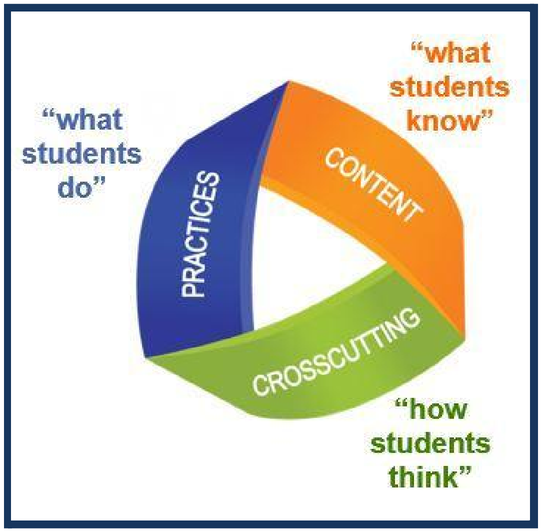
Ledyard Public Schools

Ledyard High School

NGSS Science Curriculum

Earth Science



1.0 Elective Science Credit Course

Table of Contents

Philosophy and Vision for Science Education	
Three Dimensions of the Next Generation Science Standards (NGSS) **Science and Engineering Practices, Disciplinary Core Ideas, Crosscutting Concepts, Connections to the Nature of Science**	
Science Inquiry	
Course Overview	
Unit 1: Astronomy	
Unit 2: Atmosphere and Weather	
Unit 3: Physical Forces and Formations	
Unit 4: Mineralogy	
Pacing Guide	

Course Overview
This course is an introduction to the understood observations, theories and phenomena when studying Earth Science. Unit One is composed of 3 subunits which explores astronomy, stars, planets, orbits, gravity and time. Unit Two shifts focus on the atmosphere, weather, seasons and climates of Earth. Unit Three exposes students to the constructive and destructive forces of this planet such as plate tectonics, volcanism, and the erosional forces of water, sand and glaciers. Unit Four exposes students to mineralogy by classifying rocks and minerals based on characteristics, formation, uses, and value. When the subject permits, the National Park system is used for reference to expand student's potential for visiting and interacting with geologic formations and associations.

Unit 1 Astronomy **What is the universe and what is Earth's place in it?** **(Suggested instructional time for Unit 1 is 20 class periods)**	
What is the universe, and what is Earth's place in it? Earth is a tiny part of a vast universe that has developed over a huge expanse of time. The history and structure of the universe can be explained using observations of their present condition together with knowledge of physics and chemistry. Similarly, the patterns of motion of the objects in the solar system can be described and predicted on the basis of observations and an understanding of gravity. Comprehension of these patterns can be used to explain many Earth phenomena, such as day and night, seasons, tides, and phases of the moon. Observations of other solar system objects and of Earth itself can be used to determine Earth's age and the history of large-scale changes on its surface.	
Unit Component Ideas	**NGSS Performance Expectations**
Unit 1-A: THE UNIVERSE AND LIFE OF STARS **Compelling question:** What is the universe and what goes on in stars?	**HS-ESS1-1, HS-ESS1-2, HS-ESS1-3**
Unit 1-B: EARTH AND THE SOLAR SYSTEM **Compelling question:** What are the predictable patterns caused by Earth's movement in the solar system?	**HS-ESS1-4**

Unit 1-C: THE HISTORY OF PLANET EARTH **Compelling question:** How do people reconstruct and date events in Earth's planetary history?	**HS-ESS1-5, HS-ESS1-6**

NGSS Performance Expectations for each standard. **Students who demonstrate understanding can:**
HS-ESS1-1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. 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 subatomic processes involved with the sun's nuclear fusion.
HS-ESS1-2, PS4.B 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 gasses (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).
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.
HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons. Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.
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 of 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 of the continental plate (a result of past plate interactions).
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.

Unit 1-A: THE UNIVERSE AND LIFE OF STARS (HS-ESS1-1, HS-ESS1-2, HS-ESS1-3) Compelling Question: What is the universe and what goes on in stars?
Suggested Content –Vocabulary in bold
THE UNIVERSE AND ITS STARS: What is the universe and what goes on in stars? The sun is but one of a vast number of stars in the Milky Way galaxy, which is one of a vast number of **galaxies** in the **universe**. The universe began with what is understood as the **Big Bang Theory;** ● This theory provides an explanation of observations of distant galaxies receding from our own through applied **red shift** of **Hubble's law**, of the measured composition of stars and of the primordial radiation that still fills the universe. ● Nearly all observable matter in the universe is hydrogen or helium which formed in the first minutes after the Big Bang. ● Distances are so vast we have developed a system of using **Parallax angles**, **Light Speed** distances to understand them. ● Heavier elements continue to form within the cores of **stars**. ● **Nuclear fusion** is the process responsible for the formation of all atomic nuclei lighter than and including iron. This process also releases the energy seen as starlight. ● Heavier elements are produced when certain massive stars achieve a supernova stage and explode. Stars radiation of visible light and other forms of energy can be measured and studied to develop explanations about the formation, age, and composition of the universe. ● Stars go through a sequence of developmental stages. ● Material from earlier stars that explode as supernovas is recycled to form younger stars. ● The sun is a medium-sized star about halfway through its predicted life span of about 10 billion years as shown on the **H-R Diagram**.

