New Jersey Student Learning Standards
Science
(NJSLS-Science)

Division of Teaching and Learning Services
New Jersey Department of Education

Table of Contents

Introduction 4

Science Framework 4

Structure of This Document 8

A Note on the Inclusion of Climate Change and Sustainability Opportunities 9

Implementation Supports and Additional Resources 9

Developmental Progressions 10

- Physical Sciences 11
- Life Science 23
- Earth and Space Sciences 32

Performance Expectations by Grade 43

- Kindergarten 44
  - Physical Science 44
  - Life Science 44
  - Earth and Space Sciences 44
- Grade 1 45
  - Physical Science 45
  - Life Science 45
  - Earth and Space Sciences 45
- Grade 2 46
  - Physical Science 46
  - Life Science 46
  - Earth and Space Sciences 46
  - K-2 Engineering, Technology and Applications of Science 47
- Grade 3 48
  - Physical Science 48
  - Life Science 48
  - Earth and Space Sciences 49
- Grade 4 50
  - Physical Science 50
  - Life Science 50
  - Earth and Space Sciences 50
- Grade 5 52
  - Physical Science 52
  - Life Science 52
  - Earth and Space Sciences 52
  - 3-5 Engineering, Technology, and Applications of Science 53

Grades 6 through 8 54
Physical Science 54
Life Science 56
Earth and Space Sciences 59
6-8 Engineering, Technology, and Applications of Science 61

Grades 9 through 12 62
Physical Science 62
Life Science 65
Earth and Space Sciences 68
9-12 Engineering, Technology and Applications of Sciences 70

Introduction

N.J.A.C. 6A:8-2.1 directs the Commissioner to engage in the review and readoption of the New Jersey Student Learning Standards (NJSLS) every five years. Science (NJSLS-S) standards were most recently adopted in 2020; the review process began in May 2025. After months of intensive review and discussion, including with external expert committees, the New Jersey Department of Education (Department) is presenting recommendations for revisions.

The external committees involved in the review and revision of the 2020 New Jersey Student Learning Standards for Science (NJSLS-S) were committed to continuing the implementation trajectory established by the adoption of the *Next Generation Science Standards: For States, By States* in 2014. As a result, revisions were made only when absolutely necessary to enhance progression of disciplinary core ideas. Revisions were recommended to only four performance expectations.

Science Framework

The New Jersey Student Learning Standards for Science (NJSLS-S) are grounded in the principles and vision outlined in the National Research Council's 2012 consensus study *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* and are aligned with the performance expectations of the *Next Generation Science Standards: For States By States* (NRC, 2013).

The New Jersey Student Learning Standards for Science (NJSLS-S) are organized into four domains:

- Physical Science (PS),
- Life Science (LS),
- Earth and Space Sciences (ESS), and
- Engineering, Technology, and Applications of Science (ETS).

Each domain is comprised of Disciplinary Core Ideas and their Components. The following describe the Disciplinary Core Ideas and Components in Physical Science, Life Science, Earth and Space Sciences, and Engineering, Technology and the Applications of Science.

Physical Science (PS)

PS1. Matter and Its Interactions: Beginning in the earliest grades, students develop increasingly sophisticated understandings of the structure, properties, and interactions of matter.

PS1.A. Structures and Properties of Matter
PS1.B. Chemical Reactions
PS1.C. Nuclear Processes

PS2. Motion and Stability: Forces and Interactions*:* Beginning in the earliest grades, students develop increasingly sophisticated understandings of how to explain and predict interactions between objects and within systems of objects.

PS2.A. Forces and Motion
PS2.B. Types of Interactions
PS2.C. Stability and Instability in Physical Systems

PS3. Energy: Beginning in the earliest grades, students develop increasingly sophisticated understandings of what is meant by conservation of energy, and how energy is transferred between objects or systems.

PS3.A. Definitions of Energy
PS3.B. Conservation of Energy and Energy Transfer
PS3.C. Relationship Between Energy and Forces
PS3.D. Energy in Chemical Processes and Everyday Life

PS4. Waves and Their Applications in Technologies for Information Transfer: Beginning in the earliest grades, students develop increasingly sophisticated understandings of *how and why waves are used to transfer energy and information*.

PS4.A. Wave Properties
PS4.B. Electromagnetic Radiation
PS4.C. Information Technologies and Instrumentation

Life Science (LS)

LS1. From Molecules to Organisms: Structures and Processes: Beginning in the earliest grades, students develop increasingly sophisticated understandings of how organisms live, grow, reproduce, and respond to their environment.

LS1.A. Structure and Function
LS1.B. Growth and Development of Organisms
LS1.C. Organization for Matter and Energy Flow in Organisms
LS1.D. Information Processing

LS2. Ecosystems: Interactions, Energy, and Dynamics: Beginning in the earliest grades, students develop increasingly sophisticated understandings of *how and why organisms interact with their environment and the effects of these interactions*.

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

LS3. Heredity: Inheritance and Variation of Traits: Beginning in the earliest grades, students develop increasingly sophisticated understandings of how characteristics are passed from one generation to the next, and why individuals of the same species—even siblings—exhibit different traits.

LS3.A. Inheritance of Traits
LS3.B. Variation of Traits

LS4. Biological Evolution: Unity and Diversity: Beginning in the earliest grades, students develop increasingly sophisticated understandings of *how there can be so many similarities among organisms*.

LS4.A. Evidence of Common Ancestry and Diversity
LS4.B. Natural Selection
LS4.C. Adaptation
LS4.D. Biodiversity and Humans

Earth and Space Science (ESS)

ESS.1. Earth's Place in the Universe: Beginning in the earliest grades, students develop increasingly sophisticated understandings of the universe, and Earth's place in it.

ESS1.A. The Universe and Its Stars
ESS1.B. Earth and The Solar System
ESS1.C. The History of Planet Earth

ESS2. Earth's Systems: Beginning in the earliest grades, students develop increasingly sophisticated understandings of how and why the Earth is constantly changing including:

ESS2.A. Earth Materials and Systems
ESS2.B. Plate Tectonics and Large-Scale System Interactions
ESS2.C. The Roles of Water in Earth's Surface Processes
ESS2.D. Weather and Climate
ESS2.E. Biogeology

ESS3. Earth and Human Activity: Beginning in the earliest grades, students develop increasingly sophisticated understandings of how and why the Earth's surface processes, and how human activities affect each other.

ESS3.A. Natural Resources
ESS3.B. Natural Hazards
ESS3.C. Human Impacts on Earth Systems
ESS3.D. Global Climate Change

Engineering, Technology and the Application of Science (ETS)

ETS1. Engineering Design: Beginning in the earliest grades, students develop increasingly sophisticated understandings of how engineers solve problems including:

ETS1.A. Defining and Delimiting Engineering Problems
ETS1.B. Developing Possible Solutions

ETS2. Links Among Engineering, Technology, Science, and Society: Beginning in the earliest grades, students develop increasingly sophisticated understandings of how engineering, technology, science, and society are interconnected.

ETS2.A. Interdependence of Science, Engineering, And Technology
ETS2.B. Influence of Engineering, Technology, and Science on Society and the Natural World

Coding of Performance Expectations

Each performance expectation has a unique code that follows a specific format, which is designed to provide a clear, structured way to identify and organize the standards across grade levels and scientific disciplines. For example, 5-PS1-1.

The first number indicates a grade K-5 or specifies MS (middle school) or HS (high school). The next alpha-numeric code specifies the discipline, core idea and sub-idea. Finally, the number at the end of each code indicates the order in which the PE appears in the standards.

5 – Grade 5

PS1 – Matter of any type can be subdivided into particles that are too small to see, but even then, the matter still exists and can be detected by other means.

1 – first PE in sequence

5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen.

Structure of This Document

Developmental Progressions

This portion of the document presents the performance expectations by disciplinary concept in a K-12 learning progression. Presenting learning standards in a K–12 progression helps educators understand how students build knowledge and skills over time, allowing for more intentional and coherent curriculum design. By mapping standards across grade levels, teachers and curriculum developers can see how foundational concepts introduced in early grades evolve into more complex and nuanced understandings in later years. This vertical alignment supports scaffolding, ensuring that instruction is developmentally appropriate and that students are prepared for increasingly sophisticated tasks. It also enables educators to identify gaps or redundancies in instruction, promote continuity in learning, and better support students' long-term mastery of essential concepts.

