

Louisiana Student Standards for Science

The Louisiana Student Standards for Science were created by over eighty content experts and educators with input from parents and teachers from across the state. Educators envisioned what students should know and be able to do to compete in our communities and created standards that would allow students to do so. The Louisiana Student Standards for Science provide appropriate content for all grades or courses, maintain high expectations and create a logical connection of content across and within grades.

The Louisiana Student Standards for Science represent the knowledge and skills needed for students to successfully transition to postsecondary educations and the workplace. The standards call for students to:

- Apply content knowledge to real world phenomena and to design solutions
- Demonstrate the practices of scientists and engineers
- Connect scientific learning to all disciplines of science
- Express ideas grounded in scientific evidence

The Louisiana Student Standards do not dictate curriculum or teaching methods. Decisions about how to teach these expectations are left to local districts, schools, and teachers.

Structure and Components of the Standards

The Louisiana Student Standards for Science are arranged by grade levels for kindergarten through grade 8 and content areas for high school. The standards include:

- **Performance expectations** define what students should be able to do by the end of the year.
- **Science and engineering practices** are the practices that scientists and engineers use when investigating real world phenomena and designing solutions to problems. There are eight science and engineering practices that apply to all grade levels and content areas.
 1. Asking questions (science) and defining problems (engineering)
 2. Developing and using models
 3. Planning and carrying out investigations
 4. Analyzing and interpreting data
 5. Using mathematical and computational thinking
 6. Constructing explanations (science) and designing solutions (engineering)
 7. Engaging in argument with evidence
 8. Obtaining, evaluating, and communicating information
- **Disciplinary Core Ideas** describe the most essential ideas (content) in the major science disciplines that students will learn. Disciplinary Core Ideas are grouped into five science domains.
 1. Physical Science (PS)
 2. Life Science (LS)
 3. Earth and Space Science (ESS)
 4. Environmental Science (EVS)
 5. Engineering, Technology, and Applications of Science (ETS)
- **Crosscutting Concepts** are common themes that have application across all disciplines of science and allow students to connect learning within and across grade levels or content areas. The seven crosscutting concepts apply to all grade levels and content areas.
 1. Patterns
 2. Cause and effect
 3. Scale, proportion, and quantity
 4. Systems and models
 5. Energy and matter
 6. Structure and function
 7. Stability and change
- **Clarification statements** provide examples or additional explanation to the performance expectation.

Interpreting Standard Codes

Each performance expectation is identified by a code and descriptor. The coding is derived by the following formula: Grade level- Domain and Topic Number- Performance Expectation Number (space)

3-PS2-1 Motion and Stability: Forces and Interactions	The grade level is 3, the domain is Physical Science, the topic number is 2, and the performance expectation number is 1. The descriptor is, "Motion and Stability: Forces and Interactions."
7-MS-ESS2-4 Earth's Systems	The grade level is 7, the standard is middle school, the domain is Earth and Space Science, the topic number is 2, and the performance expectation is 1. The descriptor is, "Earth's Systems."
HS-LS1-1 From Molecules to Organisms: Structures and Processes	The standard is high school, the domain is Life Science, the topic number is 1, and the performance expectation number is 1. The descriptor is, "From Molecules to Organisms: Structures and Processes."

8-MS-PS1-1

Grade Level: 8
Standard: MS
Domain: PS
Performance Expectation: 1
Topic Number: 1

Descriptor: MATTER AND ITS INTERACTIONS

Performance Expectation	Develop models to describe the atomic composition of simple molecules and extended structures.	
Clarification Statement	Emphasis is on developing models of molecules that vary in complexity. Examples of extended structures could include minerals such as but not limited to halite (NaCl), agate (SiO ₂), calcite (CaF ₂), or sapphire (Al ₂ O ₃). Examples of molecular-level models could include drawings, 3-D models, or computer representations showing different molecules with different types of atoms.	
Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> Asking questions (for science) and defining problems (for engineering) Developing and using models: Modeling in 6–8 builds on K–5 experiences and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. <ul style="list-style-type: none"> Develop and/or use a model to predict and/or describe phenomena. Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>STRUCTURE AND PROPERTIES OF MATTER Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS.PS1A.a)</p> <p>Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS.PS1A.e)</p>	<p>SCALE, PROPORTION, AND QUANTITY Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.</p>

