Chariho Regional School District - Science Curriculum
September, 2016

GEOLOGY CURRICULUM

Unit 1: Introduction to Geology

OVERVIEW

Summary

In this unit students will be introduced to the field of geology. They will begin by getting an overview of major geological processes and basic terminology associated with the discipline. They will review earth's layers, the spheres of the earth (including hydrosphere, geosphere, etc), and the basic rock cycle, so that they will have common foundational knowledge as they begin to explore these topics in more depth.

Content to Be Learned

- Compare historical and current geologic study and practices.
- Describe composition, structure, and properties that make up the earth's systems (geosphere, atmosphere, hydrosphere, and biosphere).
- Describe the composition, structure, and properties that make up the earth's layers (crust, mantle, core, lithosphere, asthenosphere, mesosphere, inner and outer core).
- Describe the basic interactions of the earth's systems that contribute to the rock cycle (melting, crystallization, weathering and transport, lithification, metamorphism).
- Describe the basic differences in the different forms of rocks created by the various process of the rock cycle.

Practices

- Developing and using models.
- Obtaining, evaluating, and communicating evidence.

Crosscutting Concepts

- Systems and system models.
- Energy and matter.
- Stability and change.

Essential Questions

- How does physical geology differ from historical geology?
- Why can earth be regarded as a system?
- What criteria were used to establish earth's layered structure?
- How does the rock cycle show the movement of matter from one form to another?
- How does the rock cycle exemplify the idea that matter on earth can exhibit both stability and change?

Next Generation Science Standards

Not applicable to this unit.

Unit 2: Minerals

OVERVIEW

Summary

Students will begin by reviewing basic atomic structure, and properties of atoms. They will then apply this knowledge to the structure and properties of minerals. Students will then learn about the various physical properties of minerals and how those properties can be used for identification purposes. There is an opportunity for hands-on practice in identification of unknown minerals based on tests of their physical and chemical properties. Next, the students will review data of mineral properties and observe how minerals can be classified based on their physical properties. Most importantly, the characteristics of silicates vs. non silicates will be discussed. Finally, they will investigate how minerals can be extracted from the earth as ores and how we as humans use these materials for various purposes.

Content to Be Learned

- Compare minerals to rocks.
- Discuss the atomic properties of minerals (bonding structures).
- Discuss and use the physical properties of minerals (crystal form, luster, color, streak, hardness, cleavage, fracture, density and specific gravity) to identify minerals and classify them.
- Identify the characteristics for classifying minerals as silicates or non-silicates.
- Discuss common uses for mineral resources.
- Explain what an ore is and its importance as a natural resource.
- Discuss the impact humans have had on mineral resources.
- Argue for proper management of mineral resources based on human need and availability.

Practices

- Constructing explanations and designing solutions.
- Engaging in argument from evidence.
- Planning and carrying out investigations.

Crosscutting Concepts

- Patterns.
- Cause and effect.
- Structure and function.

Essential Questions

- What are minerals and how do they differ from rocks?

- How has the availability of certain minerals influenced human activities?
- How do the properties of a mineral at the atomic level influence its structure and function on a bulk scale?
- How can physical and chemical properties of a mineral be used to distinguish one mineral from another?

Next Generation Science Standards

HS-ESS3-1 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-1. **Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

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 knowledge, 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.

Disciplinary Core Ideas

ESS3.A: Natural Resources
- Resource availability has guided the development of human society.

ESS3.B: Natural Hazards
- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.

Crosscutting Concepts

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

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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.

Connections to other DCIs in this grade-band: N/A
Articulation of DCIs across grade-bands:
MS.LS2.A ; **MS.LS4.D** ; **MS.ESS2.A** ; **MS.ESS3.A** ; **MS.ESS3.B**
Common Core State Standards Connections:
ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-ESS3-1)*
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS3-1)

Mathematics -

MP.2	Reason abstractly and quantitatively. *(HS-ESS3-1)*
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *(HS-ESS3-1)*
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS3-1)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-ESS3-1)*

HS-ESS3-2 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-2. **Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*** [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

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 natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Disciplinary Core Ideas

ESS3.A: Natural Resources

- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*

Crosscutting Concepts

Connections to Engineering, Technology, and Applications of Science

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

- Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.
- Analysis of costs and benefits is a critical aspect of decisions about technology.

