

DCI: Matter and Its Interactions

HS.PS1.A: Structure and Properties of Matter

Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.

(HS-PS1-1)

DCI: Matter and Its Interactions

HS.PS1.A: Structure and Properties of Matter

The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1), (HS-PS1-2)

DCI: Matter and Its Interactions

HS.PS1.A: Structure and Properties of Matter

The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3)

DCI: Matter and Its Interactions

HS.PS1.A: Structure and Properties of Matter

A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4)

DCI: Matter and Its Interactions

HS.PS1.B: Chemical Reactions

Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4), (HS-PS1-5)

DCI: Matter and Its Interactions

HS.PS1.B: Chemical Reactions

In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6)

DCI: Matter and Its Interactions

HS.PS1.B: Chemical Reactions

The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2), (HS-PS1-7)

DCI: Matter and Its Interactions

HS.PS1.C: Nuclear Processes

Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS-PS1-8)

DCI: Motion and Stability: Forces and Interactions

HS.PS2.B: Types of Interactions

Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS1-1), (HS-PS1-3)

DCI: Engineering Design

HS.ETS1.C: Optimizing the Design Solution

Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-PS1-6)

DCI: Energy

HS.PS3.A: Definitions of Energy

Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1)

DCI: Energy

HS.PS3.B: Conservation of Energy and Energy Transfer

Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)

DCI: Energy

HS.PS3.B: Conservation of Energy and Energy Transfer

Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1)

DCI: Energy

HS.PS3.B: Conservation of Energy and Energy Transfer

Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)

DCI: Energy

HS.PS3.B: Conservation of Energy and Energy Transfer

The availability of energy limits what can occur in any system. (HS-PS3-1)

DCI: Energy

HS.PS3.A: Definitions of Energy

Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-2)

DCI: Energy

HS.PS3.A: Definitions of Energy

At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2)

DCI: Energy

HS.PS3.A: Definitions of Energy

These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)

DCI: Energy

HS.PS3.A: Definitions of Energy

At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-3)

DCI: Energy

HS.PS3.D: Energy in Chemical Processes and Everyday Life

Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3)

DCI: Engineering Design

HS.ETS1.A: Defining and Delimiting Engineering Problems

Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-PS3-3)

DCI: Energy

HS.PS3.B: Conservation of Energy and Energy Transfer

Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-4)

DCI: Energy

HS.PS3.B: Conservation of Energy and Energy Transfer

Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4)

DCI: Energy

HS.PS3.D: Energy in Chemical Processes and Everyday Life

Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-4)

DCI: Energy

HS.PS3.C: Relationship Between Energy and Forces

When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)

DCI: From Molecules to Organisms: Structures and Processes

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

The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5)

DCI: From Molecules to Organisms: Structures and Processes

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

As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6)

DCI: From Molecules to Organisms: Structures and Processes

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

The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (HS-LS1-6)

DCI: From Molecules to Organisms: Structures and Processes

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

As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-7)

DCI: From Molecules to Organisms: Structures and Processes

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

As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7)

DCI: Ecosystems: Interactions, Energy, and Dynamics

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

Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3)

DCI: Ecosystems: Interactions, Energy, and Dynamics

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

Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)

DCI: Energy

HS.PS3.D: Energy in Chemical Processes and Everyday Life

The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (HS-LS2-5)

DCI: Ecosystems: Interactions, Energy, and Dynamics

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

Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)

DCI: Energy

HS.PS3.D: Energy in Chemical Processes and Everyday Life

Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (HS-ESS1-1)

DCI: Earth's Place in the Universe

HS.ESS1.A: The Universe and Its Stars

The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1)

DCI: Waves and Their Applications in Technologies for Information Transfer

HS.PS4.B: Electromagnetic Radiation

Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (HS-ESS1-2)

DCI: Earth's Place in the Universe

HS.ESS1.A: The Universe and Its Stars

The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2)

