Clarification Statement: Emphasis is on: Examples of human activities can include urbanization, building dams, and dissemination of invasive species
Big Idea(s): ● Human progress often creates a "biological debt" that must be managed through innovative engineering and a deep understanding of ecosystem resilience.
Essential Question(s): ● Can we design a future where human industry and natural biodiversity exist in a state of mutual benefit rather than conflict?
Examples of Engaging Phenomenon: ● The spread of cities through urbanization has destroyed wildlife habitats across the planet. ● Air pollution from driving cars has made the air unsafe to breathe in many areas. ● Dams have led to flooding of large areas of land, destroying animal habitats. ● Fishing has drastically changed marine ecosystems, removing certain predators or certain prey.

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)
Ecosystem Dynamics, Functioning, and Resilience • 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. **Biodiversity and Humans** • Biodiversity is increased by the formation of	**Constructing Explanations and Designing Solutions** ● Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. ● Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information or features. ● Express or complete a causal chain explaining how human

new species (speciation) and decreased by the loss of species (extinction). • Humans depend on the living world for the resources and other benefits provided by biodiversity. • Human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. • Biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. • Biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. **<u>Developing Possible Solutions</u>** • The range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts when evaluating solutions.	activity impacts the environment. This may include indicating directions of causality in an incomplete model such as a flow chart or diagram, or completing cause-and-effect chains. ● Identify evidence supporting the inference of causation that is expressed in a causal chain. ● Predict the environmental outcome, given a change in the design of human technology. ● Describe, identify, and/or select information needed to support an explanation. ● Identify or describe relevant aspects of the problem that given design solutions for reducing the impacts of human activities on the environment and biodiversity, if implemented, will resolve or improve. ● Select or identify criteria, using given information about the effects of human activities on the environment and biodiversity, against which the solution should be judged. ● Select or identify constraints that the solution must meet, using given information about the effects of human activities on the environment and biodiversity. ● Evaluate the criteria and constraints, along with trade-offs, for a proposed or given solution to resolve or improve the impact of human activities on the environment and biodiversity. ● Propose, using given data, a potential solution to resolve or improve the impact of human activities on the environment and biodiversity. ● Test a proposed solution to resolve or improve the impact of human activities on the environment and biodiversity and evaluate the outcomes, using a simulator. ● Evaluate and/or revise a solution to resolve or improve the impact of human activities on the environment and biodiversity and evaluate the outcomes
<u>Cross-Cutting Concepts</u>: Stability and Change - Much of science deals with constructing explanations of how things change and how they remain stable.	
<u>Academic Vocabulary:</u> - Science vocabulary students ARE expected to know:	

- Carrying capacity, competition, urbanization, conservation biology, endangered species, threatened, species, introduced species, overharvesting, extinction, greenhouse effect, carbon footprint

- Additional tier 2 words that students should be familiar with:
  - Design, evaluate, refine, evidence, criteria, explanations, stability, change
  -

Science vocabulary students are NOT expected to know: Laws of thermodynamics, Hardy-Weinberg equilibrium, Lotka-Volterra equations, allelopathy, density-dependent population regulation, extinction vortex, minimum viable population (MVP), effective population size, movement corridor, biodiversity hot spot, zoned reserve, critical load, biological magnification, assisted migration, sustainable development.

Resources: NGSS Phenomenon Master List, Easter Island Deforestation, Google Maps Timelapse, The Salmon Cannon, Algae Fuel and Food, Vegetable Oil as Fuel

Group Behavior between species for survival [HONORS] (back to top)

Priority Standard (Performance Expectation): HS-LS2-8
Evaluate the evidence for the role of group behavior on individual and species chances to survive and reproduce.

Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.

Big Idea(s):

- Group behavior is an evolved trait because membership in a collective increases the chances of survival and reproduction for both individuals and their genetic relatives. Animals, including humans, possess a strong innate drive for social affiliation with members of their own species. This drive is so fundamental that individuals can suffer significant physiological and behavioral harm if they are raised in isolation, even if their basic physical needs for food and shelter are met.
- Species utilize a wide array of collective behaviors—such as flocking, schooling, herding, and swarming—to navigate their environments. These behaviors facilitate critical life functions, including cooperative hunting, migration, and foraging, which allow a group to overcome environmental challenges or predators more effectively than an individual could alone.
- Effective group living relies on sophisticated communication and cooperation. For example, worker bees use distinct movement patterns to share information with the colony, and weaver ants cooperate to form living bridges. These social interactions support mutual protection and help optimize energy costs and benefits when searching for resources.