Connections to Nature of Science

Science Addresses Questions About the Natural and Material World

- Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions.
- Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge.
- Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.

Connections to other DCIs in this grade-band:
HS.PS3.B ; **HS.PS3.D** ; **HS.LS2.A** ; **HS.LS2.B** ; **HS.LS4.D** ; **HS.ESS2.A**

Articulation of DCIs across grade-bands:
MS.PS3.D ; **MS.LS2.A** ; **MS.LS2.B** ; **MS.LS4.D** ; **MS.ESS3.A** ; **MS.ESS3.C**

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS3-2)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS3-2)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-ESS3-2)

HS-PS1-3 Matter and its Interactions

Students who demonstrate understanding can:

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.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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.	**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.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Connections to other DCIs in this grade-band:
HS.ESS2.C

Articulation of DCIs across grade-bands:
MS.PS1.A ; **MS.PS2.B**

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3)
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS1-3)*

Mathematics -

HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *(HS-PS1-3)*
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-3)*

Unit 3: Rock Cycle

OVERVIEW

Summary

In this unit students will study the three types of rocks in more depth. For each type of rock, igneous, sedimentary, and metamorphic, students will learn about the properties of the type of rock, how they are classified, and how they are formed. For each rock type, students can investigate how physical properties can be used to identify the rock name and type. Students will have opportunities to analyze many examples of each type of rock for classification and differentiation purposes. Students will also investigate how magma is formed, and how liquid rock, either in the form of magma or lava, creates igneous rocks. They will compare the different types of volcanic eruptions, the different types of lava, and the similarities and differences in volcano anatomy and geologic features. While studying sedimentary rocks, they will investigate the processes of weathering and erosion, including mechanical vs. chemical weathering. They will look at geoscience data to draw conclusions regarding how the rate of weathering is influenced by the characteristics of the parent rock and the climate which acts upon that rock. They will also look at soils, the products of weathering and erosion. Finally, while studying metamorphic rocks, students will investigate and compare the various environments under which metamorphic rocks are formed, including thermal, hydrothermal, and regional metamorphism.

Content to Be Learned

- Describe the processes that create extrusive and intrusive igneous rocks and identify common types.
- Explain how crystallization occurs and what happens under different temperature constraints.
- Describe the relationship between crystallization and texture of igneous rocks (aphanitic, phaneritic, and porphyritic).
- Explain the relationship between chemical makeup of the parent magma and the environment in creating crystals.
- Discuss the formation of magma.
- Identify how the anatomy of a volcano contributes to the type of magma formed.
- Discuss types of volcanoes and eruptive styles.
- Explain the processes that contribute to a volcanic eruption.
- Identify factors that impact the viscosity of lava.
- Define extrusion and discuss what minerals are extruded during an eruption.
- Define sediment and sedimentary rocks.
- Explain the lithification process.
- Differentiate between cementation and compaction.
- Use particle size to distinguish between detrital sedimentary rocks.
- Describe the two ways in which chemical sediments are precipitated to form chemical sedimentary rocks.
- Discuss clastic texture as it pertains to detrital rocks.
- Explain the classification system for chemical sedimentary rocks and identify common types.
- Describe how weathering, mass wasting, and erosion change geologic structures.
- Differentiate between mechanical vs chemical weathering.
- Identify factors contributing to the rate of weathering.
- Discuss the direction of soil formation and the construct of horizons.
- Identify the horizons of a soil profile.
- Describe the process of erosion and the factors that increase or decrease its impacts.
- Define metamorphism.
- Discuss how heat, pressure and chemical activity contribute to metamorphism.
- Identify common types of metamorphic rock.
- Identify and discuss the three geologic environments in which metamorphism most commonly occurs (thermal or contact, hydrothermal, and regional).

Practices

- Developing and using models.
- Analyzing and interpreting data.

- Obtaining, evaluating, and communicating information.

Crosscutting Concepts

- Energy and matter.
- Stability and change.
- Cause and effect.