Performance Expectations by Grade

This portion of the document presents the performance expectations by grade level and grade band. Presenting learning standards by grade bands is essential for ensuring clarity, consistency, and instructional relevance for educators implementing the standards directly. When standards are organized this way, educators can easily identify what students are expected to learn at each stage of their academic journey, making it easier to plan lessons that are developmentally appropriate and aligned with the NJSLS. Grade-banded standards also help curriculum developers ensure that content builds logically from year to year, avoiding gaps or unnecessary repetition. For teachers, this structure supports targeted instruction and assessment, allowing them to meet students where they are and guide them toward mastery. Overall, grade-banded organization promotes coherence across classrooms and schools, helping all educators work toward shared learning goals.

A Note on the Inclusion of Climate Change and Sustainability Opportunities 🌱

With the adoption of the 2020 New Jersey Student Learning Standards (NJSLS), New Jersey became the first state in the nation to include climate change education across content areas. The goal of inclusion of climate change education is to foster generations of New Jersey students that can analyze, question, interpret, think independently, and bring critical deduction to fulfill and to lead in jobs created by burgeoning industries of the future green economy.

The New Jersey Student Learning Standards for Science include performance expectations in Weather and Climate (ESS2.D) and Human Impacts on Earth Systems (ESS3.C) that are directly aligned with climate change. Beginning in kindergarten, students develop increasingly sophisticated understanding of how weather and climate are shaped by complex interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions can drive changes that occur over multiple time scales—from days, weeks, and months for weather to years, decades, centuries, and beyond—for climate. Students also make sense of how humans have become one of the most significant agents of change in the near-surface Earth system. And because all of Earth's subsystems are interconnected, changes in one system can produce unforeseen changes in others. This symbol (🌱) is used in the science standards to identify performance expectations directly related to climate, climate change, or the effects of a changing climate on environmental systems.

Implementation Supports and Additional Resources

To support the successful implementation of the 2025 NJSLS – Science, guidance documents will be made available on the Standards Transparency and Mastery Platform (STAMP) webpage. The documents will support districts in developing a clear understanding of the expectations and help guide curriculum development at the local level. To ensure professional learning is high-quality and responsive to the needs of the field, New Jersey educators will be included in the development of resources in collaboration with the Department. The outcome will include the delivery of guidance documents, professional learning opportunities, and other NJSLS-supporting resources.

Developmental Progressions

Physical Science

An overarching goal for learning in the physical sciences, therefore, is to help students see that there are mechanisms of cause and effect in all systems and processes that can be understood through a common set of physical and chemical principles. The first three physical science core ideas answer two fundamental questions: “What is everything made of?” and “Why do things happen?” These core ideas can be applied to explain and predict a wide variety of phenomena that occur in people’s everyday lives, such as the evaporation of a puddle of water, the transmission of sound, the digital storage and transmission of information, the tarnishing of metals, and photosynthesis. And because such explanations and predictions rely on a basic understanding of matter and energy, students’ abilities to conceive of the interactions of matter and energy are central to their science education. The fourth core idea, Waves and Their Applications in Technologies for Information Transfer, introduces students to the ways in which advances in the physical sciences during the 20th century underlay all sophisticated technologies available today. This fourth idea stresses the interplay of physical science and technology, as well as expanding students’ understanding of light and sound as mechanisms of both energy transfer and transfer of information between objects that are not in contact. Modern communication, information, and imaging technologies are applications of scientific understandings of light and sound and their interactions with matter.

PS1 Matter and Its Interactions

PS1 Matter and Its Interactions examines how one can explain the structure, properties, and interactions of matter. The atomic model helps explain both qualitative and quantitative observations of matter. Matter is understood through the types of atoms it contains and their interactions, which determine its states, properties, and behaviors. Chemical reactions rearrange atoms into new molecules while conserving their number, and nuclear reactions alter atomic nuclei, playing a key role in phenomena like solar energy and isotope formation.

Core Idea	K-2	3-5	6- 8	9-12
PS1.A. Structures and Properties of Matter	2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose. 2-PS1-3. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be	5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen. 5-PS1-2. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved. (PS1.A and PS1.B) 5-PS1-3. Make observations and measurements to identify materials based on their properties.	MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures. MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. (PS1.A and PS1.B) MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and	HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the

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Core Idea	K-2	3-5	6- 8	9-12
	disassembled and made into a new object.		impact society. (PS1.A and PS1.B) MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. (PS1.A and PS1.B)	patterns of chemical properties. (PS1.A and PS1.B) HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. (PS1.A and PS1.B) HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. (PS1.A and PS1.B)
PS1.B. Chemical Reactions	2-PS1-4. Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.	5-PS1-2. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved. (PS1.A and PS1.B) 5-PS1-4. Conduct an investigation to determine whether the mixing of two or more substances results in new substances.	MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. (PS1.A and PS1.B) MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. (PS1.A and PS1.B) MS-PS1-5. Develop and use a model to describe how the total	HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. (PS1.A and PS1.B) HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in

PS1 Matter and Its Interactions

PS1 Matter and Its Interactions examines how one can explain the structure, properties, and interactions of matter. The atomic model helps explain both qualitative and quantitative observations of matter. Matter is understood through the types of atoms it contains and their interactions, which determine its states, properties, and behaviors. Chemical reactions rearrange atoms into new molecules while conserving their number, and nuclear reactions alter atomic nuclei, playing a key role in phenomena like solar energy and isotope formation.

Core Idea	K-2	3-5	6- 8	9-12
			number of atoms does not change in a chemical reaction and thus mass is conserved. MS-PS1-6. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. (PS1.B, ETS1.B and ETS1.C)	total bond energy. (PS1.A and PS1.B) HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. (PS1.B and ETS1.C) HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
PS1.C. Nuclear Processes	Intentionally left blank	Intentionally left blank	Intentionally left blank	HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

PS2 Motion and Stability: Forces and Interactions

PS2 Motion and Stability: Forces and Interactions examines how one can explain and predict interactions between objects and within systems of objects. Interactions between any two objects can cause changes in one or both of them. An understanding of the forces between objects is important for describing how their motions change, as well as for predicting stability or instability in systems at any scale. All forces between objects arise from a few types of interactions: gravity, electromagnetism, and the strong and weak nuclear interactions.

Core Idea	K-2	3-5	6- 8	9-12
PS2.A. Forces and Motion	K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. (PS2.A, PS2.B and PS3C) K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull. (PS2.A and ETS1.A)	3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. (PS2.A and PS2.B) 3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.	MS-PS2-1.Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.	HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. (PS2.A, ETS1.A and ETS1.C)
PS2.B. Types of Interactions	K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. (PS2.A, PS2.B and PS3C)	3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. (PS2.A and PS2.B) 3-PS2-3. Ask questions to determine cause and effect	MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. MS-PS2-4. Construct and present arguments using evidence to support the claim that	HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. (PS1.A and PS2.B)

PS2 Motion and Stability: Forces and Interactions

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Core Idea	K-2	3-5	6- 8	9-12
		relationships of electric or magnetic interactions between two objects not in contact with each other. 3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets. 5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.	gravitational interactions are attractive and depend on the masses of interacting objects. MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. MS-PS1-6. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. (PS1.B, ETS1.B and ETS1.C)	HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. (PS2.B and PS3.A) HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

PS3: Energy

PS3: Energy focuses on how energy is transferred and conserved. Interactions of objects can be explained and predicted using the concept of transfer of energy from one object or system of objects to another. The total energy within a defined system changes only by the transfer of energy into or out of the system.

Core Idea	K-2	3-5	6- 8	9-12
PS3.A. Definitions of Energy	Intentionally left blank	4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object. 4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. (PS3.A, PS3.B and PS3.C) 4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.	MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. (PS1.A and PS3.A) MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. (PS3.A and PS3.C) MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. (PS3.A, PS3.C and ETS1.A) MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as	HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. (PS2.B and PS3.A) HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. (PS3.A and PS3.B) HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects). HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. (PS3.A, PS3.D and ETS1.A)

PS3: Energy

PS3: Energy focuses on how energy is transferred and conserved. Interactions of objects can be explained and predicted using the concept of transfer of energy from one object or system of objects to another. The total energy within a defined system changes only by the transfer of energy into or out of the system.