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RESOURCES AND RESOURCE MANAGEMENT

<p>Performance Expectation</p>	<p>Analyze and interpret data to identify the factors that affect sustainable development and natural resource management in Louisiana.</p>
<p>Clarification Statement</p>	<p>Evidence of Louisiana’s natural resource wealth is found in understanding functions and values of varied ecosystems and environments, supply of non-renewable mining products and profitable agricultural commodities. Examples of key natural resources include state waterways (such as rivers, lakes, and bayous) and the aquatic life found in them, regions of agriculture (pine forests, sugar cane and rice fields) and high concentrations of minerals and fossil fuels on and off shore. Factors to consider in reviewing the management of natural resources include a review of historical practices, costs of resource extraction and waste management, consumption of natural resources, ongoing research and the advancements in technology.</p>



<p>Science & Engineering Practices</p>	<p>Disciplinary Core Ideas</p>	<p>Crosscutting Concepts</p>
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data: Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. <ul style="list-style-type: none"> • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. 5. Using mathematics and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information 	<p>LOUISIANA’S NATURAL RESOURCES Ecosystem capital can be characterized as goods (removable products) and services such as the functions and values of wetlands. (HS.EVS1A.a)</p>	<p>STABILITY AND CHANGE Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.</p>

RESOURCES AND RESOURCE MANAGEMENT

<p>Performance Expectation</p>	<p>Obtain, evaluate and communicate information on the effectiveness of management or conservation practices for one of Louisiana’s natural resources with respect to common considerations such as social, economic, technological, and influencing political factors over the past 50 years.</p>
<p>Clarification Statement</p>	<p>The rate of land loss and habitat conversion from a variety of forces results in stresses and constraints that influence decisions and carry consequences that affect quality of life and have a bearing on sustainability. Increases in commercial and recreational uses may result in the need for environmental policies and call for changes in long established practices. Community efforts to address changes to secure growth while preserving the resources depend on education and collaboration between groups. Examples may include ground water conservation, erosion/flood control, forestry stewardship, game and wildlife, commercial fishing, oil and gas industry, dredging, or regulatory factors.</p>



<p>Science & Engineering Practices</p>	<p>Disciplinary Core Ideas</p>	<p>Crosscutting Concepts</p>
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. <ul style="list-style-type: none"> • Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. • Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. 	<p>RESOURCE MANAGEMENT FOR LOUISIANA Population growth along with cultural and economic factors impact resource availability, distribution and use. (HS.EVS1B.a)</p> <p>RESOURCE MANAGEMENT FOR LOUISIANA Some changes to our natural environment such as the building of levees and hydrological modification have provided for economic and social development but have resulted in unintended negative impacts. (HS.EVS1.B.b)</p>	<p>SYSTEMS AND SYSTEM MODELS When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.</p>

RESOURCES AND RESOURCE MANAGEMENT

<p>Performance Expectation</p>	<p>Analyze and interpret data about the consequences of environmental decisions to determine the risk-benefit values of actions and practices implemented for selected issues.</p>
<p>Clarification Statement</p>	<p>Examples could be taken from system interactions: (1) loss of ground vegetation causing an increase in water runoff and soil erosion. (2) dammed rivers increasing ground-water recharge, decreasing sediment transport, and increasing coastal erosion. (3) loss of wetlands reducing storm protection buffer zones allowing further wetland reduction. (4) hydrological modification such as levees providing protection to infrastructure at a cost to ecosystems.</p>

<p>Science & Engineering Practices</p>	<p>Disciplinary Core Ideas</p>	<p>Crosscutting Concepts</p>
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data: Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. <ul style="list-style-type: none"> • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success. 5. Using mathematics and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information 	<p>RESOURCE MANAGEMENT FOR LOUISIANA Some changes to our natural environment such as the building of levees and hydrological modification have provided for economic and social development but have resulted in unintended negative impacts. (HS.EVS1B.b)</p>	<p>CAUSE AND EFFECT Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.</p>