Essential Questions

- How does the cooling rate of magma influence the crystal size of igneous rocks?
- How are the physical properties of a rock used to classify that rock?
- What is the primary basis for distinguishing among various types of igneous rocks, or among various types of sedimentary rocks, or among various types of metamorphic rocks?
- What factors determine the nature of a volcanic eruption?
- How do the eruptive patterns and basic characteristics of the three types of volcanoes differ from each other?
- What factors control soil formation and soil erosion?
- How are soil layers created and differentiated?
- How does the composition of the parent rock and the climate influence the rate of weathering of that rock?
- How is the intensity of metamorphism reflected in the texture and mineralogy of metamorphic rocks?
- Using specific examples, how can one change to the earth's surface create a feedback mechanism that results in a change to another earth system?

Next Generation Science Standards

HS-ESS2-2 Earth's Systems

Students who demonstrate understanding can:

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. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Analyzing and Interpreting Data
Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.

Crosscutting Concepts

Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system.

Connections to Engineering, Technology, and Applications of Science

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

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Connections to other DCIs in this grade-band:
HS.PS3.B ; **HS.PS4.B** ; **HS.LS2.B** ; **HS.LS2.C** ; **HS.LS4.D** ; **HS.ESS3.C** ; **HS.ESS3.D**

Articulation of DCIs across grade-bands:
MS.PS3.D ; **MS.PS4.B** ; **MS.LS2.B** ; **MS.LS2.C** ; **MS.LS4.C** ; **MS.ESS2.A** ; **MS.ESS2.B** ; **MS.ESS2.C** ; **MS.ESS2.D** ; **MS.ESS3.C** ; **MS.ESS3.D**

Common Core State Standards Connections:
ELA/Literacy -

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-ESS2-2)*

RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. *(HS-ESS2-2)*

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-ESS2-2)

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-2)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-2)

HS-ESS2-3 Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. [Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

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.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
- Science knowledge is based on empirical evidence.
- Science disciplines share common rules of evidence used to evaluate explanations about natural systems.
- Science includes the process of coordinating patterns of evidence with current theory.

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.

ESS2.B: Plate Tectonics and Large-Scale System Interactions
- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.

Crosscutting Concepts

Energy and Matter
- Energy drives the cycling of matter within and between systems.

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.

Connections to other DCIs in this grade-band:
HS.PS2.B ; **HS.PS3.B** ; **HS.PS3.D**
Articulation of DCIs across grade-bands:
MS.PS1.A ; **MS.PS1.B** ; **MS.PS2.B** ; **MS.PS3.A** ; **MS.PS3.B** ; **MS.ESS2.A** ; **MS.ESS2.B**
Common Core State Standards Connections:
ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-ESS2-3)*
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-ESS2-3)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS2-3)
MP.4	Model with mathematics. (HS-ESS2-3)
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-3)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-3)
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-3)

Unit 4: Water

OVERVIEW

Summary

This unit will focus on water and its influence on geologic processes. Students begin by reviewing the hydrologic cycle. The focus on water will be on three areas: running water, groundwater, and glaciers. When learning about running water, students will focus on how water influences erosion, transportation and deposition of earth materials. They will study the various land forms created by running water, including channels and valleys, deltas, levees, and alluvial fans. They will look at historical data for drainage patterns of streams and rivers and predict flood patterns based on those data. Finally, students will look at causes and types of floods and what we as humans are doing with regards to flood control. When learning about groundwater, students will focus on the processes of porosity and permeability of soil and how they influence the storage and movement of groundwater. They will identify the water table as the boundary between the zone of saturation and the zone of aeration. Finally, they will look at examples of aquitards and aquifers, and the differences between springs, geysers, wells and artesian wells. When learning about glaciers, students will begin by comparing glacier types, including alpine glaciers, ice sheets, piedmont glaciers, and ice caps. They will study how glaciers advance and retreat and then study the landforms and deposits that are formed from glacial movement. Many of these landforms can be seen in the local geology, so there is an opportunity to apply their knowledge from the classroom to the local area, including Kettle Pond, the East and West Passages of Narragansett Bay, the Charlestown and Block Island moraines, and many glacial erratics in the area.