Core Idea	K-2	3-5	6- 8	9-12
			measured by the temperature of the sample. (PS3.A and PS3.B)	
PS3.B. Conservation of Energy and Energy Transfer	K-PS3-1. Make observations to determine the effect of sunlight on Earth's surface. K-PS3-2. Use tools and materials provided to design and build a structure that will reduce the warming effect of sunlight on Earth's surface.	4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. (PS3.A, PS3.B and PS3.C) 4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. (PS3.A, PS3.B and PS3.C) 4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. (PS3.B, PS3.D and ETS1.A)	MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. (PS3.A, PS3.C and ETS1.A) MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. (PS3.A and PS3.B) MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.	HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other components. and energy flows in and out of the system are known. (PS3.A and PS3.B) HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. (PS3.A, PS3.D and ETS1.A) HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system second law of thermodynamics. (PS3.B and PS3.D)
PS3.C. Relationship Between Energy and Forces	K-PS2-1. Plan and conduct an investigation to compare the	4-PS3-2. Make observations to provide evidence that energy can	MS-PS3-2. Develop a model to describe that when the	HS-PS3-5. Develop and use a model of two objects

PS3: Energy

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Core Idea	K-2	3-5	6- 8	9-12
	effects of different strengths or different directions of pushes and pulls on the motion of an object. (PS2.A, PS2.B and PS3.C)	be transferred from place to place by sound, light, heat, and electric currents. (PS3.A, PS3.B and PS3.C)	arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. (PS3.A and PS3.C) MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. (PS3.A, PS3.C and ETS1.A)	interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.
PS3.D. Energy in Chemical Processes and Everyday Life	Intentionally left blank	4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. (PS3.B, PS3.D and ETS1.A)	MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. (PS3.D and LS1.C) MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. (PS3.D and LS1.C)	HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. (PS3A, PS3.D and ETS1.A) HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system second law of thermodynamics. (PS3.B and PS3.D) HS-PS4-5. Communicate technical information about

PS3: Energy

PS3: Energy focuses on how energy is transferred and conserved. Interactions of objects can be explained and predicted using the concept of transfer of energy from one object or system of objects to another. The total energy within a defined system changes only by the transfer of energy into or out of the system.

Core Idea	K-2	3-5	6- 8	9-12
				how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. (PS3.D, PS4.A, PS4.B and PS4.C) HS-LS2-5.Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. (LS2.B and LS3.D) 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. (LS1.C and PS3.D) HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. (ESS1.A and PS3.D)

PS4: Waves and Their Applications in Technologies for Information Transfer

PS4: Waves and Their Applications in Technologies for Information Transfer examines how waves are used to transfer energy and information. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. Light and sound are wavelike phenomena. By understanding wave properties and the interactions of electromagnetic radiation with matter, scientists and engineers can design systems for transferring information across long distances, storing information, and investigating nature on many scales—some of them far beyond direct human perception.

Core Idea	K-2	3-5	6- 8	9-12
PS4.A. Wave Properties	1-PS4-1. Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.	4- PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.	MS-PS4-1. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. (PS4.A and PS4.B)	HS-PS4-1.Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information. HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. (PS4.A and PS4.B) HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

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Core Idea	K-2	3-5	6- 8	9-12
				(PS3.D, PS4.A, PS4.B and PS4.C)
PS4.B. Electromagnetic Radiation	1-PS4-2. Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated. 1-PS4-3. Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light.	4-PS4-2. Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.	MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. (PS4.A and PS4.B)	HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. (PS4.A and PS4.B) HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. (PS3.D, PS4.A, PS4.B and PS4.C)

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PS4: Waves and Their Applications in Technologies for Information Transfer examines how waves are used to transfer energy and information. Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. Light and sound are wavelike phenomena. By understanding wave properties and the interactions of electromagnetic radiation with matter, scientists and engineers can design systems for transferring information across long distances, storing information, and investigating nature on many scales—some of them far beyond direct human perception.

Core Idea	K-2	3-5	6- 8	9-12
				HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. (ESS1.A and PS4.B)
PS4.C. Information Technologies and Instrumentation	1-PS4-4. Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.	4-PS4-3. Generate and compare multiple solutions that use patterns to transfer information. (PS4.C and ETS1.C)	MS-PS4-3. Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.	HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. (PS3.D, PS4.A, PS4.B and PS4.C)

Life Science

Life Sciences provide a framework for building students' understanding of biological concepts across grade levels. They are organized into four main strands. LS1: From Molecules to Organisms – Structures and Processes emphasizes how living organisms function, grow, and reproduce. It includes instruction on cells, body systems, and the role of energy in sustaining life. LS2: Ecosystems – Interactions, Energy, and Dynamics focusses on how organisms interact within ecosystems, focusing on energy transfer, food webs, population dynamics, and the impact of environmental changes. LS3: Heredity – Inheritance and Variation of Traits This includes how genetic information is passed from one generation to the next, and how traits vary due to genetic and environmental factors. LS4: Biological Evolution – Unity and Diversity investigates the evidence for evolution, mechanisms like natural selection, and the diversity of life resulting from common ancestry.

LS1: From Molecules to Organisms: Structures and Processes

LS1: From Molecules to Organisms: Structures and Processes addresses how individual organisms are configured and how these structures function to support life, growth, behavior, and reproduction. The first core idea hinges on the unifying principle that cells are the basic unit of life.

Core Idea	K-2	3-5	6- 8	9-12
LS1.A: Structure and Function	1-LS1-1. Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs. (LS1.A and LS1.D)	4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.	MS-LS1-1. Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function. MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.	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. HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. 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. (LS1.A and LS3.A)

LS1: From Molecules to Organisms: Structures and Processes

LS1: From Molecules to Organisms: Structures and Processes addresses how individual organisms are configured and how these structures function to support life, growth, behavior, and reproduction. The first core idea hinges on the unifying principle that cells are the basic unit of life.

Core Idea	K-2	3-5	6- 8	9-12
LS1.B: Growth and Development of Organisms	1-LS1-2. Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.	3-LS1-1. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.	MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively. MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. MS-LS3-2. Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. (LS1.B, LS3.A and LS3.B)	HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. (LS.3A and LS3.B) HS-LS1-4. Use a model to illustrate the role of cellular division mitosis. and differentiation in producing and maintaining complex organisms.
LS1.C: Organization for Matter and Energy Flow in Organisms	K-LS1-1. Use observations to describe patterns of what plants and animals including humans. need to survive.	5-PS3-1. Use models to describe that energy in animals' food (used for body repair, growth, and motion and to maintain body warmth) was once energy from the sun. (LS1.C and PS3.D) 5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water.	MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. (LS1. And PS3.D) MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release	HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. 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

LS1: From Molecules to Organisms: Structures and Processes

LS1: From Molecules to Organisms: Structures and Processes addresses how individual organisms are configured and how these structures function to support life, growth, behavior, and reproduction. The first core idea hinges on the unifying principle that cells are the basic unit of life.

Core Idea	K-2	3-5	6- 8	9-12
			energy as this matter moves through an organism. (LS1.C and PS3.D)	other large carbon-based molecules. 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. (LS1.C and PS3.D)
LS1.D: Information Processing	1-LS1-1. Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs. (LS1.A and LS1.D)	4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.	MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.	Intentionally left blank

LS2: Ecosystems: Interactions, Energy, and Dynamics

LS2: Ecosystems: Interactions, Energy, and Dynamics explores organisms' interactions with each other and their physical environment. This includes how organisms obtain resources, how they change their environment, how changing environmental factors affect organisms and ecosystems, how social interactions and group behavior play out within and between species, and how these factors all combine to determine ecosystem functioning.

Core Idea	K-2	3-5	6- 8	9-12
LS2.A: Interdependent Relationships in Ecosystems	2-LS2-1. Plan and conduct an investigation to determine if	5-LS2-1. Develop a model to describe the movement of matter among plants, animals,	MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on	HS-LS2-1. Use mathematical and/or computational representations to support

LS2: Ecosystems: Interactions, Energy, and Dynamics

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Core Idea	K-2	3-5	6- 8	9-12
	plants need sunlight and water to grow. 2-LS2-2. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants. (LS2.A and ETS1.B)	decomposers, and the environment. (LS2.A and LS2B)	organisms and populations of organisms in an ecosystem. MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.	explanations of factors that affect carrying capacity of ecosystems at different scales. 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. (LS2.A and LS2.C)
LS2.B: Cycles of Matter and Energy Transfer in Ecosystems	Intentionally left blank	5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. (LS2.A and LS2B)	MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	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. HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. HS-LS2-5.Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. (LS2.B and PS3.D)

LS2: Ecosystems: Interactions, Energy, and Dynamics

LS2: Ecosystems: Interactions, Energy, and Dynamics explores organisms' interactions with each other and their physical environment. This includes how organisms obtain resources, how they change their environment, how changing environmental factors affect organisms and ecosystems, how social interactions and group behavior play out within and between species, and how these factors all combine to determine ecosystem functioning.

Core Idea	K-2	3-5	6- 8	9-12
LS2.C: Ecosystem Dynamics, Functioning, and Resilience	Intentionally left blank	3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. (LS2.C and LS4.D)	MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. (LS2.C, LS4.D and ETS1.B)	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. (LS2.A and LS2.C) HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. (LS2.C, LS4.D, and ETS1.B)
LS2.D: Social Interactions and group behaviors	Intentionally left blank	3-LS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.	Intentionally left blank	HS-LS2-8. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

LS3: Heredity: Inheritance and Variation of Traits

LS3: Heredity: Inheritance and Variation of Traits across generations focuses on the flow of genetic information between generations. This idea explains the mechanisms of genetic inheritance and describes the environmental and genetic causes of gene mutation and the alteration of gene expression.