ENVIRONMENTAL AWARENESS AND PROTECTION

<p>Performance Expectation</p>	<p>Design and evaluate a solution to limit the introduction of non-point source pollution into state waterways.</p>
<p>Clarification Statement</p>	<p>Examples of non-point source water pollution could include nitrogen and phosphorus compounds from agricultural activities and sediments from poor land-use practices. Nitrogen and phosphorus contribute to eutrophication and are anthropogenic drivers of the Gulf of Mexico hypoxic area known as the dead zone.</p>

<p>Science & Engineering Practices</p>	<p>Disciplinary Core Ideas</p>	<p>Crosscutting Concepts</p>
<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. <ul style="list-style-type: none"> Design, evaluate and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria and trade-off considerations. Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>POLLUTION AND THE ENVIRONMENT Pollution includes both natural and man-made substances which occur at rates or levels which incur harm (i.e. combustion of fossil fuels, agricultural waste, and industrial byproducts). Pollution can be categorized as point-source pollution and non-point source pollution. (HS.EVS2A.a)</p> <p>ENVIRONMENTAL CHOICES Different approaches can be used to manage impacts to our environment. Generally speaking, we can change human activities to limit negative impacts. Alternately, we can use technologies that reduce impact or we can perform restoration work to recover natural functions and values. (HS.EVS2C.a)</p> <p>Trade-offs occur when we make environmental choices. (HS.EVS2C.b)</p> <p>DEFINING AND DELIMITING ENGINEERING PROBLEMS Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS.ETS1A.b)</p>	<p>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.</p>

ENVIRONMENTAL AWARENESS AND PROTECTION

<p>Performance Expectation</p>	<p>Use a model to predict the effects that pollution as a limiting factor has on an organism's population density.</p>
<p>Clarification Statement</p>	<p>The law of limiting factors is often illustrated as a graphic tolerance curve and can be used to infer the range of tolerance a species has for specific pollution hazards. When combined with real-world data such as field measurements of abiotic factors, these models can be used to help predict the suitability of an ecosystem for a particular species.</p>

<p>Science & Engineering Practices</p>	<p>Disciplinary Core Ideas</p>	<p>Crosscutting Concepts</p>
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models: Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s) <ul style="list-style-type: none"> • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems and/or solve problems 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information 	<p>POLLUTION AND THE ENVIRONMENT Different organisms have unique tolerances to pollution hazards. Many of the organisms most tolerant of pollution are the least desirable to humans (e.g., for food, for recreation, for ecosystem services). (HS.EVS2A.b)</p>	<p>CAUSE AND EFFECT Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.</p>

ENVIRONMENTAL AWARENESS AND PROTECTION

Performance Expectation	Use multiple lines of evidence to construct an argument addressing the negative impacts that introduced organisms have on Louisiana’s native species.
Clarification Statement	The exotic organisms introduced in Louisiana include plants such as Chinese tallow, kudzu and water hyacinth and animals including nutria, Asian tiger mosquitoes and zebra mussels. These organisms can have impacts on scales ranging from the level of the individual (e.g. competition) to that of the landscape (e.g. the destruction of coastal marshes by nutria).

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science <ul style="list-style-type: none"> • Construct, use, and/or present an oral and written argument or counterarguments based on data and evidence 8. Obtaining, evaluating, and communicating information 	<p>ECOSYSTEM CHANGE</p> <p>The introduction of exotic/invasive species causes a disruption in natural ecosystems and can lead to the loss of native species (i.e. threatened/endangered). (HS.EVS2B.a)</p> <p>Changes in ecosystems impact the availability of natural resources (e.g. sediment starvation, climate change). (HS.EVS2B.b)</p>	<p>CAUSE AND EFFECT</p> <p>Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.</p>

PERSONAL RESPONSIBILITIES

<p>Performance Expectation</p>	<p>Construct and evaluate arguments about the positive and negative consequences of using disposable resources versus reusable resources.</p>
<p>Clarification Statement</p>	<p>Resources can be both natural or man-made and may include renewable and non-renewable energy sources, soil, ecosystems, forestry, fisheries, plastic, paper, or aluminum products. Energy used to create and dispose of products may also be considered.</p>



Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. <ul style="list-style-type: none"> • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. • Construct, use, and/or present an oral and written argument or counterarguments based on data and evidence. 8. Obtaining, evaluating, and communicating information 	<p>STEWARDSHIP Ecosystem sustainability can be used as a model for a sustainable society (e.g. recycling, energy efficiency, diversity). (HS.EVS3A.a)</p> <p>Louisiana citizens are responsible for conserving our state’s natural resources. Personal actions can have a positive or negative impact. (HS.EVS3A.b)</p>	<p>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.</p>

EARTH'S SYSTEMS

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

<p>Science & Engineering Practices</p>	<p>Disciplinary Core Ideas</p>	<p>Crosscutting Concepts</p>
<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data: Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data <ul style="list-style-type: none"> Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>EARTH MATERIALS AND SYSTEMS Earth's systems, being dynamic and interacting, include feedback effects that can increase or decrease the original changes. (HS.ESS2A.a)</p> <p>WEATHER AND CLIMATE The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, hydrosphere, and land systems, and this energy's re-radiation into space. (HS.ESS2D.a)</p>	<p>STABILITY AND CHANGE Feedback (negative or positive) can stabilize or destabilize a system.</p>

EARTH'S SYSTEMS

Performance Expectation	Analyze and interpret data to explore how variations in the flow of energy into and out of Earth's systems result in changes in atmosphere and climate.
Clarification Statement	Changes differ by timescale, from sudden (large volcanic eruption, hydrosphere circulation) to intermediate (hydrosphere circulation, solar output, human activity) and long-term (Earth's orbit and the orientation of its axis and changes in atmospheric composition). Examples of human activities could include fossil fuel combustion, cement production, or agricultural activity and natural processes such as changes in incoming solar radiation or volcanic activity. Examples of data can include tables, graphs, maps of global and regional temperatures, and atmospheric levels of gases.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data: Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data <ul style="list-style-type: none"> Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>EARTH AND THE SOLAR SYSTEM Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on Earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (HS.ESS1B.b)</p> <p>EARTH MATERIALS AND SYSTEMS The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, hydrosphere circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS.ESS2A.d)</p> <p>WEATHER AND CLIMATE The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, hydrosphere and land systems, and this energy's re-radiation into space. (HS.ESS2D.a)</p> <p>Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS.ESS2D.b)</p> <p>Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS.ESS2D.c)</p>	<p>CAUSE AND EFFECT Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</p>

EARTH'S SYSTEMS

Performance Expectation	Plan and conduct an investigation on the properties of water and its effects on Earth materials and surface processes.
Clarification Statement	Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids)

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. <ul style="list-style-type: none"> • Plan an investigation (science) or test a design (engineering) individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information 	<p>THE ROLE OF WATER IN EARTH'S SURFACE PROCESSES</p> <p>The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks (HS.ESS2C.a)</p>	<p>STRUCTURE AND FUNCTION</p> <p>The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.</p>

EARTH'S SYSTEMS

<p>Performance Expectation</p>	<p>Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.</p>
<p>Clarification Statement</p>	<p>Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.</p>

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models: Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. <ul style="list-style-type: none"> • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information 	<p>WEATHER AND CLIMATE</p> <p>Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS.ESS2D.b)</p> <p>Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS.ESS2D.c)</p>	<p>ENERGY AND MATTER</p> <p>The total amount of energy and matter in closed systems is conserved.</p>

HUMAN SUSTAINABILITY

<p>Performance Expectation</p>	<p>Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.</p>
<p>Clarification Statement</p>	<p>Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Natural hazards and other geologic events exhibit some non-random patterns of occurrence. Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, or the types of crops and livestock that can be raised.</p>

<p>Science & Engineering Practices</p>	<p>Disciplinary Core Ideas</p>	<p>Crosscutting Concepts</p>
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. <ul style="list-style-type: none"> • 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. 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information 	<p>NATURAL RESOURCES Resource availability has guided the development of human society. (HS.ESS3A.a)</p> <p>NATURAL HAZARDS Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS.ESS3B.a)</p>	<p>CAUSE AND EFFECT Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</p>