Essential Question(s):

- How does group behavior influence the survival and reproductive success of individuals and species within different environments?
- What types of evidence support the role of group behavior in shaping population dynamics, evolutionary outcomes, and species interactions?
- How can we critically evaluate and communicate the strength of evidence regarding the impact of group behavior on survival and reproduction in the natural world?

Examples of Engaging Phenomenon: Several hundred naked mole rats are observed living together in a colony. However, only one large naked mole rat is observed reproducing, while the others in the colony bring her food.

- A worker bee is observed flying away from its colony. Upon returning many other worker bees crowd around him while he moves in a distinct pattern.
- A lioness charges toward a large herd of galloping zebras, but then stops and runs away in the opposite direction.
- A certain species of short-horned grasshoppers changes color, band together, and fly over several square kilometers over a period of a few weeks.
- Weaver ants and bridge formation: https://www.youtube.com/watch?v=A4uv27nSaH4
- HS-LS2-8: Social Interactions and Group Behavior

Students will know: (Disciplinary Core Ideas)	As evidenced by: (Science & Engineering Practices)
<u>**Social Interactions and Group Behavior**</u> ● Animals, including humans, have a strong drive for social affiliation with members of their own species and will suffer, behaviorally as well as physiologically, if reared in isolation, even if all of their physical needs are met. ● Some forms of affiliation arise from the bonds between offspring and parents. Other groups form among peers. ● Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.	**Engaging in Argument from Evidence** ● Evaluate the evidence behind currently accepted explanations to determine the merits of arguments. ● Identify, describe, or construct a claim, based on the provided data, regarding how specific group behavior(s) can increase an individual's or species' chances of surviving and reproducing. ● Sort inferences about the effect of specific group behaviors on an individual's and species' chances to survive and reproduce into those that are supported by the data, contradicted by the data, outliers in the data, or neither, or some similar classification. ● Identify patterns of information/evidence in the data that support correlative/causative inferences about the effect of specific group behaviors on an individual's and species' chances to survive and reproduce. ● Construct an argument using scientific reasoning, drawing on credible evidence to explain the effect of specific group behaviors on an individual's and species' chances to survive and reproduce. ● Identify additional evidence that would help clarify, support, or contradict a claim or causal argument regarding the effect of specific group behaviors on an individual's and species' chances to survive and reproduce. ● Identify, summarize, or organize given data or other information to support or refute a claim regarding the effect of specific group behaviors on an individual's and species' chances to survive and reproduce.

Cross-Cutting Concepts: Cause and Effect

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

Academic Vocabulary:

- Science vocabulary students ARE expected to know:
  - Behavioral ecology, cooperative behavior, altruism, environmental stimuli, circadian clock, communication, foraging, optimal foraging model, energy costs and benefits, competition, predator,mutual protection, packs
- Additional tier 2 words that students should be familiar with:
  - Evidence, arguments, evidence, cause, effect

Science vocabulary students are NOT expected to know: Fixed action pattern, pheromones, innate behavior, learning, imprinting, spatial learning, socialearning, associative learning, problem solving, cognition, game theory, agonistic behavior, mating behavior, mating systems, parental care, mate choice, male competition for mates, reciprocal altruism, shoaling

Resources:NGSS Phenomenon Master List, Termite Olympics, Can Prairie Dogs Talk?, Ant Cooperation, Shrew Caravan