Core Idea	K-2	3-5	6- 8	9-12
LS3.A: Inheritance of Traits	1-LS3-1. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents. (LS3.A and LS3.B)	3-LS3-1. Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. (LS3.A and LS3.B) 3-LS3-2. Use evidence to support the explanation that traits can be influenced by the environment. (LS3.A and LS3.B)	MS-LS3-1. Develop and use a model to describe why structural changes to genes mutations. located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. (LS3.A and LS3.B) MS-LS3-2. Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. (LS1.B, LS3.A, and LS3.B)	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. (LS1.A and LS3.A)
LS3.B: Variation of Traits	1-LS3-1. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents. (LS3.A and LS3.B)	3-LS3-1. Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. (LS3.A and LS3.B) 3-LS3-2. Use evidence to support the explanation that traits can be influenced by the environment. (LS3.A and LS3.B)	MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. (LS3.A and LS3.B) MS-LS3-2. Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. (LS1.B, LS3.A, and LS3.B)	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. (LS1.B, LS.3A and LS3.B) HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

LS4: Biological Evolution: Unity and Diversity

LS4: Biological Evolution: Unity and Diversity explores “changes in the traits of populations of organisms over time” and the factors that account for species’ unity and diversity alike.

Core Idea	K-2	3-5	6- 8	9-12
LS4.A: Evidence of Common Ancestry and Diversity	Intentionally left blank	3-LS4-1. Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.	MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. MS-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. MS-LS4-3. Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.	HS-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
LS4.B: Natural Selection	Intentionally left blank	3-LS4-2. Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. (LS4.B and LS4.C)	MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals’ probability of surviving and reproducing in a specific environment.	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

LS4: Biological Evolution: Unity and Diversity

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Core Idea	K-2	3-5	6- 8	9-12
			MS-LS4-5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.	reproduction, 3. competition for limited resources, and 4. the proliferation of those organisms that are better able to survive and reproduce in the environment. (LS4.B and LS4.C) 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. (LS4.B and LS4.C)
LS4.C: Adaptation	Intentionally left blank	3-LS4-2. Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. (LS4.B and LS4.C) 3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.	MS-LS4-6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.	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. (LS4.B and LS4.C) HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion

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Core Idea	K-2	3-5	6- 8	9-12
				to organisms lacking this trait. (LS4.B and LS4.C) HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. 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. HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. (LS4.C, LS4.D and ETS1.B)
LS4.D: Biodiversity and Humans	2-LS4-1. Make observations of plants and animals to compare the diversity of life in different habitats.	3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. (LS2.C and LS4.D)	MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. (LS2.C, LS4.D and ETS1.B)	HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. (LS4.C, LS4.D and ETS1.B) HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. (LS2.C, LS4.D and ETS1.B)

Earth and Space Sciences

Earth and space sciences (ESS) investigate processes that operate on Earth and also address its place in the solar system and the galaxy. Thus, ESS involve phenomena that range in scale from the unimaginably large to the invisibly small. Earth and space sciences (ESS) share common ground with other scientific disciplines but also pursue unique inquiries. Early studies in physical sciences such as forces, energy, and gravity helped explain the nature of Earth, the sun, and the moon, eventually leading to the development of physics and chemistry as distinct fields. Life sciences also intersect with ESS, as Earth is the only known biologically active planet, and fossils in rocks are of interest to both biologists and geologists. Most ESS research is interdisciplinary, spanning astrophysics, geophysics, geochemistry, and geobiology, though traditional geology focused on identifying, analyzing, and mapping rocks remains foundational.

ESS1: Earth's Place in the Universe

ESS1: Earth's Place in the Universe describes the universe as a whole and addresses its grand scale in both space and time. This idea includes the overall structure, composition, and history of the universe, the forces and processes by which the solar system operates, and Earth's planetary history.

Core Idea	K-2	3-5	6- 8	9-12
ESS1.A: The Universe and Its Stars	1-ESS1-1. Use observations of the sun, moon, and stars to describe patterns that can be predicted.	5-ESS1-1. Support an argument that the apparent brightness of the sun and stars is due to their relative distances from the Earth.	MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. (ESS1.A and ESS1.B) MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. (ESS1.A and ESS1.B)	HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation. (ESS1.A and PS3.D) HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. (ESS1.A and PS4.B) HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements.
ESS1.B: Earth and the Solar System	1-ESS1-2. Make observations at different times of year to relate	5-ESS1-2. Represent data in graphical displays to reveal	MS-ESS1-1. Develop and use a model of the Earth-sun-moon	HS-ESS1-4. Use mathematical or

ESS1: Earth’s Place in the Universe

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Core Idea	K-2	3-5	6- 8	9-12
	the amount of daylight to the time of year.	patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.	system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. (ESS1.A and ESS1.B) MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. (ESS1.A and ESS1.B) MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system.	computational representations to predict the motion of orbiting objects in the solar system. HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate. (ESS1.B, ESS2.A and ESS2.D)
ESS1.C: The History of Planet Earth	2-ESS1-1. Use information from several sources to provide evidence that Earth events can occur quickly or slowly.	4-ESS1-1. Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.	MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. (ESS1.C and ESS2.B)	HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. (ESS1.C, ESS2.B, PS1.C) HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth’s formation and early history. (ESS1.C, ESS2.B, PS1.C)

ESS2: Earth's Systems

ESS2: Earth's Systems encompasses the processes that drive Earth's conditions and its continual evolution (i.e., change over time). It addresses the planet's large-scale structure and composition, describes its individual systems, and explains how they are interrelated. It also focuses on the mechanisms driving Earth's internal motions and on the vital role that water plays in all of the planet's systems and surface processes.

Core Idea	K-2	3-5	6- 8	9-12
ESS2.A: Earth Materials and Systems	2-ESS2-1. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land. (ESS2.A and ETS1.C)	4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. 5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.	MS-ESS2-1.Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. (ESS2.A and ESS2.C)	HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. (ESS2.A and ESS2.B) HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. (ESS1.B, ESS2.A and ESS2.D)
ESS2.B: Plate Tectonics and Large Scale System Interactions	2-ESS2-2. Develop a model to represent the shapes and kinds of land and bodies of water in an area.	4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features.	MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide	HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate

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Core Idea	K-2	3-5	6- 8	9-12
			evidence of the past plate motions. (ESS1.C and ESS2.B)	tectonics to explain the ages of crustal rocks. (ESS1.C, ESS2.B and PS1.C) HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. (ESS2.A and ESS2.B) HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. (ESS2.A, ESS2.B and PS4.A)
ESS2.C: The Roles of Water in Earth's Surface Processes	2-ESS2-3. Obtain information to identify where water is found on Earth and that it can be solid or liquid.	5-ESS2-2. Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.	MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. (ESS2.A and ESS2.C) MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. MSESS2- 5. Collect data to provide evidence for how the motions and complex	HS- ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

ESS2: Earth’s Systems

ESS2: Earth’s Systems encompasses the processes that drive Earth’s conditions and its continual evolution (i.e., change over time). It addresses the planet’s large-scale structure and composition, describes its individual systems, and explains how they are interrelated. It also focuses on the mechanisms driving Earth’s internal motions and on the vital role that water plays in all of the planet’s systems and surface processes.

Core Idea	K-2	3-5	6- 8	9-12
			interactions of air masses results in changes in weather conditions. (ESS2.C and ESS2.D) MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. (ESS2.C and ESS2.D)	
ESS2.D: Weather and Climate	K-ESS2-1. Use and share observations of local weather conditions to describe patterns over time.	3-ESS2-1. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. 3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.	MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. (ESS2.C and ESS2.D) MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. (ESS2.C and ESS2.D)	HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. (ESS2.A and ESS2.D) HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate. (ESS1.B, ESS2.A and ESS2.D) HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

ESS2: Earth's Systems

ESS2: Earth's Systems encompasses the processes that drive Earth's conditions and its continual evolution (i.e., change over time). It addresses the planet's large-scale structure and composition, describes its individual systems, and explains how they are interrelated. It also focuses on the mechanisms driving Earth's internal motions and on the vital role that water plays in all of the planet's systems and surface processes.