Disciplinary Core Ideas	**Observable features of student performance**
• The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1)	HS-ESS1-1 1. Components of the model a. Students use evidence to develop a model in which they identify and describe the relevant components, including: i. Hydrogen as the sun's

• Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (HS-ESS1-1,PS3.D) • 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, HS-ESS1-3) • The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non stellar gasses, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2, HS ESS1-3) • 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, HS-ESS1-3) • 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. (secondary) (HS-ESS1-2, HS-ESS1-3, PS4.B)	fuel; ii. Helium and energy as the products of fusion processes in the sun; and iii. That the sun, like all stars, has a life span based primarily on its initial mass, and that the sun's lifespan is about 10 billion years. 2. Relationships a. In the model, students describe relationships between the components, including a description* of the process of radiation, and how energy released by the sun reaches Earth's system. 3. Connections a. Students use the model to predict how the relative proportions of hydrogen to helium change as the sun ages. b. Students use the model to qualitatively describe the scale of the energy released by the fusion process as being much larger than the scale of the energy released by chemical processes. c. Students use the model to explicitly identify that chemical processes are unable to produce the amount of energy flowing out of the sun over long periods of time, thus requiring fusion processes as the mechanism for energy release in the sun. HS-ESS1-2 1. Articulating the explanation of phenomena a. Students construct an explanation that includes a description* of how astronomical evidence from numerous sources is used collectively to support the Big Bang theory, which states that the universe is expanding and that thus it was hotter and denser in the past, and that the entire visible universe emerged from a very tiny region and expanded. 2. Evidence a. Students identify and describe the evidence to construct the explanation, including: i. The composition (hydrogen, helium and heavier elements) of stars; ii. The hydrogen-helium ratio of stars and interstellar gases; iii. The redshift of the majority of galaxies and the redshift vs. distance relationship; and iv. The existence of cosmic background radiation. b. Students use a variety of valid and reliable sources for the evidence, which may include students' own investigations, theories, simulations, and peer review. c. Students describe the source of the evidence and the technology

	used to obtain that evidence. 3. Reasoning a. Students use reasoning to connect evidence, along with 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, to construct the explanation for the early universe (the Big Bang theory). Students describe the following chain of reasoning for their explanation: i. Redshifts indicate that an object is moving away from the observer, thus the observed redshift for most galaxies and the redshift vs. distance relationship is evidence that the universe is expanding. ii. The observed background cosmic radiation and the ratio of hydrogen to helium have been shown to be consistent with a universe that was very dense and hot a long time ago and that evolved through different stages as it expanded and cooled (e.g., the formation of nuclei from colliding protons and neutrons predicts the hydrogen-helium ratio [numbers not expected from students], later formation of atoms from nuclei plus electrons, background radiation was a relic from that time). iii. An expanding universe must have been smaller in the past and can be extrapolated back in time to a tiny size from which it expanded. HS-ESS1-3 1.Communication Style and Format a. Students use at least two different formats (e.g., oral, graphical, textual, and mathematical) to communicate scientific information, and cite the origin of the information as appropriate. 2.Connecting the DCI's and the CCC's a. Students identify and communicate the relationships between the life cycle of the stars, the production of elements, and the conservation of the number of protons plus neutrons in stars. Students identify that atoms are not conserved in nuclear fusion, but the total number of protons plus neutrons is conserved. b. Students describe that: i. Helium and a small amount of other light nuclei (i.e., up to lithium) were formed from high energy collisions starting from protons and neutrons in

	the early universe before any stars existed. ii. More massive elements, up to iron, are produced in the cores of stars by a chain of processes of nuclear fusion, which also releases energy. iii. Supernova explosions of massive stars are the mechanism by which elements more massive than iron are produced. iv. There is a correlation between a star's mass and stage of development and the types of elements it can create during its lifetime. v. Electromagnetic emission and absorption spectra are used to determine a star's composition, motion and distance to Earth.

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), (HS-PS1-8), (HS-HS-ESS1-1)
- Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2)

Scale, Proportion, and Quantity

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1)
- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)

Connections to Nature 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)
- 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

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)

Science and Engineering Practices

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.
    - o Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-8),(HS-ESS1-1)

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.
    - o Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, 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)

Obtaining, Evaluating, and Communicating Information

- 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)

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. (HS-ESS1-2)

Grade Band Endpoint for Unit 1-A
By the end of grade 12: The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. The sun is just one of more than 200 billion stars in the Milky Way galaxy, and the Milky Way is just one of hundreds of billions of galaxies in the universe. The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from earth. **K-12 Endpoint Progression**

Activities and Labs
Required activities: The Life Cycle of Stars- This multifaceted lesson has students exploring what makes a star a star, including an in-depth focus on the process of nuclear fusion in the core of stars. Additionally, students also get a glimpse of the astronomical "life cycle" of stars in our galaxy. Students also develop an understanding of planetary accretion theory. Suggested activities: ● The Big Bang- Students identify the two main pieces of evidence to support the Big Bang, as well as holistically exploring the Big Bang as a cosmological theory of the beginning of the universe. ● Light speed and spatial distance calculations ● Parallax modeling ● H-R diagram development lab ● Earth Science Week-classroom activities-Classroom Activities, categorized by the Next Generation Science Standards (NGSS) ● NGSS-HUB (project ideas)- link to various activities

Modifications to Content/Differentiation	
Students in need	**Students requiring higher engagement**
-To include suggestions regarding depth of coverage *-Minimum depth of coverage* - The energy produced in stars is produced via a nuclear reaction (fusion) rather than a chemical reaction and involves a much larger amount of energy per kilogram of material. The nuclear equations will not be assessed.	*-To include suggested extensions to investigations* *-Increased depth* -Nuclear fusion reactions are shown and conservation of mass and energy can be discussed. - The red shift can be explained in more detail using the Doppler effect and semi-quantitatively with the wave equation, $c=\lambda v$.