Content to Be Learned

- Describe the hydrologic cycle and the role of the sun in this cycle (transpiration, runoff, infiltration, evaporation, precipitation).
- Running water is the single most important agent sculpturing the earth's land surface.
- Identify and describe the zones of erosion, transportation, and deposition in river systems.
- Discuss factors that impact the velocity of running water.
- Identify the depositional landforms and explain the process by which they are formed (levees, alluvial fans, and deltas).
- Discuss the causes of floods and their impacts.
- Suggest strategies for flood control.
- Define groundwater and explain its place in the sediment and rocks.
- Explain the interaction of streams and groundwater.
- Define porosity and permeability as means to move groundwater.
- Discuss porosity as it pertains to aquitards and aquifers.
- Explain the geological processes that contribute to springs, wells, and geysers.
- Identify human interactions as they pertain to threats to our groundwater stores.
- Differentiate between glacier types and their structures.
- Explain how glaciers form.
- Explain the processes of plucking and abrasion and how they create landforms and deposits.

Practices

- Constructing explanations and designing solutions.
- Analyzing and interpreting data.

Crosscutting Concepts

- Cause and effect.
- Systems and system models.

Essential Questions

- How do the processes of running water in a stream or river work together to move earth materials?
- Why do floods occur? What are some flood-control strategies that are currently being utilized? What are the positive and negative aspects of those strategies?
- What is the importance of groundwater as a resource and as a geological agent?
- What are some environmental problems associated with groundwater?

- How do springs, geysers, wells and artesian wells form?
- How do glaciers move?
- What are the features created by glacial erosion and deposition?
- How does water, and its unique properties, affect earth materials and surface processes?

Next Generation Science Standards

HS-ESS2-2 Earth's Systems

Students who demonstrate understanding can:

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. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Analyzing and Interpreting Data
Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.
- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems
- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

ESS2.D: Weather and Climate
- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.

Crosscutting Concepts

Stability and Change
- Feedback (negative or positive) can stabilize or destabilize a system.

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World
- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Connections to other DCIs in this grade-band:
HS.PS3.B ; HS.PS4.B ; HS.LS2.B ; HS.LS2.C ; HS.LS4.D ; HS.ESS3.C ; HS.ESS3.D
Articulation of DCIs across grade-bands:
MS.PS3.D ; MS.PS4.B ; MS.LS2.B ; MS.LS2.C ; MS.LS4.C ; MS.ESS2.A ; MS.ESS2.B ; MS.ESS2.C ; MS.ESS2.D ; MS.ESS3.C ; MS.ESS3.D
Common Core State Standards Connections:
ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-ESS2-2)*
RST.11-12.2	Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. *(HS-ESS2-2)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS2-2)
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-2)
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-2)

HS-ESS2-5 Earth's Systems

Students who demonstrate understanding can:

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).]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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.	**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.	**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.

Connections to other DCIs in this grade-band:
HS.PS1.A ; HS.PS1.B ; HS.PS3.B ; HS.ESS3.C
Articulation of DCIs across grade-bands:
MS.PS1.A ; MS.PS4.B ; MS.ESS2.A ; MS.ESS2.C ; MS.ESS2.D
Common Core State Standards Connections:
ELA/Literacy -
WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-ESS2-5)
Mathematics -
HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-5)

Unit 5: Earthquakes and the Interior

OVERVIEW

Summary

This unit will focus on the events within the earth and how those events affect the surface of the earth. Students will review the locations of earthquakes globally and identify common geological features of these locations. They will identify the epicenter of an earthquake based on data from S waves and P waves from multiple locations. Students will explain why S and P waves move at different speeds. Student will look at historical data from various earthquakes to explain how the Mercalli and Richter Scales were created and are used to discuss the intensity of an earthquake. Students will research and discuss factors that contribute to destruction created by an earthquake. Finally, they will explain how the earth's layers can be identified by either composition or physical properties.

Content to Be Learned

- Explain how rocks interact along a fault to create an earthquake (focus, faults, elastic rebound, foreshocks, and aftershocks).
- Differentiate between surface and body waves of a seismic wave.
- Explain the movement of seismic waves through a variety of media.