DCI: Earth's Place in the Universe

HS.ESS1.A: The Universe and Its Stars

The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2)

DCI: Earth's Place in the Universe

HS.ESS1.A: The Universe and Its Stars

Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2)

DCI: Earth's Place in the Universe

HS.ESS1.A: The Universe and Its Stars

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DCI: Earth's Place in the Universe

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DCI: Matter and Its Interactions

HS.PS1.C: Nuclear Processes

Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (HS-ESS1-5)

DCI: Earth's Place in the Universe

HS.ESS1.C: The History of Planet Earth

Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5)

DCI: Earth's Systems

HS.ESS2.B: Plate Tectonics and Large-Scale System Interactions

Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (HS-ESS1-5)

DCI: Matter and Its Interactions

HS.PS1.C: Nuclear Processes

Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (HS-ESS1-6)

DCI: Earth's Place in the Universe

HS.ESS1.C: The History of Planet Earth

Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6)

DCI: Earth's Systems

HS.ESS2.C: The Roles of Water in Earth's Surface Processes

The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)

Performance Expectation

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.

Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.

Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.

Performance Expectation

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.

Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.

Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.

Performance Expectation

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.

Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.

Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.

Performance Expectation

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.

Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.

Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.

Performance Expectation

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.

Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.

Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.

Performance Expectation

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.*

Clarification Statement: Emphasis is on the application of Le Chatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.

Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.

** This performance expectation integrates traditional science content with engineering through a practice or disciplinary code idea.*

Performance Expectation

HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques

Assessment Boundary: Assessment does not include complex chemical reactions.]

Performance Expectation

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.

Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.

Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.

Performance Expectation

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.

Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.

Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.

Performance Expectation

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 motions of particles (objects) and energy associated with the relative positions of particles (objects).

Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.

Assessment Boundary: none

Performance Expectation

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.*

Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.

Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.

** This performance expectation integrates traditional science content with engineering through a practice or disciplinary code idea.*

Performance Expectation

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).

Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.

Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.

Performance Expectation

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.

Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.

Assessment Boundary: Assessment is limited to systems containing two objects.

Performance Expectation

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

Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models

Assessment Boundary: Assessment does not include specific biochemical steps.

Performance Expectation

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

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

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

Performance Expectation

HS-LS1-7: Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration

Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.

Performance Expectation

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

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

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

Performance Expectation

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

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

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

Performance Expectation

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.

Clarification Statement: Examples of models could include simulations and mathematical models.

Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.

Performance Expectation

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.

Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.

Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.

Performance Expectation

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.

Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).

Assessment Boundary: none

Performance Expectation

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

Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.

Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.

Performance Expectation

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.

Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions).

Assessment Boundary: none

Performance Expectation

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.

Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.

Assessment Boundary: none

Performance Expectation

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

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

Assessment Boundary: none

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4), (HS-PS1-8)

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Science and Engineering Practices

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

Science and Engineering Practices

Using Mathematics and Computational Thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Use mathematical representations of phenomena to support claims. (HS-PS1-7)

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)

Science and Engineering Practices

Using Mathematics and Computational Thinking

Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

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

(HS-PS3-2)

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3)

Science and Engineering Practices

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-4)

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-5)

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-5)

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS1-6)

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-7)

Science and Engineering Practices

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Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS2-3)

Science and Engineering Practices

Using Mathematics and Computational Thinking

Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Use mathematical representations of phenomena or design solutions to support claims. (HS-LS2-4)

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS2-5)

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS1-1)

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-2)

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ESS1-3)

Science and Engineering Practices

Engaging in Argument from Evidence

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

Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-ESS1-5)

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6)

Science and Engineering Practices

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-ESS2-5)

Crosscutting Concepts

Patterns

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1), (HS-PS1-2), (HS-PS1-3), (HS-PS1-5)

Crosscutting Concepts

Energy and Matter

In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)

Crosscutting Concepts

Energy and Matter

The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)

Crosscutting Concepts

Energy and Matter

Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4)

Crosscutting Concepts

Stability and Change

Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)