Assessments
Require assessments: To be determined Suggested assessments: ● Traditional assessment: multiple choice and free response questions, or ● The above project(s) using the eight science and engineering practice standards, or ● A combination of traditional assessment with project, or ● Other format of teacher's choice

Unit 1-B: EARTH AND THE SOLAR SYSTEM (HS-ESS1-4) **Supporting Question**: ***What are the predictable patterns caused by Earth's movement in the solar system?***
Suggested Content-Vocabulary in **bold**
Unit 1-B: EARTH AND THE SOLAR SYSTEM ***What are the predictable patterns caused by Earth's movement in the solar system?***
- The solar system consists of the sun and a collection of objects of varying sizes and conditions held in orbit around the sun by the **force of gravity.** - Earth and the **moon**, sun, and **planets** have predictable patterns of movement. These patterns explain many large-scale phenomena observed on Earth. - Gradual changes on the shape of the Earth's orbit, together with the **tilt** of the planet's spin axis, have altered the **intensity** and **distribution of sunlight** falling on Earth. These phenomena cause cycles of **climate change**. - Gravity holds Earth in orbit around the sun, and it holds the moon in orbit around Earth. - The pulls of gravity from the sun and the moon cause patterns of ocean **tides.** - The moon's monthly orbit around Earth, the relative positions of the sun, the moon, and the observer explain the observed **phases of the moon** - Even though the Earth's orbit is nearly circular, the intensity of sunlight on a given location varies as it orbits around the sun. - Earth's spin axis is tilted relative to the plane of its orbit, and the **seasons** are a result of that tilt. - The intensity of sunlight striking the Earth is greatest at the **equator**. - Seasonal variations in that intensity are greatest at the poles.

Disciplinary Core Ideas	Observable features of student performanceObservable features of student performance
• Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)	*Students who understand the concepts are able to:* 1. Representation a. Students identify and describe the following relevant components in the given mathematical or computational representations of orbital motion: the trajectories of orbiting bodies, including planets, moons, or human-made spacecraft; each of which depicts a revolving body's eccentricity e = f/d, where f is the distance between foci of an ellipse, and d is the ellipse's major axis length (Kepler's first law of planetary motion). 2. Mathematical or computational modeling a. Students use the given mathematical or computational representations of orbital motion to depict that the square of a revolving body's period of revolution is proportional to the cube of its distance to a gravitational center ($T^2 \propto R^3$, where T is the orbital period and R is the semi major axis of the orbit — Kepler's third law of planetary motion). 3. Analysis a. Students use the given mathematical or computational representation of Kepler's second law of planetary motion (an orbiting body sweeps out equal areas in equal time) to predict the relationship between the distance between an orbiting body and its star, and the object's orbital velocity (i.e., that the closer an orbiting body is to a star, the larger its orbital velocity will be).

	b. Students use the given mathematical or computational representation of Kepler's third law of planetary motion ($T^2 \propto R^3$, where T is the orbital period and R is the semi-major axis of the orbit) to predict how either the orbital distance or orbital period changes given a change in the other variable. c. Students use Newton's law of gravitation plus his third law of motion to predict how the acceleration of a planet towards the sun varies with its distance from the sun, and to argue qualitatively about how this relates to the observed orbits.

Crosscutting Concepts
Scale, Proportion, and Quantity • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-ESS1-4) **<u>Connections to Engineering, Technology, and Applications of Science</u>** **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.
Science and Engineering Practices
<u>Using Mathematical and Computational Thinking</u> 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 or computational representations of phenomena to describe explanations.

Grade Band Endpoint for Unit 1-B
By the end of grade 12: Keplers's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to gravitational effects from, or collisions with, other objects in the solar system. Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the orientation or the planet's axis of rotation, both occurring over tens to hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. **K-12 Endpoint Progression**

Activities
Required activities: To be determined Suggested activities: ● Planetary Orbit Simulator - Explore each of Kepler's three laws with this interactive planetary orbit simulator. ● Develop ratioed distance model of our solar system ● Tracking sunspots lab ● Tracking Galilean moons for development of Kepler's laws ● Reason for seasons sunlight modeling ● Kepler's Laws of Motion (Genesis) – Theme-based unit (pdf). Sample handout to accompany. ● NGSS-HUB (project ideas)- link to various activities

Modifications to Content/Differentiation	
Students in need of support	**Students in need of deeper engagement**
-To include suggestions regarding depth of coverage *-Minimum depth of coverage* -Kepler's Laws of Motion will be taught through an interactive lesson unless students are mathematically capable.	*-To include suggested extensions to investigations* *-Increased depth* -Kepler's Laws of Motion and the accompanying equations will be used.