- Use S and P waves to determine the location of the epicenter of an earthquake.
- Differentiate between intensity and magnitude.
- Explain how the Richter Scale and Mercalli Scale are used in reporting earthquake data.
- Identify and discuss factors that contribute to the amount of destruction an earthquake may cause.
- Explain the organization of the earth's internal structure (crust, mantle, and core).
- Describe the physical properties of each inner layer (lithosphere, asthenosphere, mesosphere, inner core, and outer core).

Practices

- Using mathematics and computational thinking.
- Developing and using models.

Crosscutting Concepts

- Energy and matter.
- Cause and effect.

Essential Questions

- Under what circumstances do earthquakes occur?
- How are faults, foci, and epicenters related?
- How is the epicenter of an earthquake determined?
- How is earthquake strength expressed?
- How can the different layers of earth's interior be distinguished due to the thermal convection of magma?

Next Generation Science Standards

HS-ESS2-3 Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. [Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

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.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence.
- Science disciplines share common rules of evidence used to evaluate explanations about natural systems.
- Science includes the process of coordinating patterns of evidence with current theory.

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems

- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.

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

- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.

Crosscutting Concepts

Energy and Matter

- Energy drives the cycling of matter within and between systems.

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.

Connections to other DCIs in this grade-band:
HS.PS2.B ; **HS.PS3.B** ; **HS.PS3.D**

Articulation of DCIs across grade-bands:
MS.PS1.A ; **MS.PS1.B** ; **MS.PS2.B** ; **MS.PS3.A** ; **MS.PS3.B** ; **MS.ESS2.A** ; **MS.ESS2.B**

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-ESS2-3)*
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-ESS2-3)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS2-3)
MP.4	Model with mathematics. (HS-ESS2-3)
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-3)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-3)
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-3)

Students who demonstrate understanding can:

HS-PS4-1. **Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.** [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] *[Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.]*

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9-12 level builds on K-8 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 describe and/or support claims and/or explanations.	**PS4.A: Wave Properties** • The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band:
HS.ESS2.A

Articulation of DCIs across grade-bands:
MS.PS4.A ; **MS.PS4.B**

Common Core State Standards Connections:
ELA/Literacy -

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-PS4-1)*

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS4-1)
MP.4 Model with mathematics. (HS-PS4-1)
HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS4-1)
HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. *(HS-PS4-1)*
HSA.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *(HS-PS4-1)*

Unit 6: Plate Tectonics

OVERVIEW

Summary

This unit will begin with a review of plate tectonics, and then dig deeper into the concepts of continental drift. Students will connect the movement of the plates with the layers of the earth, learned in the previous unit. They will compare the events that occur at each type of plate boundary and discuss the geological reasons for those events. They will investigate the differences between continental and oceanic crust and identify the layers that are unique to oceanic crust. Finally, they will differentiate between passive and active continental margins.

Content to Be Learned

- Describe the theory of continental drift and discuss what evidence was used to support this theory.
- Compare the theory of continental drift to the theory of plate tectonics.
- Explain evidence used to support the theory of plate tectonics.
- Identify the various forms of plate boundaries (convergent, divergent, and transform).
- Explain the forces that act on each type of plate boundary and the events that occur as a result.
- Explain how transform boundaries add to the transport of oceanic crust.

- Identify and explain the layers that make up the oceanic crust.
- Differentiate between passive and active continental margins.

Practices

- Engaging in argument from evidence.
- Developing and using models.

Crosscutting Concepts

- Stability and change.
- Patterns.

Essential Questions

- How can the age of crustal rock be determined based on the movement of the plates?
- What evidence is used to support the idea of continental drift?
- What evidence is used to support the theory of plate tectonics?
- What models have been proposed to explain the driving mechanism for plate motion? What are the strengths and weaknesses of each model?
- How does oceanic crust form and how is it different from continental crust?

Next Generation Science Standards

HS-ESS1-5 Earth's Place in the Universe

Students who demonstrate understanding can:

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 decreasing with distance away from a central ancient core (a result of past plate interactions).]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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.	**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. **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. *(ESS2.B Grade 8 GBE) (secondary)* **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. *(secondary)*	**Patterns** • Empirical evidence is needed to identify patterns.