Core Idea	K-2	3-5	6- 8	9-12
				HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. (ESS2.D and ESS2.E) HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. (ESS2.D and ESS3.D)
ESS2.E: Biogeology	K-ESS2-2. Construct an argument supported by evidence for how plants and animals including humans. can change the environment to meet their needs. (ESS2.E and ESS3.C)	4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. (ESS2.A and ESS2.E	Intentionally left blank	HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. (ESS2.D and ESS2.E)

ESS3: Earth and Human Activity

ESS3: Earth and Human Activity addresses society's interactions with the planet. Connecting the ESS to the scale of human life, this idea explains how Earth's processes affect people through natural resources and natural hazards, and it describes some of the ways in which humanity affects Earth's systems.

Core Idea	K-2	3-5	6- 8	9-12
ESS3.A: Natural Resources	K-ESS3-1. Use a model to represent the relationship between the needs of different plants and animals including humans. and the places they live.	4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.	MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.	HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity. (ESS3.A and ESS3.B) HS-ESS3-2. Evaluate competing design solutions for developing, conserving, managing, and utilizing energy and mineral resources based on the associated economic, social, environmental, and geopolitical costs and risks, as well as benefits. (ESS3.A and ETS1.B)
ESS3.B: Natural Hazards	K-ESS3-2. Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather. (ESS3.B and ETS1.A)	3-ESS3-1. Make a claim about the merit of a design solution that reduces the impacts of weather-related hazard. 4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes and climate change have on humans. (ESS3.B and ETS1.B)	MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.	HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity. (ESS3A and ESS3.B)
ESS3.C: Human Impacts on Earth Systems	K-ESS3-2. Ask questions to obtain information about the purpose of weather forecasting to prepare	5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources,	MS- ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a	HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of

ESS3: Earth and Human Activity

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Core Idea	K-2	3-5	6- 8	9-12
	for, and respond to, severe weather. (ESS2.E and ESS3.C) K-ESS3-3. Communicate solutions that will reduce the impact humans on the land, water, air, and/or other living things in the local environment. (K-ESS3.C and ETS1.B)	environment, and address climate change issues.	human impact on the environment. MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.	natural resources, the sustainability of human populations, and biodiversity. HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.
ESS3.D: Global Climate Change	Intentionally left blank	Intentionally left blank	MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused climate change over the past century.	HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change). (ESS2.D and ESS3.D)

Engineering, Technology, and the Application of Science

The fields of science and engineering are mutually supportive. New technologies expand the reach of science, allowing the study of realms previously inaccessible to investigation; scientists depend on the work of engineers to produce the instruments and computational tools they need to conduct research. Engineers in turn depend on the work of scientists to understand how different technologies work so they can be improved; scientific discoveries are exploited to create new technologies in the first place. Scientists and engineers often work together in teams, especially in new fields, such as nanotechnology or synthetic biology that blur the lines between science and engineering. Students should come to understand these interactions and at increasing levels of sophistication as they mature. Their appreciation of the interface of science, engineering, and society should give them deeper insights into local, national, and global issues.

ETS1: Engineering Design

ETS1: Engineering Design is the iterative cycle of design that offers the greatest potential for applying science knowledge in the classroom and engaging in engineering practices. The components of this core idea include understanding how engineering problems are defined and delimited, how models can be used to develop and refine possible solutions to a design problem, and what methods can be employed to optimize a design.

Core Idea	K-2	3-5	6- 8	9-12
ETS1.A: Defining and Delimiting an Engineering Problem	K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool. K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull. (PS2.A and ETS1A) K-ESS3-2. Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather. (ESS3.B and ETS1.A)	3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. 4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. (PS3.B, PS3.D and ETS1A)	MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. (PS3.A, PS3.B, ETS1.A and ETS1.B)	HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. (PS2.A, ETS1.A, and ETS1.C) HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. (PS3.A, PS3.D, and ETS1.A)

ETS1: Engineering Design

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Core Idea	K-2	3-5	6- 8	9-12
ETS1.B: Developing Possible Solutions	K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem. K-ESS3-3. Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment. (ESS3.C and ETS1.B) 2-LS2-2. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants. (LS2.A and ETS1.B)	3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. 4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes and climate change have on humans. (ESS3.B and ETS1.B)	MS-ETS1-1. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. MS-ETS-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (ETS1.B and ETS1.C) MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (ETS1.B and ETS1.C) MS-PS1-6. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. (PS1.B, ETS1.B, and ETS1.C) MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (ETS1.B and ETS1.C)	HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. (LS2.C, LS4.D and ETS1.B) HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. (LS4.C, LS4.D and ETS1.B) HS-ESS3-2. Evaluate competing design solutions

ETS1: Engineering Design

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Core Idea	K-2	3-5	6- 8	9-12
			MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. (PS3.A, PS3.B, ETS1.A and ETS1.B) MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. (LS2.C, LS4.D, and ETS1.B)	for developing, conserving, managing, and utilizing energy and mineral resources based on the associated economic, social, environmental, and geopolitical costs and risks, as well as benefits. (ESS3.A and ETS1.B) HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.(ESS3.C and ETS1.B)
ETS1.C: Optimizing the Design Solution	K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs. 2-ESS2-1. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land	3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. 4-PS4-3. Generate and compare multiple solutions that use patterns to transfer information.	MS-ETS-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (ETS1.B and ETS1.C) MS-PS1-6. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.	HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

Performance Expectations by Grade

Kindergarten

Students are expected to develop understanding of patterns and variations in local weather and the purpose of weather forecasting to prepare for, and respond to, severe weather. Students are able to apply an understanding of the effects of different strengths or different directions of pushes and pulls on the motion of an object to analyze a design solution. Students are also expected to develop understanding of what plants and animals (including humans) need to survive and the relationship between their needs and where they live. Students use their understanding of sunlight warming Earth's surface to design a structure to keep their playground cool.

Physical Science

PS2: Motion and Stability: Forces and Interactions

K-PS2-1 Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.

K-PS2-2 Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.

PS3: Energy

K-PS3-1 Make observations to determine the effect of sunlight on Earth's surface.

K-PS3-2 Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.

Life Science

LS1: From Molecules to Organisms: Structures and Processes

K-LS1-1 Use observations to describe patterns of what plants and animals (including humans) need to survive.

Earth and Space Sciences

ESS2: Earth's Systems

K-ESS2-1 Use and share observations of local weather conditions to describe patterns over time.

K-ESS2-2 Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

ESS3: Earth and Human Activity

K-ESS3-1 Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live.

K-ESS3-2 Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.

K-ESS3-3 Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.

Grade 1

Students are expected to develop understanding of the relationship between sound and vibrating materials as well as between the availability of light and ability to see objects. The idea that light travels from place to place can be understood by students at this level through determining the effect of placing objects made with different materials in the path of a beam of light. Students are also expected to develop understanding of how plants and animals use their external parts to help them survive, grow, and meet their needs as well as how behaviors of parents and offspring help the offspring survive. The understanding is developed that young plants and animals are like, but not exactly the same as, their parents. Students are able to observe, describe, and predict some patterns of the movement of objects in the sky.

Physical Science

PS4: Waves and Their Applications in Technologies for Information Transfer

1-PS4-1 Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.

1-PS4-2 Make observations to construct an evidence-based account that objects can be seen only when illuminated.

1-PS4-3 Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.

1-PS4-4 Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

Life Science

LS1: From Molecules to Organisms: Structure and Processes

1-LS1-1 Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.

1-LS1-2 Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.

1-LS3: Heredity: Inheritance and Variation of Traits

1-LS3-1 Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.

Earth and Space Sciences

ESS1: Earth's Place in the Universe

1-ESS1-1 Use observations of the sun, moon, and stars to describe patterns that can be predicted.

1-ESS1-2 Make observations at different times of year to relate the amount of daylight to the time of year.

Grade 2

Students are expected to develop an understanding of what plants need to grow and how plants depend on animals for seed dispersal and pollination. Students are also expected to compare the diversity of life in different habitats. Students develop an understanding of observable properties of materials at this level through analysis and classification of different materials. Students are able to apply their understanding of the idea that wind and water can change the shape of the land to compare design solutions to slow or prevent such change. Students are able to use information and models to identify and represent the shapes and kinds of land and bodies of water in an area and where water is found on Earth.

Physical Science

PS1: Matter and Its Interactions

2-PS1-1 Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

2-PS1-2 Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

2-PS1-3 Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.

2-PS1-4 Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.

Life Science

LS2: Ecosystems: Interactions, Energy, and Dynamics

2-LS2-1 Plan and conduct an investigation to determine if plants need sunlight and water to grow.

2-LS2-2 Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.

LS4: Biological Evolution: Unity and Diversity

2-LS4-1 Make observations of plants and animals to compare the diversity of life in different habitats.

Earth and Space Sciences

ESS1: Earth's Place in the Universe

2-ESS1-1 Use information from several sources to provide evidence that Earth events can occur quickly or slowly.