Assessments
Require assessments: To be determined Suggested assessments: ● Traditional assessment: multiple choice and free response questions, or ● The above project(s) using the eight science and engineering practice standards, or ● A combination of traditional assessment with project, or ● Other format of teacher's choice

Unit 1-C: THE HISTORY OF PLANET EARTH

[(HS-ESS1-5)](), [(HS-ESS1-6)]()

Supporting Question: ***How do people reconstruct and date events in Earth's planetary history?***

Suggested Content-Vocabulary in **bold**

Unit 1-C: THE HISTORY OF PLANET EARTH ***How do people reconstruct and date events in Earth's planetary history?***

- Earth scientists use the **structure**, **sequence**, and properties of **rocks**, **sediments**, and **fossils**, as well as the locations of current and past **ocean basins**, **lakes**, and **rivers**, to reconstruct events in Earth's planetary history.
- Analysis of rock formations and the fossil record are used to establish **relative ages**.
- Rock layers have sometimes been rearranged by **tectonic forces**. These forces can lead to events that occur over hours to millions of years.
- Other objects in our solar system, such as **asteroids** and **meteorites**, have changed little over billions of years. Studying these helps scientists deduce the solar system's age and history.
- Because many individual plant and animal species existed during known periods of time (e.g., dinosaurs), the location and certain types of fossils in the rock record can reveal the age of rocks and help **geologists** decipher the history of **landforms**.

Disciplinary Core Ideas	**Observable features of student performance**
• 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) • 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	*Students who understand the concepts are able to:* (HS-ESS1-5) 1. Identifying the given explanation and the supporting evidence a. Students identify the given explanation, which includes the following idea: that crustal materials of different ages are arranged on Earth's surface in a pattern that can be attributed to plate tectonic activity and formation of new rocks from magma rising where plates are moving apart.

provide information about Earth's formation and early history. (HS-ESS1-6) • 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.	b. Students identify the given evidence to be evaluated. 2. <u>Identifying any potential additional evidence that is relevant to the evaluation</u> a. Students identify and describe additional relevant evidence (in the form of data, information, models, or other appropriate forms) that was not provided but is relevant to the explanation and to evaluating the given evidence, including: i. Measurement of the ratio of parent to daughter atoms produced during radioactive decay as a means for determining the ages of rocks; ii. Ages and locations of continental rocks; iii. Ages and locations of rocks found on opposite sides of mid-ocean ridges; and iv. The type and location of plate boundaries relative to the type, age, and location of crustal rocks 3. <u>Evaluating and critiquing</u> a. Students use their additional evidence to assess and evaluate the validity of the given evidence. b. Students evaluate the reliability, strengths, and weaknesses of the given evidence along with its ability to support logical and reasonable arguments about the motion of crustal plates. 4. <u>Reasoning/synthesis</u> a. Students describe how the following patterns observed from the evidence support the explanation about the ages of crustal rocks:

	i. The pattern of the continental crust being older than the oceanic crust; ii. The pattern that the oldest continental rocks are located at the center of continents, with the ages decreasing from their centers to their margin; and iii. The pattern that the ages of oceanic crust are greatest nearest the continents and decrease in age with proximity to the mid-ocean ridges. b. Students synthesize the relevant evidence to describe the relationship between the motion of continental plates and the patterns in the ages of crustal rocks, including that: i. At boundaries where plates are moving apart, such as mid-ocean ridges, material from the interior of the Earth must be emerging and forming new rocks with the youngest ages. ii. The regions furthest from the plate boundaries (continental centers) will have the oldest rocks because new crust is added to the edge of continents at places where plates are coming together, such as subduction zones. iii. The oldest crustal rocks are found on the continents because oceanic crust is constantly being destroyed at places where plates are coming together, such as subduction zones. (HS-ESS1-6) 5. <u>Articulating the explanation of phenomena</u> a. Students construct an account of Earth's formation and early history that includes that:

	i. Earth formed along with the rest of the solar system 4.6 billion years ago. ii. The early Earth was bombarded by impacts just as other objects in the solar system were bombarded. iii. Erosion and plate tectonics on Earth have destroyed much of the evidence of this bombardment, explaining the relative scarcity of impact craters on Earth. 6. <u>Evidence</u> a. Students include and describe the following evidence in their explanatory account: i. The age and composition of Earth's oldest rocks, lunar rocks, and meteorites as determined by radiometric dating; ii. The composition of solar system objects; iii. Observations of the size and distribution of impact craters on the surface of Earth and on the surfaces of solar system objects (e.g., the moon, Mercury, and Mars); and iv. The activity of plate tectonic processes, such as volcanism, and surface processes, such as erosion, operating on Earth. 7. <u>Reasoning</u> a. Students use reasoning to connect the evidence to construct the explanation of Earth's formation and early history, including that: i. Radiometric ages of lunar rocks, meteorites and the oldest Earth rocks point to an origin of the solar

	system 4.6 billion years ago, with the creation of a solid Earth crust about 4.4 billion years ago. ii. Other planetary surfaces and their patterns of impact cratering can be used to infer that Earth had many impact craters early in its history. iii. The relative lack of impact craters and the age of most rocks on Earth compared to other bodies in the solar system can be attributed to processes such as volcanism, plate tectonics, and erosion that have reshaped Earth's surface, and that this is why most of Earth's rocks are much younger than Earth itself.

Crosscutting Concepts

Patterns

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

Stability and Change

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

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. (HS-ESS1-5)

· Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments.