Crosscutting Concepts

Systems and System Models

Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1)

Crosscutting Concepts

Energy and Matter

Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)

Crosscutting Concepts

Energy and Matter

Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS3-3)

Crosscutting Concepts

Systems and System Models

When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)

Crosscutting Concepts

Cause and Effect

Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5)

Crosscutting Concepts

Energy and Matter

Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5)

Crosscutting Concepts

Energy and Matter

Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

(HS-LS1-6)

Crosscutting Concepts

Energy and Matter

Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HS-LS1-7)

Crosscutting Concepts

Energy and Matter

Energy drives the cycling of matter within and between systems. (HS-LS2-3)

Crosscutting Concepts

Energy and Matter

Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HS-LS2-4)

Crosscutting Concepts

Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS2-5)

Crosscutting Concepts

Scale, Proportion, and Quantity

The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1)

Crosscutting Concepts

Energy and Matter

Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2)

Crosscutting Concepts

Energy and Matter

In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3)

Crosscutting Concepts

Patterns

Empirical evidence is needed to identify patterns. (HS-ESS1-5)

Crosscutting Concepts

Stability and Change

Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6)

Crosscutting Concepts

Structure and Function

The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)

Connections to Engineering, Technology, and Applications of Science

Scientific Knowledge Is Open to Revision in Light of New Evidence

Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-LS2-3)

Connections to Engineering, Technology, and Applications of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-2)

Connections to Engineering, Technology, and Applications of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-6)

Connections to Engineering, Technology, and Applications of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6)

Connections to Engineering, Technology, and Applications of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)

Connections to Engineering, Technology, and Applications of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)

Connections to Engineering, Technology, and Applications of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology

Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS1-2)

Common Core State Standards for ELA/Literacy

Reading in Science

RST.11-12.1 - Key Ideas and Details

Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3), (HS-PS1-5)

Common Core State Standards for ELA/Literacy

Reading in Science

RST.9-10.7 - Integration of Knowledge and Ideas

Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

Common Core State Standards for ELA/Literacy

Speaking & Listening

SL.11-12.5 - Presentation of Knowledge and Ideas

Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Common Core State Standards for ELA/Literacy

Writing in Science

WHST.11-12.7 - Research to Build and Present Knowledge

Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3), (HS-PS1-6)

Common Core State Standards for ELA/Literacy

Writing in Science

WHST.11-12.8 - Research to Build and Present Knowledge

Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3)

Common Core State Standards for ELA/Literacy

Writing in Science

WHST.11-12.9 - Research to Build and Present Knowledge

Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

Common Core State Standards for ELA/Literacy

Writing in Science

WHST.9-12.2 - Text Types and Purposes

Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2), (HS-PS1-5)

Common Core State Standards for ELA/Literacy

Writing in Science

WHST.9-12.5 - Production and Distribution of Writing

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)

Common Core State Standards for Mathematics

Number and Quantity » Quantities

HSN-Q.A.1 - Reason quantitatively and use units to solve problems.

Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5), (HS-PS1-7), (HS-PS1-8)

Common Core State Standards for Mathematics

Number and Quantity » Quantities

HSN-Q.A.2 - Reason quantitatively and use units to solve problems.

Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4), (HS-PS1-7), (HS-PS1-8)

Common Core State Standards for Mathematics

Number and Quantity » Quantities

HSN-Q.A.3 - Reason quantitatively and use units to solve problems.

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5), (HS-PS1-6), (HS-PS1-7), (HS-PS1-8)

Common Core State Standards for Mathematics

Mathematical Practices

MP.2 - Reason abstractly and quantitatively

Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems involving quantitative relationships: the ability to decontextualize—to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to contextualize, to pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects. (HS-PS1-5), (HS-PS1-7)

Common Core State Standards for Mathematics

Mathematical Practices

MP.4 - Model with mathematics

Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. A student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose. (HS-PS1-4), (HS-PS1-8)