ESS2: Earth's Systems

2-ESS2-1 Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.

2-ESS2-2 Develop a model to represent the shapes and kinds of land and bodies of water in an area.

2-ESS2-3 Obtain information to identify where water is found on Earth and that it can be solid or liquid.

K-2 Engineering, Technology and Applications of Science

ETS1: Engineering Design

K-2-ETS1-1 Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2 Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3 Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Grade 3

Students are expected to be able to determine the effects of balanced and unbalanced forces on the motion of an object and the cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. They are then able to apply their understanding of magnetic interactions to define a simple design problem that can be solved with magnets. Students develop an understanding of the similarities and differences of organisms' life cycles. Students acquire an understanding that organisms have different inherited traits, and that the environment can also affect the traits that an organism develops, at this level. In addition, students are able to construct an explanation using evidence for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. Students are expected to develop an understanding of types of organisms that lived long ago and also about the nature of their environments. Third graders are expected to develop an understanding of the idea that when the environment changes, some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die.

Physical Science

PS2: Motion and Stability: Forces and Interactions

3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

3-PS2-2 Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

3-PS2-3 Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

3-PS2-4 Define a simple design problem that can be solved by applying scientific ideas about magnets.

Life Science

LS1: From Molecules to Organisms: Structures and Processes

3-LS1-1 Develop models to describe that organisms have unique and diverse life cycles, but all have in common birth, growth, reproduction, and death.

LS2: Ecosystems: Interactions, Energy, and Dynamics

3-LS2-1 Construct an argument that some animals form groups that help members survive.

LS3: Heredity: Inheritance and Variation of Traits

3-LS3-1 Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.

3-LS3-2 Use evidence to support the explanation that traits can be influenced by the environment.

LS4: Biological Evolution: Unity and Diversity

3-LS4-1 Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.

3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.

3-LS4-3 Construct an argument with evidence that in a particular habitat, some organisms can survive well, some survive less well, and some cannot survive at all.

3-LS4-4 Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.

Earth and Space Sciences

ESS2: Earth’s Systems

3-ESS2-1 Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. 🌱

3-ESS2-2 Obtain and combine information to describe climates in different regions of the world. 🌱

3-ESS3: Earth and Human Activity

3-ESS3-1 Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.

Grade 4

Fourth graders are expected to develop a model to describe that an object can be seen when light reflected from its surface enters the eye. They are able to use evidence to construct an explanation of the relationship between the speed of an object and the energy of that object. Students are expected to develop an understanding that energy can be transferred from place to place by sound, light, heat, and electric currents or from object to object through collisions. They apply their understanding of energy to design, test, and refine a device that converts energy from one form to another. Students are expected to develop an understanding that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. Students are also expected to develop understanding of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. They apply their knowledge of natural Earth processes to generate and compare multiple solutions to reduce the impacts of such processes on humans. Finally, students analyze and interpret data from maps to describe patterns of Earth's features.

Physical Science

PS3: Energy

4-PS3-1 Use evidence to construct an explanation relating the speed of an object to the energy of that object.

4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

4-PS3-3 Ask questions and predict outcomes about the changes in energy that occur when objects collide.

4-PS3-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

PS4: Waves and Their Applications in Technologies for Information Transfer

4-PS4-1 Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

4-PS4-2 Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.

4-PS4-3 Generate and compare multiple solutions that use patterns to transfer information.

Life Science

LS1: From Molecules to Organisms: Structures and Processes

4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

4-LS1-2 Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.

Earth and Space Sciences

ESS1: Earth's Place in the Universe

4-ESS1-1 Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.

ESS2: Earth's Systems

4-ESS2-1 Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth's features.

ESS3: Earth and Human Activity

4-ESS3-1 Obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment. 🌱

4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes and climate change have on humans. 🌱

Grade 5

Students are able to describe that matter is made of particles too small to be seen through the development of a model. Students develop an understanding of the idea that regardless of the type of change that matter undergoes, the total weight of matter is conserved. Students determine whether the mixing of two or more substances results in new substances. Through the development of a model using an example, students are able to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. They describe and graph data to provide evidence about the distribution of water on Earth. Students develop an understanding of the idea that plants get the materials they need for growth chiefly from air and water. Using models, students can describe the movement of matter among plants, animals, decomposers, and the environment and that energy in animals' food was once energy from the sun. Students are expected to develop an understanding of patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Physical Science

PS1: Matter and Its Interactions

5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen.

5-PS1-2 Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.

5-PS1-3 Make observations and measurements to identify materials based on their properties.

5-PS1-4 Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

PS2: Motion and Stability: Forces and Interactions

5-PS2-1 Support an argument that the gravitational force exerted by Earth on objects is directed down.

PS3: Energy

5-PS3-1 Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.

Life Science

LS1: From Molecules to Organisms: Structures and Processes

5-LS1-1 Support an argument that plants get the materials they need for growth chiefly from air and water.

LS2: Ecosystems: Interactions, Energy, and Dynamics

5-LS2-1 Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

Earth and Space Sciences

ESS1: Earth's Place in the Universe

5-ESS1-1 Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.

5-ESS1-2 Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

ESS2: Earth's Systems

5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. 🌱

5-ESS2-2 Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.

5-ESS3: Earth and Human Activity

5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources, environment and address climate change issues. 🌱

3-5 Engineering, Technology, and Applications of Science

ETS1: Engineering Design

3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Grades 6 through 8

Physical Science

There are four physical science disciplinary core ideas in middle school: Matter and Its Interactions (PS1), Motion and Stability: Forces and Interactions (PS2), Energy (PS3), and Waves and Their Applications in Technologies for Information Transfer (PS4).

The performance expectations in **PS1: Matter and its Interactions** help students to formulate an answer to the question, “How do atomic and molecular interactions explain the properties of matter that we see and feel?” by building understanding of what occurs at the atomic and molecular scale. By the end of middle school, students will be able to apply understanding that pure substances have characteristic physical and chemical properties and are made from a single type of atom or molecule. They will be able to provide molecular level accounts to explain states of matters and changes between states, that chemical reactions involve regrouping of atoms to form new substances, and that atoms rearrange during chemical reactions. Students are also able to apply an understanding of the design and the process of optimization in engineering to chemical reaction systems.

The performance expectations in **PS2: Motion and Stability: Forces and Interactions** help students construct an evidence-based answer to the question, “How can one describe physical interactions between objects and within systems of objects?” By the end of middle school, students will be able to apply Newton’s Third Law of Motion to relate forces to explain the motion of objects. Students also apply ideas about gravitational, electrical, and magnetic forces to explain a variety of phenomena including beginning ideas about why some materials attract each other while others repel. In particular, students will develop understanding that gravitational interactions are always attractive but that electrical and magnetic forces can be both attractive and negative. Students also develop ideas that objects can exert forces on each other even though the objects are not in contact, through fields. Students are also able to apply an engineering practice and concept to solve a problem caused when objects collide.

The performance expectations in **PS3: Energy** help students formulate an answer to the question, “How can energy be transferred from one object or system to another?” Students develop their understanding of important qualitative ideas about energy including that the interactions of objects can be explained and predicted using the concept of transfer of energy from one object or system of objects to another, and the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students understand that objects that are moving have kinetic energy and that objects may also contain stored (potential) energy, depending on their relative positions. Students will also come to know the difference between energy and temperature, and begin to develop an understanding of the relationship between force and energy. Students are also able to apply an understanding of design to the process of energy transfer.

The performance expectations in **PS4: Waves and Their Applications in Technologies for Information Transfer** help students formulate an answer to the question, “What are the characteristic properties of waves and how can they be used?” At the middle school level, students are able to describe and predict characteristic properties and behaviors of waves when the waves interact with matter. Students can apply an understanding of waves as a means to send digital information.

PS1: Matter and Its Interactions

MS-PS1-1	Develop models to describe the atomic composition of simple molecules and extended structures.
MS-PS1-2	Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
MS-PS1-3	Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

MS-PS1-4 Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

MS-PS1-5 Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

MS-PS1-6 Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

PS2: Motion and Stability: Forces and Interactions

MS-PS2-1 Apply Newton's third law to design a solution to a problem involving the motion of two colliding objects.

MS-PS2-2 Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

MS-PS2-3 Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

MS-PS2-4 Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.

MS-PS2-5 Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

PS3: Energy

MS-PS3-1 Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

MS-PS3-2 Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

MS-PS3-3 Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

MS-PS3-4 Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

MS-PS3-5 Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

PS4: Waves and Their Applications in Technologies for Information Transfer

MS-PS4-1 Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

MS-PS4-2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

MS-PS4-3 Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.

Life Science

There are four life science disciplinary core ideas in middle school: From Molecules to Organisms: Structures and Processes (LS1), Ecosystems: Interactions, Energy, and Dynamics (LS2), Heredity: Inheritance and Variation of Traits (LS3), and Biological Evolution: Unity and Diversity (LS4).