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. (HS-ESS1-6)

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

Grade Band Endpoint for Unit 1-C
By the end of grade 12: Radioactive decay lifetimes and isotopic content in rocks provide a way of dating rock formations and thereby fixing the scale of geological time. Continental rocks, which can be older than 4 billion years, are generally much older than rocks on the ocean floor, which are less than 200 million years old. Tectonic processes continually generate new ocean seafloor at ridges and destroy old seafloor at trenches. Although active geological processes, such as plate tectonics (link to ESS2.B) 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. **K-12 Endpoint Progression**
Activities
Suggested activities:

- MnM Half Life Lab
- Dating-Popcorn- How do geologists understand the Earth's history? In part, they measure the age of rocks and other natural materials by dating techniques.
- Geologic Age-Decay of Zorkium- Radioisotopic dating and half-life determination activity
- NGSS-HUB (project ideas)- link to various activities

Modifications to Content/Differentiation	
Students in need of support	**Students in need of deeper engagement**
-To include suggestions regarding depth of coverage *-Minimum depth of coverage* -Measurement of the ratio of parent to daughter atoms produced during radioactive decay as a means for determining the ages of rocks.	*-To include suggested extensions to investigations* *-Increased depth* -Specific nuclear decay sequences may be provided to emphasize conservation of energy and mass as well as nuclear isotopes.

Assessments

Suggested assessments:

- Traditional assessment: multiple choice and free response questions, or
- The above project(s) using the eight science and engineering practice standards, or
- A combination of traditional assessment with project, or
- Other format of teacher's choice

Unit 2: Atmosphere and Weather
CORE IDEA:
How and why is Earth constantly changing?
(Suggested instructional time for unit two is 25 class periods)

Earth's surface is a complex and dynamic set of interconnected systems—principally the geosphere, hydrosphere, atmosphere, and biosphere—that interact over a wide range of temporal and spatial scales. All of Earth's processes are the result of energy flowing and matter cycling within and among these systems. Weather and climate are shaped by complex interactions involving sunlight, the ocean, the atmosphere, clouds, ice, land, and life forms. Earth's biosphere has changed the makeup of the geosphere, hydrosphere, and atmosphere over geological time; conversely, water is essential to the dynamics of most earth systems, and it plays a significant role in shaping Earth's landscape.

Component Ideas	Performance Expectations
Unit 2-A: WEATHER AND CLIMATE Supporting question: What regulates weather and climate?	**HS-ESS2-2, HS-ESS2-6, HS-ESS2-7, HS-ESS2-4** and **HS-ESS3-6**

NGSS Performance Expectations

Students who demonstrate understanding can:

HS-ESS2-2
Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems. Clarification Statement: Examples should include climate feedback, such as how an increase in greenhouse gasses 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.

HS-ESS2-4

Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.]
Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.

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).

Unit 2-A: WEATHER AND CLIMATE

(HS-ESS2-2, HS-ESS2-4, HS-ESS2-6, HS-ESS2-7, HS-ESS3-6)
Supporting Question*: What regulates weather and climate?*

Suggested Content– Vocabulary in **bold**

WEATHER AND CLIMATE: ***What regulates weather and climate?***

- The foundation for **Earth's global climate system** 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.
- **Weather patterns and ecosystems** fluctuate when certain parts of Earth's systems are altered.

- **Geological** evidence indicates that past **weather patterns and ecosystems** were either sudden changes caused by alterations in the **atmosphere**; longer term changes (e.g., ice ages) due to variations in **solar output, Earth's orbit,** or the orientation of its axis; or even more gradual atmospheric changes due to plants and other organisms that captured carbon dioxide and released oxygen.
- The **atmosphere** is composed of various gasses (water vapor, Oxygen, Hydrogen, Oxides, trace elements and compounds) which affect the **humidity,** heating and ecosystems in various areas.
- Weather is affected by changes in **pressure**, **temperature**, **humidity, wind speed**, **geographic location**, **location topography** and surrounding topography.
    - Precipitation changes are based on these factors as well as season **orbital heating.**
    - Temperature changes are based on these factors as well as **albedo** and composition material of the surface (water vs soil)

Disciplinary Core Ideas	Observable features of student performance
· Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. HS-ESS2-2 / ESS2.A · The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. HS-ESS2-4/ ESS2.A · Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have	**HS-ESS2-2** 1. Organizing data a. Students organize data that represent measurements of changes in hydrosphere, cryosphere, atmosphere, biosphere, or geosphere in response to a change in Earth's surface. b. Students describe what each data set represents. 2. Identifying relationships a. Students use tools, technologies, and/or models to analyze the data and identify and describe relationships in the datasets, including: i. The relationships between the changes in one system and changes in another (or within the same) Earth system; and ii. Possible feedback, including one example of feedback to the climate.

altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary) HS-ESS2-4/ ESS1.B · 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 reradiation into space. HS-ESS2-2 / ESS2.D Weather and Climate · Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. · Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. HS-ESS2-6/ ESS2.D · Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. HS-ESS2-7/ ESS2.D · The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth's surface and the life that exists on it. HS-ESS2-7/ ESS2.E · Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gasses added to the atmosphere each year and by the ways in which these gasses are absorbed by the ocean and biosphere. (secondary) HS-ESS3-6/ ESS2.D · Through computer simulations and other studies, important discoveries are still being made about how the ocean, the	b. Students analyze data to identify effects of human activity and specific technologies on Earth's systems if present. 3. <u>Interpreting data</u> a. Students use the analyzed data to describe a mechanism for the feedback between two of Earth's systems and whether the feedback is positive or negative, increasing (destabilizing) or decreasing (stabilizing) the original changes. b. Students use the analyzed data to describe a particular unanticipated or unintended effect of a selected technology on Earth's systems if present. c. Students include a statement regarding how variation or uncertainty in the data (e.g., limitations, accuracy, any bias in the data resulting from choice of sample, scale, instrumentation, etc.) may affect the interpretation of the data. **HS-ESS2-4** 1. <u>Components of the model</u>: a. From the given model, students identify and describe the components of the model relevant for their mechanistic descriptions. Given models include at least one factor that affects the input of energy, at least one factor that affects the output of energy, and at least one factor that affects the storage and redistribution of energy. Factors are derived from the following list: i. Changes in Earth's orbit and the orientation of its axis; ii. Changes in the sun's energy output; iii. Configuration of continents resulting from tectonic activity; iv. Ocean circulation;