Appendix A: Vocabulary

Abiotic: Non-living physical and chemical elements in an ecosystem, such as sunlight, water, and minerals.
Adaptation: A heritable trait that increases an organism's ability to survive and reproduce in its environment.
Allele: One of two or more alternative forms of a gene that arise by mutation and are found at the same place on a chromosome.
Altruism: Behavior by an animal that may be to its disadvantage but that benefits others of its kind.
Amino acids: The organic building blocks that combine to form proteins.
Anaerobic: A biological process that occurs in the absence of oxygen.
Anthropogenic: Resulting from the influence of human beings on nature (e.g., human-induced climate change).
Apex predator: A predator at the top of a food chain that has no natural predators.
Argument: A process for reaching explanations or solutions through the use of evidence and reasoning.
ATP (Adenosine Triphosphate): The primary energy-carrying molecule used by cells to fuel biological processes.
Autotroph: An organism that can produce its own food using light, water, carbon dioxide, or other chemicals.
Behavioral ecology: The study of the evolutionary basis for animal behavior due to ecological pressures.
Biodiversity: The variety of life in the world or in a particular habitat or ecosystem.
Biomass: The total mass of organisms in a given area or volume.
Biotic: Living components of an ecosystem, such as plants, animals, and bacteria.
Carbohydrates: Organic compounds, including sugars and starches, used by cells for short-term energy and structure.
Carbon cycle: The series of processes by which carbon compounds are interconverted in the environment.
Carrying capacity: The maximum number of individuals of a particular species that a particular environment can support.
Cause and Effect: The relationship between events or things, where one is the result of the other.
Cell cycle: The series of events that take place in a cell as it grows and divides.
Cellular respiration: The process by which cells break down glucose and other molecules to produce energy.
Claim: A statement or conclusion that answers a scientific question, which must be supported by evidence.
Common ancestry: The idea that multiple species share a single ancestral population.
Competition: The struggle between organisms for limited resources, such as food or territory.
Components: The individual parts that make up a whole system.
Cooperative behavior: Groups of organisms working together for mutual benefit, such as hunting in packs.
DNA (Deoxyribonucleic acid): The molecule that carries the genetic instructions for the development and functioning of living things.
DNA replication: The process by which a double-stranded DNA molecule is copied to produce two identical DNA molecules.
Daughter cells: The cells that result from the division of a single parent cell.

Differentiation: The process by which a less specialized cell becomes a more specialized cell type.
Dominant: An allele that expresses its phenotype even when paired with a different allele.
Dynamic equilibrium: A state of balance between continuing processes in an ecosystem.
Ecosystem: A biological community of interacting organisms and their physical environment.
Evidence: The data and information used to support or refute a scientific claim or theory.
Evolution: The change in the heritable characteristics of biological populations over successive generations.
Extinction: The dying out or extermination of a species.
Feedback mechanism: A process in which the level of one substance or activity influences the level of another to maintain stability.
Fitness: The ability of an organism to survive and reproduce in its environment.
Gene expression: The process by which information from a gene is used in the synthesis of a functional gene product (protein).
Genes: Segments of DNA that serve as the basic unit of heredity.
Genotype: The genetic makeup of an organism.
Heterozygous: Having two different alleles for a particular gene.
Hierarchical organization: The levels of biological complexity, from cells to tissues to organs to systems.
Homeostasis: The state of steady internal physical and chemical conditions maintained by living systems.
Homozygous: Having two identical alleles for a particular gene.
Inheritance: The process by which genetic information is passed on from parent to offspring.
Interaction: The way in which two or more things have an effect on one another.
Limiting factors: Environmental conditions that limit the growth, abundance, or distribution of an organism or a population.
Lipids: A group of organic compounds (fats/oils) used for long-term energy storage and cell membranes.
Macromolecules: Large molecules, such as proteins and nucleic acids, built from smaller chemical units.
Meiosis: A type of cell division that results in four daughter cells each with half the number of chromosomes of the parent cell.
Mitosis: A type of cell division that results in two daughter cells each having the same number and kind of chromosomes as the parent nucleus.
Mutation: A change in the DNA sequence of an organism.
Natural selection: The process whereby organisms better adapted to their environment tend to survive and produce more offspring.
Nucleic acids: Complex organic substances present in living cells, such as DNA or RNA, whose molecules consist of many nucleotides.
Phenotype: The observable physical characteristics of an organism.
Photosynthesis: The process by which green plants and some other organisms use sunlight to synthesize foods from carbon dioxide and water.
Population: A group of individuals of the same species living and interbreeding within a given area.
Probability: The likelihood of a specific event occurring, often used in genetics to predict trait inheritance.
Proteins: Large molecules composed of one or more long chains of amino acids; they perform most of the work in cells.
Recessive: An allele that is only expressed when an organism has two copies of that allele.
Recombination: The rearrangement of genetic material, especially by crossing over in chromosomes.

Resilience: The capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage and recovering quickly.
Scale: The relative size or extent of something (e.g., microscopic vs. macroscopic).
Speciation: The formation of new and distinct species in the course of evolution.
Stability: The tendency of a system to return to its original state after being disturbed.
System: A set of interacting or interdependent component parts forming a complex/intricate whole.
Trophic level: The position an organism occupies in a food web.
Variation: Any difference between cells, individual organisms, or groups of organisms of any species caused either by genetic differences or environmental factors.