The performance expectations in **LS1: From Molecules to Organisms: Structures and Processes** help students formulate an answer to the question, “How can one explain the ways cells contribute to the function of living organisms?” Students will gather information and use this information to support explanations of the structure and function relationship of cells. They can communicate understanding of cell theory. They have a basic understanding of the role of cells in body systems and how those systems work to support the life functions of the organism. The understanding of cells provides a context for the plant process of photosynthesis and the movement of matter and energy needed for the cell. Students can construct an explanation for how environmental and genetic factors affect growth of organisms. They can connect this to the role of animal behaviors in reproduction of animals as well as the dependence of some plants on animal behaviors for their reproduction.

The performance expectations in **LS2: Interactions, Energy, and Dynamics Relationships in Ecosystems** help students formulate an answer to the question, “How does a system of living and non-living things operate to meet the needs of the organisms in an ecosystem?” Students can analyze and interpret data, develop models, and construct arguments and demonstrate a deeper understanding of resources and the cycling of matter and the flow of energy in ecosystems. They can also study patterns of the interactions among organisms within an ecosystem. They consider biotic and abiotic factors in an ecosystem and the effects these factors have on population. They evaluate competing design solutions for maintaining biodiversity and ecosystem services.

The performance expectations in **LS3: Heredity: Inheritance and Variation of Traits** help students formulate an answer to the question, “How do living organisms pass traits from one generation to the next?” Students can use models to describe ways gene mutations and sexual reproduction contribute to genetic variation. Crosscutting concepts of cause and effect and structure and function provide students with a deeper understanding of how gene structure determines differences in the functioning of organisms.

The performance expectations in **LS4: Biological Evolution: Unity and Diversity** help students formulate an answer to the question, “How do organisms change over time in response to changes in the environment?” Students can construct explanations based on evidence to support fundamental understandings of natural selection and evolution. They can use ideas of genetic variation in a population to make sense of organisms surviving and reproducing, hence passing on the traits of the species. They are able to use fossil records and anatomical similarities of the relationships among organisms and species to support their understanding. Crosscutting concepts of patterns and structure and function contribute to the evidence students can use to describe biological evolution.

LS1: From Molecules to Organisms: Structures and Processes

MS-LS1-1 Conduct an investigation to provide evidence that living things are made of cells, either one cell or many different numbers and types of cells.

MS-LS1-2 Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.

MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

MS-LS1-4 Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively.

MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

MS-LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

MS-LS1-7 Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

MS-LS1-8 Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

LS2: Ecosystems: Interactions, Energy, and Dynamics

MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

MS-LS2-2 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

LS3: Heredity: Inheritance and Variation of Traits

MS-LS3-1 Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

MS-LS3-1 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

LS4: Biological Evolution: Unity and Diversity

MS-LS4-1 Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.

MS-LS4-2 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

MS-LS4-3 Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.

MS-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

MS-LS4-5 Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

MS-LS4-6 Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

Earth and Space Sciences

There are three Earth and space sciences disciplinary core ideas: Earth's Place in the Universe (ESS1), Earth's Systems (ESS2), and Earth and Human Activity (ESS3).

The performance expectations in **ESS1: Earth's Place in the Universe**, help students formulate an answer to questions such as, "What is Earth's place in the Universe?", "What makes up our solar system and how can the motion of Earth explain seasons and eclipses?", and "How do people figure out that the Earth and life on Earth have changed through time?" Students examine the Earth's place in relation to the solar system, Milky Way galaxy, and universe. There is a strong emphasis on a systems approach, using models of the solar system to explain astronomical and other observations of the cyclic patterns of eclipses and seasons. There is also a strong connection to engineering through the instruments and technologies that have allowed us to explore the objects in our solar system and obtain the data that support the theories that explain the formation and evolution of the universe. Students examine geoscience data in order to understand the processes and events in Earth's history.

The performance expectations in **ESS2: Earth's Systems**, help students formulate an answer to questions such as, "How do the materials in and on Earth's crust change over time?", "How does the movement of tectonic plates impact the surface of Earth?", "How does water influence weather, circulate in the oceans, and shape Earth's surface?", "What factors interact and influence weather?", and "How have living organisms changed the Earth and how have Earth's changing conditions impacted living organisms?" Students understand how Earth's geosystems operate by modeling the flow of energy and cycling of matter within and among different systems. Students investigate the controlling properties of important materials and construct explanations based on the analysis of real geoscience data. Of special importance in both topics are the ways that geoscience processes provide resources needed by society but also cause natural hazards that present risks to society; both involve technological challenges, for the identification and development of resources. Students develop understanding of the factors that control weather. A systems approach is also important here, examining the feedbacks between systems as energy from the sun is transferred between systems and circulates through the ocean and atmosphere.

The performance expectations in **ESS3: Earth and Human Activity** help students formulate an answer to questions such as "How is the availability of needed natural resources related to naturally occurring processes?", "How can natural hazards be predicted?", "How do human activities affect Earth systems?", and "How do we know our global climate is changing?" Students understand the ways that human activities impact Earth's other systems. Students use many different practices to understand the significant and complex issues surrounding human uses of land, energy, mineral, and water resources and the resulting impacts of their development.

ESS1: Earth's Place in the Universe

MS-ESS1-1 Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

MS-ESS1-2 Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.

MS-ESS1-3 Analyze and interpret data to determine scale properties of objects in the solar system.

MS-ESS1-4 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.

ESS2: Earth's Systems

MS-ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.

MS-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

MS-ESS2-3 Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

MS-ESS2-4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

MS-ESS2-5 Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

MS-ESS2-6 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. 🌱

ESS3: Earth and Human Activity

MS-ESS3-1 Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. 🌱

MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

MS-ESS3-5 Ask questions to clarify evidence of the factors that have caused climate change over the past century. 🌱

6-8 Engineering, Technology, and Applications of Science

There are three Engineering, Technology, and Applications of Science disciplinary core ideas: Defining and Delimiting Engineering Problems (ETS1.A), Developing Possible Solutions (ETS1.B), and Optimizing the Design Solution (ETS1.C).

ETS1.A: Defining and Delimiting Engineering Problems with "precision" involves thinking deeply about the needs a problem is intended to address, or the goals a design is intended to reach. How will the end user decide whether the design is successful? Also, at this level students are expected to consider not only the end user but also the broader society and the environment. Every technological change is likely to have both intended and unintended effects. It is up to the designer to try to anticipate the effects it may have and to behave responsibly in developing a new or improved technology. These considerations may take the form of either criteria or constraints on possible solutions.

ETS1.B: Developing Possible Solutions is a two-stage process of evaluating the different ideas that have been proposed: by using a systematic method, such as a tradeoff matrix, to determine which solutions are most promising, and by testing different solutions and then combining the best ideas into new solution that may be better than any of the preliminary ideas.

ETS1.C: Optimizing the Design Solution involves an iterative process in which students test the best design, analyze the results, modify the design accordingly, and then re-test and modify the design again. Students may go through this cycle two, three, or more times in order to reach the optimal (best possible) result.

Connections with other science disciplines help students develop these capabilities in various contexts. For example, in the life sciences, students apply their engineering design capabilities to evaluate plans for maintaining biodiversity and ecosystem services (MS-LS25). In the physical sciences, students define and solve problems involving a number of core ideas in physical science, including chemical processes that release or absorb energy (MS-PS1-6), Newton's third law of motion (MS-PS2-1), and energy transfer (MS-PS3-3). In the Earth and space sciences, students apply their engineering design capabilities to problems related to the impacts of humans on Earth systems (MS-ESS3-3).

ETS1: Engineering Design

MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Grades 9 through 12

Physical Science

There are four physical science disciplinary core ideas in grades 9 – 12: Matter and Its Interactions (PS1), Motion and Stability: Forces and Interactions (PS2), Energy (PS3), and Waves and Their Applications in Technologies for Information Transfer (PS4).

The performance expectations in **PS1: Matter and its Interactions** help students formulate an answer to the question, “How can one explain the structure, properties, and interactions of matter?” Students are expected to develop understanding of the substructure of atoms and to provide more mechanistic explanations of the properties of substances. Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students are able to use the periodic table as a tool to explain and predict the properties of elements. Using this expanded knowledge of chemical reactions, students are able to explain important biological and geophysical phenomena. Phenomena involving nuclei are also important to understand, as they explain the formation and abundance of the elements, radioactivity, the release of energy from the sun and other stars, and the generation of nuclear power. Students are also able to apply an understanding of the process of optimization in engineering design to chemical reaction systems.