atmosphere, and the biosphere interact and are modified in response to human activities. HS-ESS3-6/ ESS3.D	v. Atmospheric composition (including amount of water vapor and CO_2); vi. Atmospheric circulation; vii. Volcanic activity; viii. Glaciation; ix. Changes in extent or type of vegetation cover; and x. Human activities. b. From the given model, students identify the relevant different time scales on which the factors operate. 2. <u>Relationships</u> a. Students identify and describe the relationships between components of the given model, and organize the factors from the given model into three groups: i. Those that affect the input of energy; ii. Those that affect the output of energy; and iii. Those that affect the storage and redistribution of energy b. Students describe the relationships between components of the model as either causal or correlational. 3. <u>Connections</u> a. Students use the given model to provide a mechanistic account of the relationship between energy flow in Earth's systems and changes in climate, including: i. The specific cause and effect relationships between the factors and the effect on energy flow into and out of Earth's systems; and ii. The net effect of all of the competing factors in changing the climate.

	HS-ESS2-6 1. Components of the model a. Students use evidence to develop a model in which they: i. Identify the relative concentrations of carbon present in the hydrosphere, atmosphere, geosphere and biosphere; and ii. Represent carbon cycling from one sphere to another. 2. Relationships a. In the model, students represent and describe the following relationships between components of the system, including: i. The biogeochemical cycles that occur as carbon flows from one sphere to another; ii. The relative amount of and the rate at which carbon is transferred between spheres; iii. The capture of carbon dioxide by plants; and iv. The increase in carbon dioxide concentration in the atmosphere due to human activity and the effect on climate. 3. Connections a. Students use the model to explicitly identify the conservation of matter as carbon cycles through various components of Earth's systems. b. Students identify the limitations of the model in accounting for all of Earth's carbon. **HS-ESS2-7** 1. Developing the claim

	a. Students develop a claim, which includes the following idea: that there is simultaneous coevolution of Earth's systems and life on Earth. This claim is supported by generalizing from multiple sources of evidence. 2. <u>Identifying scientific evidence</u> a. Students identify and describe evidence supporting the claim, including: i. Scientific explanations about the composition of Earth's atmosphere shortly after its formation; ii. Current atmospheric composition; iii. Evidence for the emergence of photosynthetic organisms; iv. Evidence for the effect of the presence of free oxygen on evolution and processes in other Earth systems; v. In the context of the selected example(s), other evidence that changes in the biosphere affect other Earth systems. 3. <u>Evaluating and critiquing</u> a. Students evaluate the evidence and include the following in their evaluation: i. A statement regarding how variation or uncertainty in the data (e.g., limitations, low signal-to-noise ratio, collection bias, etc.) may affect the usefulness of the data as sources of evidence; and ii. The ability of the data to be used to determine causal or correlational effects between changes in the biosphere and changes in Earth's other systems. 4. <u>Reasoning and synthesis</u>

	a. Students use at least two examples to construct oral and written logical arguments. The examples: i. Include that the evolution of photosynthetic organisms led to a drastic change in Earth's atmosphere and oceans in which the free oxygen produced caused worldwide deposition of iron oxide formations, increased weathering due to an oxidizing atmosphere and the evolution of animal life that depends on oxygen for respiration; and ii. Identify causal links and feedback mechanisms between changes in the biosphere and changes in Earth's other systems. **HS-ESS3-6** 1. Representation a. Students identify and describe the relevant components of each of the Earth systems modeled in the given computational representation, including system boundaries, initial conditions, inputs and outputs, and relationships that determine the interaction (e.g., the relationship between atmospheric CO2 and production of photosynthetic biomass and ocean acidification). 2. Computational modeling a. Students use the given computational representation of Earth systems to illustrate and describe relationships among at least two of Earth's systems, including how the relevant components in each individual Earth system can drive changes in another, interacting Earth system. 3. Analysis

	a. Students use evidence from the computational representation to describe how human activity could affect the relationships between the Earth's systems under consideration.

Crosscutting Concepts
Stability and Change · Feedback (negative or positive) can stabilize or destabilize a system. · Much of science deals with constructing explanations of how things change and how they remain stable. **Cause and Effect** · Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Energy and Matter** (HS-ESS2-6) · The total amount of energy and matter in closed systems is conserved. **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. **<u>Connections to Engineering, Technology, and Applications of Science</u>** **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. (HS-ESS2-2)
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.
    - o 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.

Scientific Knowledge is Based on Empirical Evidence

· Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

Developing and Using Models

o 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).

- o Use a model to provide mechanistic accounts of phenomena.
- o Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

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).
    - o Arguments may also come from current scientific or historical episodes in science.
    - o Construct an oral and written argument or counter-arguments based on data and evidence.

Using Mathematics and Computational Thinking from ESS3?

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

· Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.