HUMAN SUSTAINABILITY

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

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. <ul style="list-style-type: none"> • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information 	<p>NATURAL RESOURCES All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS.ESS3A.b)</p> <p>DESIGNING SOLUTIONS TO ENGINEERING PROBLEMS When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS.ETS1B.a)</p>	<p>SYSTEMS AND SYSTEM MODELS Systems can be designed to do specific tasks.</p>

HUMAN SUSTAINABILITY

Performance Expectation	Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.
Clarification Statement	Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g. trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. <ul style="list-style-type: none"> • Create a computational model or simulation of a phenomenon, designed device, process, or system 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information 	<p>HUMAN IMPACTS ON EARTH SYSTEMS The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS.ESS3C.a)</p>	<p>STABILITY AND CHANGE Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.</p>

HUMAN SUSTAINABILITY

<p>Performance Expectation</p>	<p>Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*</p>
<p>Clarification Statement</p>	<p>Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).</p>

<p>Science & Engineering Practices</p>	<p>Disciplinary Core Ideas</p>	<p>Crosscutting Concepts</p>
<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. <ul style="list-style-type: none"> Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>HUMAN IMPACTS ON EARTH SYSTEMS Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS.ESS3C.b)</p> <p>DESIGNING SOLUTIONS TO ENGINEERING PROBLEMS When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS.ETS1B.a)</p>	<p>STABILITY AND CHANGE Feedback (negative or positive) can stabilize or destabilize a system.</p>

HUMAN SUSTAINABILITY

Performance Expectation	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
Clarification Statement	Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g. trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. <ul style="list-style-type: none"> • Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information 	<p>WEATHER AND CLIMATE Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (HS.ESS2D.d)</p> <p>GLOBAL CLIMATE CHANGE Important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities (e.g., through computer simulations and other discoveries satellite imagery). (HS.ESS3D.b)</p>	<p>SYSTEMS AND SYSTEM MODELS When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.</p>

ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS

<p>Performance Expectation</p>	<p>Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity, biodiversity and populations of ecosystems at different scales.</p>
<p>Clarification Statement</p>	<p>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, or population changes gathered from simulations or historical data sets.</p>

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g. trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. <ul style="list-style-type: none"> Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges as predation, competition, and disease that affect biodiversity, including genetic diversity within a population and species diversity within an ecosystem. 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. (HS.LS2A.a)</p> <p>Human activity directly and indirectly affect biodiversity and ecosystem health (e.g., habitat fragmentation, introduction of nonnative or invasive species, over-harvesting, pollution and climate change). (HS.LS2A.b)</p>	<p>SCALE, PROPORTION, AND QUANTITY The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.</p>

ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS

<p>Performance Expectation</p>	<p>Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.</p>
<p>Clarification Statement</p>	<p>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.</p>

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ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS

<p>Performance Expectation</p>	<p>Evaluate the claims, evidence and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.</p>
<p>Clarification Statement</p>	<p>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. Emphasis should be on describing drivers of ecosystem stability and change, not on the organismal mechanisms of responses and interactions.</p>

<p>Science & Engineering Practices</p>	<p>Disciplinary Core Ideas</p>	<p>Crosscutting Concepts</p>
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence: Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. <ul style="list-style-type: none"> • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. 8. Obtaining, evaluating, and communicating information 	<p>ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE</p> <p>The dynamic 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 and may result in new ecosystems. (HS.LS2C.a)</p>	<p>STABILITY AND CHANGE</p> <p>Much of science deals with constructing explanations of how things change and how they remain stable.</p>

ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS

<p>Performance Expectation</p>	<p>Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.</p>
<p>Clarification Statement</p>	<p>Examples of human activities can include urbanization, building dams, and dissemination of invasive species.</p>

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. <ul style="list-style-type: none"> • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information 	<p>ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE Ecosystems with a greater biodiversity tend to have a greater resistance and resilience to change. Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS.LS2C.b)</p> <p>BIODIVERSITY AND HUMANS Biodiversity is increased by the formation of 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. Thus, sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (HS.LS4D.a)</p> <p>DEVELOPING POSSIBLE SOLUTIONS When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (HS.ETS1B.a)</p>	<p>STABILITY AND CHANGE Much of science deals with constructing explanations of how things change and how they remain stable.</p>