Connections to other DCIs in this grade-band:
HS.PS3.B ; **HS.ESS2.A**

Articulation of DCIs across grade-bands:
MS.ESS1.C ; **MS.ESS2.A** ; **MS.ESS2.B**

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-ESS1-5)*
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS1-5)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. *(HS-ESS1-5)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS1-5)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-5)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS1-5)*
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-5)

HS-ESS2-1 Earth's Systems

Students who demonstrate understanding can:

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. [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] [*Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

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.

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

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. *(ESS2.B Grade 8 GBE)*

Crosscutting Concepts

Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Connections to other DCIs in this grade-band:
HS.PS2.B
Articulation of DCIs across grade-bands:
MS.PS2.B ; **MS.LS2.B** ; **MS.ESS1.C** ; **MS.ESS2.A** ; **MS.ESS2.B** ; **MS.ESS2.C** ; **MS.ESS2.D**
Common Core State Standards Connections:
ELA/Literacy -

SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-ESS2-1)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS2-1)
MP.4	Model with mathematics. (HS-ESS2-1)
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-1)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-1)
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-1)

Unit 7: Geologic Time and Earth's History

OVERVIEW

Summary

The course will end with an overview of geologic time and the geological evidence that can be found within the earth's layers. Students will differentiate between relative and radiometric dating and will discuss the merits of each. They will gain practice with ordering geological events and the formation of strata by decoding relative dating maps. They will be able to mathematically and theoretically support the process of radiometric dating. They will explore the theoretical conditions that likely existed on early earth, and how those conditions have changed over the 4.5 billion years of earth's history. They will correlate the major geological events with changes to biodiversity and track large-scale evolution, as supported by evidence, such as fossils.

Content to Be Learned

- Differentiate and describe processes for relative and radiometric dating.
- Describe the mechanisms classifying time periods and creating the geologic time scale.
- Discuss the conditions of the early earth's atmosphere and how it has changed.
- Explain the major events of the major eras: Precambrian, Paleozoic, Mesozoic, Cenozoic.

Practices

- Using mathematics and computational thinking.
- Constructing explanations and designing solutions.
- Developing and using models.

Crosscutting Concepts

- Stability and change.
- Energy and matter.

Essential Questions

- How can relative dating and radiometric dating be used to interpret earth's history?
- What are the laws, principles, and techniques used to establish relative dates?
- What are the conditions that favor the preservation of organisms as fossils?
- How are radioactive isotopes used in radiometric dating?
- Why is it difficult to assign reliable numerical dates to samples of sedimentary rock?
- How has earth's atmosphere, geosphere, and biosphere evolved and changed through time?

Next Generation Science Standards

HS-ESS1-6 Earth's Place in the Universe

Students who demonstrate understanding can:

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.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

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.

Connections to Nature of Science

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

- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.
- Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.

Disciplinary Core Ideas

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.

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. *(secondary)*

Crosscutting Concepts

Stability and Change

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

Connections to other DCIs in this grade-band:
HS.PS2.A ; HS.PS2.B
Articulation of DCIs across grade-bands:
MS.PS2.B ; MS.ESS1.B ; MS.ESS1.C ; MS.ESS2.A ; MS.ESS2.B
Common Core State Standards Connections:
ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-ESS1-6)*
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS1-6)
WHST.9-12.1	Write arguments focused on *discipline-specific content.* (HS-ESS1-6)

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS1-6)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-6)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS1-6)*
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-6)
HSF-IF.B.5	Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. *(HS-ESS1-6)*
HSS-ID.B.6	Represent data on two quantitative variables on a scatter plot, and describe how those variables are related. *(HS-ESS1-6)*

HS-PS1-8 Matter and its Interactions

Students who demonstrate understanding can:

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.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**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.	**Energy and Matter** • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Connections to other DCIs in this grade-band:
HS.PS3.A ; HS.PS3.B ; HS.PS3.C ; HS.PS3.D ; HS.ESS1.A ; HS.ESS1.C ; HS.ESS3.A ; HS.ESS3.C
Articulation of DCIs across grade-bands:
MS.PS1.A ; MS.PS1.B ; MS.ESS2.A
Common Core State Standards Connections:
Mathematics -

MP.4	Model with mathematics. *(HS-PS1-8)*
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-8)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-8)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-8)*