The performance expectations associated with **PS2: Motion and Stability: Forces and Interactions** support students’ developing an answer to the question, “How can one explain and predict interactions between objects and within systems of objects?” Students are expected to develop an understanding of forces and interactions and Newton’s Second Law. Students also develop understanding that the total momentum of a system of objects is conserved when there is no net force on the system. Students are able to use Newton’s law of gravitation and Coulomb’s law to describe and predict the gravitational and electrostatic forces between objects.

The Performance Expectations associated with **PS3: Energy** help students formulate an answer to the question, “How is energy transferred and conserved?” Students develop an understanding that energy at both the macroscopic and the atomic scale can be accounted for as either motions of particles or energy associated with the configuration (relative positions) of particles. In some cases, the energy associated with the configuration of particles can be thought of as stored in fields. Students also demonstrate their understanding of engineering principles when they design, build, and refine devices associated with the conversion of energy.

The Performance Expectations associated with **PS4: Waves and Their Applications in Technologies for Information Transfer** are critical to understand how many new technologies work. As such, this core idea helps students answer the question, “How are waves used to transfer energy and send and store information?” Students are able to apply understanding of how wave properties and the interactions of electromagnetic radiation with matter can transfer information across long distances, store information, and investigate nature on many scales. Models of electromagnetic radiation as either a wave of changing electric and magnetic fields or as particles are developed and used. Students understand that combining waves of different frequencies can make a wide variety of patterns and thereby encode and transmit information. Students also demonstrate their understanding of engineering ideas by presenting information about how technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

PS1: Matter and Its Interactions

HS-PS1-1	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
HS-PS1-2	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
HS-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
HS-PS1-5	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
HS-PS1-6	Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
HS-PS1-7	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
HS-PS1-8	Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

PS2: Motion and Stability: Forces and Interactions

HS-PS2-1	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
HS-PS2-2	Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
HS-PS2-3	Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
HS-PS2-4	Use mathematical representations of Newton's law of gravitation and Coulomb's law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS2-5	Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
HS-PS2-6	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

PS3: Energy

HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative position of particles (objects).

HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

PS4: Waves and Their Applications in Technologies for Information Transfer

HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

HS-PS4-2 Evaluate questions about the advantages of using digital transmission and storage of information.

HS-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

HS-PS4-4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Life Science

There are four life science disciplinary core ideas in high school: From Molecules to Organisms: Structures and Processes (LS1), Ecosystems: Interactions, Energy and Dynamics (LS2), Heredity: Inheritance and Variation of Traits (LS3), and Biological Evolution: Unity and Diversity (LS4).

The performance expectations in **LS1: From Molecules to Organisms: Structures and Processes** help students formulate an answer to the question, “How do organisms live and grow?” In these performance expectations, students demonstrate that they can use investigations and gather evidence to support explanations of cell function and reproduction. They understand the role of proteins as essential to the work of the cell and living systems. Students can use models to explain photosynthesis, respiration, and the cycling of matter and flow of energy in living organisms. The cellular processes can be used as a model for understanding of the hierarchical organization of organism.

The performance expectations in **LS2: Ecosystems: Interactions, Energy, and Dynamics** help students formulate an answer to the question, “How and why do organisms interact with their environment, and what are the effects of these interactions?” High school students can use mathematical reasoning to demonstrate understanding of fundamental concepts of carrying capacity, factors affecting biodiversity and populations, and the cycling of matter and flow of energy among organisms in an ecosystem. These mathematical models provide support of students’ conceptual understanding of systems and their ability to develop design solutions for reducing the impact of human activities on the environment and maintaining biodiversity.

The performance expectations in **LS3: Heredity: Inheritance and Variation of Traits** help students formulate answers to the questions, “How are characteristics of one generation passed to the next?” and “How can individuals of the same species and even siblings have different characteristics?” Students are able to ask questions, make and defend a claim, and use concepts of probability to explain the genetic variation in a population. Students demonstrate understanding of why individuals of the same species vary in how they look, function, and behave. Students can explain the mechanisms of genetic inheritance and describe the environmental and genetic causes of gene mutation and the alteration of gene expression.

The performance expectations in **LS4: Biological Evolution: Unity and Diversity** help students formulate an answer to the question, “What evidence shows that different species are related?” Students can construct explanations for the processes of natural selection and evolution and communicate how multiple lines of evidence support these explanations. Students can evaluate evidence of the conditions that may result in new species and understand the role of genetic variation in natural selection. Additionally, students can apply concepts of probability to explain trends in populations as those trends relate to advantageous heritable traits in a specific environment.

LS1: From Molecules to Organisms: Structures and Processes

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.

HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

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.

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.

LS2: Ecosystems: Interactions, Energy, and Dynamics

HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. 🌱

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.

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.

HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. 🌱

HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. 🌱

HS-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

LS3: Heredity: Inheritance and Variation of Traits

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.

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.

HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

LS4: Biological Evolution: Unity and Diversity

HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

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.

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.

HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

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. 🌱

HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. 🌱

Earth and Space Sciences

There are three Earth and Space Sciences disciplinary core ideas: Earth's Place in the Universe (ESS1), Earth's Systems (ESS2), and Earth and Human Activity (ESS3).

The performance expectations in **ESS1: Earth's Place in the Universe**, help students formulate an answer to the question, "What is the universe, and what is Earth's place in it?" Students examine the processes governing the formation, evolution, and workings of the solar system and universe. Some concepts studied are fundamental to science, such as understanding how the matter of our world formed during the Big Bang and within the cores of stars. Other concepts are practical, such as understanding how short-term changes in the behavior of our sun directly affect humans. Engineering and technology play a large role here in obtaining and analyzing the data that support the theories of the formation of the solar system and universe.

The performance expectations in **ESS2: Earth's Systems**, help students formulate an answer to the question, "How and why is Earth constantly changing?" Students develop models and explanations to understand how feedback between Earth systems shapes the planet's surface. They explore the dynamic between internal processes that build landforms and sun-driven surface processes like weathering and erosion that break them down. Students also investigate how human activities trigger system-wide feedbacks and changes. They examine interactions that influence weather and climate, with a focus on climate change mechanisms and impacts. Additionally, students model energy flow within the weather system and its effects on chemical cycles, such as the carbon cycle.

The performance expectations in **ESS3: Earth and Human Activity** help students formulate an answer to the question, "How do Earth's surface processes and human activities affect each other?" Students understand the complex and significant interdependencies between humans and the rest of Earth's systems through the impacts of natural hazards, our dependencies on natural resources, and the significant environmental impacts of human activities. Engineering and technology figure prominently here, as students use mathematical thinking and the analysis of geoscience data to examine and construct solutions to the many challenges facing long-term human sustainability on Earth.

ESS1: Earth's Place in the Universe

HS-ESS1-1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.

HS-ESS1-2 Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements.

HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

HS-ESS1-5 Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

ESS2: Earth's Systems

HS-ESS2-1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. 🌱

HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. 🌱

HS-ESS2-7 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

ESS3: Earth and Human Activity

HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity. 🌱

HS-ESS3-2 Evaluate competing design solutions for developing, conserving, managing, and utilizing energy and mineral resources based on the associated economic, social, environmental, and geopolitical costs and risks, as well as benefits. 🌱

HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. 🌱

HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems. 🌱

HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. 🌱

HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change). 🌱

9-12 Engineering, Technology and Applications of Sciences

There are three Engineering, Technology, and Applications of Science disciplinary core ideas: Defining and Delimiting Engineering Problems (ETS1.A), Developing Possible Solutions (ETS1.B), and Optimizing the Design Solution (ETS1.C). At the high school level, students are expected to engage with major global issues at the interface of science, technology, society, and the environment and to bring to bear the kinds of analytical and strategic thinking that prior training and increased maturity make possible.

ETS1.A: Defining and Delimiting Engineering Problems at the high school level requires both qualitative and quantitative analysis. For example, the need to provide food and fresh water for future generations comes into sharp focus when considering the speed at which world population is growing and conditions in countries that have experienced famine. While high school students are not expected to solve these challenges, they are expected to begin thinking about them as problems that can be addressed, at least in part, through engineering.

ETS1.B: Developing Possible Solutions for major global problems begins by breaking them down into smaller problems that can be tackled with engineering methods. To evaluate potential solutions, students are expected not only to consider a wide range of criteria, but also to recognize that criteria need to be prioritized.

ETS1.C: Optimizing the Design Solution at the high school level may involve sophisticated methods, such as using computer simulations to model proposed solutions. Students are expected to use such methods to take into account a range of criteria and constraints, to try to anticipate possible societal and environmental impacts, and to test the validity of their simulations by comparison to the real world.

ETS1: Engineering Design

HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. 🌱

HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. 🌱

HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. 🌱