<u>Connections to Nature of Science</u>

Scientific Knowledge is Based on Empirical Evidence
● Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

Grade Band Endpoints
By the end of grade 12: The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Global climate models are used to predict future changes, including changes influenced by human behavior and natural factors. K-12 Endpoint Progression
Activities
Suggested activities: ● Monitoring and predicting weather ● Measuring Dew point and Humidity lab ● Modeling cloud development ● Seasonal heating application ● Albedo effect investigation ● Rain/Snow Calculations ● Wind speed vs wind sock conversions. ● Monitor Hurricanes – investigate formation of hurricane ● Energy Use – model use of soil as insulator and how colors affect differential surface heating ● Ocean Conveyor – Model water convection currents and relate to global oceanic current patterns ● Your Own El Nino- develop model of mixing which occurs in oceans building energy for the El Nino effect

Modifications to Content/Differentiation	
Students in need of support	**Students in need of deeper engagement**

- *To include suggestions regarding depth of coverage* - *Minimum depth of coverage* - Understanding the components of weather. - How does the Sun create changes in weather and ocean patterns? - What are the major climate zones of the planet?	- *To include suggested extensions to investigations* - *Increased depth* - Predict weather - Potential to investigate micro climates - Potential to investigate extreme climates and seasonal swings of the planet.

Assessments

Suggested assessments:

- Traditional assessment: multiple choice and free response questions, or
- The above project(s) using the eight science and engineering practice standards, or
- A combination of traditional assessment with project, or
- Other format of teacher's choice

Unit 3 : Physical Forces and Formations CORE IDEA: How and why is Earth constantly changing? (Suggested instructional time for this unit is 25 class periods)	
Earth's surface is a complex and dynamic set of interconnected systems—principally the geosphere, hydrosphere, atmosphere, and biosphere—that interact over a wide range of temporal and spatial scales. All of Earth's processes are the result of energy flowing and matter cycling within and among these systems. For example, the motion of tectonic plates is part of the cycles of convection in Earth's mantle, driven by outflowing heat and the downward pull of gravity, which result in the formation and changes of many features of Earth's land and undersea surface; conversely, geological events and conditions have influenced the evolution of life on the planet. Water is essential to the dynamics of most earth systems, and it plays a significant role in shaping Earth's landscape.	
Component Ideas	**Performance Expectations**
Unit 3-A: PLATE TECTONICS AND LARGE-SCALE SYSTEM INTERACTIONS Supporting question: Why do the continents move, and what causes earthquakes and volcanoes?	**HS-ESS2-1, HS-ESS2-2, HS-ESS2-3, HS-ESS2-4**
Unit 3-B: THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES Supporting question: How do the properties and movements of water shape Earth's surface and affect its systems?	**HS-ESS2-1, HS-ESS1-5, HS-ESS2-3** and **HS-ESS2-5**

NGSS Performance Expectations **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. **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. **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).

Unit 3-A: Plate Tectonics and Large –Scale System Interactions (HS-ESS1-5, HS-ESS2-1, HS-ESS2-3) **Supporting Question*: Why do the continents move, and what causes earthquakes and volcanoes?***
Suggested Content– Vocabulary in **bold**

- Re-Construction and understanding of the layers of the planet based on evidence collected
- Student's support this understanding by using evidence and data from ;
  ● **Deep probes** of the atmosphere, crust and long term studies.
  ● **Seismic wave** for understanding the composition of the planet.
  ● Reconstructions of historical changes in Earth's surface based on evidence
  ● The planet's **magnetic field** it's influence on the atmosphere
- Develop an understanding of physical and chemical processes which lead to a model of Earth with:
  ● a hot but solid **inner core**, a liquid **outer core** and a solid **mantle** and **crust.**
- The top part of the **mantle,** along with the **crust**, forms structures known as **tectonic plates**
- 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 the gravitational movement of denser materials toward the interior.
  ● **tectonic** events which change landforms.
- How **plates** move and change surface of planet and position of features of the planet due to constructive (Sea floor spreading, volcanism) or destructive (subduction) plate interactions.
- These changes can occur on a variety of time scales from sudden (e.g., **volcanic ash clouds**) to intermediate (**ice ages**) to very long-term tectonic cycles.
- How **mountains** are built due to lifting and plate interaction or torn down due erosional forces.
- **Volcanism,** the source of growing magma, the point of origin due to subduction, how land masses evolve as volcanoes age.
- **Hot spots** and their importance either in island chain development or the potential for catastrophe in regards to Yellowstone.
- Movement and change of magnetic field as presented due to field lines and changes in polarity discovered in oceanic rock.
- **Radioactive dating** and how its development has helped us understand how old the planet is, when important eras on the planet occurred and the age of species that have existed.
- **Earthquakes** and how they develop due to plate on plate interactions which build up stress and release either as short

tremors or large area wide catastrophes.	
Disciplinary Core Ideas	**Observable features of student performance**
· 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) HS-ESS1-5/ ESS2.B -Nuclear Processes Spontaneous radioactive decay follows a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary) HS-ESS1-5 · Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. HS-ESS2-1/ ESS2.A: 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) HS-ESS1-5 · Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. HS-ESS2-1/ ESS2.A: · 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	**HS-ESS1-5** 1. Identifying the given explanation and the supporting evidence a. Students identify the given explanation, which includes the following idea: that crustal materials i. of different ages are arranged on Earth's surface in a pattern that can be attributed to plate ii. tectonic activity and formation of new rocks from magma rising where plates are moving apart. b. Students identify the given evidence to be evaluated. 2. Identifying any potential additional evidence that is relevant to the evaluation a. Students identify and describe additional relevant evidence (in the form of data, information, models, or other appropriate forms) that was not provided but is relevant to the explanation and to evaluating the given evidence, including: i. Measurement of the ratio of parent to daughter atoms produced during radioactive decay as a means for determining the ages of rocks; ii. Ages and locations of continental rocks; i. Ages and locations of rocks found on opposite sides of mid-ocean ridges; and

ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE) HS-ESS2-1/ ESS2.B: · 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. HS-ESS2-3/ ESS2.A · 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. HS-ESS2-3/ ESS2.B	ii. The type and location of plate boundaries relative to the type, age, and location of crustal rocks. 3. <u>Evaluating and critiquing</u> a. Students use their additional evidence to assess and evaluate the validity of the given evidence. b. Students evaluate the reliability, strengths, and weaknesses of the given evidence along with its ability to support logical and reasonable arguments about the motion of crustal plates. 4. <u>Reasoning/synthesis</u> a. Students describe how the following patterns observed from the evidence support the explanation about the ages of crustal rocks: i. The pattern of the continental crust being older than the oceanic crust ii. The pattern that the oldest continental rocks are located at the center of continents with the ages decreasing from their centers to their margin; and iii. The pattern that the ages of oceanic crust are greatest nearest the continents and decrease in age with proximity to the mid-ocean ridges. b. Students synthesize the relevant evidence to describe the relationship between the motion of continental plates and the patterns in the ages of crustal rocks, including that: i. At boundaries where plates are moving apart, such as mid-ocean ridges, material from the

	the interior of the Earth must be emerging and forming new rocks with the youngest ages. ii. The regions furthest from the plate boundaries (continental centers) will have the oldest rocks because new crust is added to the edge of continents at places where plates are coming together, such as subduction zones. iii. The oldest crustal rocks are found on the continents because oceanic crust is constantly being destroyed at places where plates are coming together, such as subduction zones. **HS-ESS2-1** 1. <u>Components of the model</u> a. Students use evidence to develop a model in which they identify and describe the following components: i. Descriptions and locations of specific continental features and specific ocean-floor features; ii. A geographic scale, showing the relative sizes/extents of continental and/or ocean floor features; iii. Internal processes (such as volcanism and tectonic uplift) and surface processes (such as weathering and erosion); and iv. A temporal scale showing the relative times over which processes act to produce continental and/or ocean-floor features. 2. <u>Relationships</u>

	a. In the model, students describe the relationships between components, including: i. Specific internal processes, mainly volcanism, mountain building or tectonic uplift, are identified as causal agents in building up Earth's surface over time. ii. Specific surface processes, mainly weathering and erosion, are identified as causal agents in wearing down Earth's surface over time. iii. Interactions and feedbacks between processes are identified (e.g., mountain-building changes weather patterns that then change the rate of erosion of mountains). iv. The rate at which the features change is related to the time scale on which the processes operate. Features that form or change slowly due to processes that act on long time scales (e.g., continental positions due to plate drift) and features that form or change rapidly due to processes that act on short time scales (e.g., volcanic eruptions) are identified. 3. <u>Connections</u> a. Students use the model to illustrate the relationship between 1) the formation of continental and ocean floor features and 2) Earth's internal and surface processes operating on different temporal or spatial scales. **HS-ESS2-3** 1. <u>Components of the model</u>

	a. Students develop a model (i.e., graphical, verbal, or mathematical) in which they identify and describe the components based on both seismic and magnetic evidence (e.g., the pattern of the geothermal gradient or heat flow measurements) from Earth's interior, including: i. Earth's interior in cross-section and radial layers (crust, mantle, liquid outer core, solid inner core) determined by density; ii. The plate activity in the outer part of the geosphere; iii. Radioactive decay and residual thermal energy from the formation of the Earth as a source of energy; iv. The loss of heat at the surface of the earth as an output of energy; and v. The process of convection that causes hot matter to rise (move away from the center) and cool matter to fall (move toward the center). 2. Relationships a. Students describe the relationships between components in the model, including: i. Energy released by radioactive decay in the Earth's crust and mantle and residual thermal energy from the formation of the Earth provide energy that drives the flow of matter in the mantle. ii. Thermal energy is released at the surface of the Earth as a new crust is formed and cooled.

	iii. The flow of matter by convection in the solid mantle and the sinking of cold, dense crust back into the mantle exert forces on crustal plates that then move, producing tectonic activity. iv. The flow of matter by convection in the liquid outer core generates the Earth's magnetic field. v. Matter is cycled between the crust and the mantle at plate boundaries. Where plates are pushed together, cold crustal material sinks back into the mantle, and where plates are pulled apart, mantle material can be integrated into the crust, forming new rock. 3. <u>Connections</u> a. Students use the model to describe the cycling of matter by thermal convection in Earth's interior, including: i. The flow of matter in the mantle that causes crustal plates to move; ii. The flow of matter in the liquid outer core that generates the Earth's magnetic field, including evidence of polar reversals (e.g., seafloor exploration of changes in the direction of Earth's magnetic field); iii. The radial layers determined by density in the interior of Earth. iv. The addition of a significant amount of thermal energy released by radioactive decay in Earth's crust and mantle.

Crosscutting Concepts
Patterns · Empirical evidence is needed to identify patterns **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. **Energy and Matter** ● Energy drives the cycling of matter within and between systems. **<u>Interdependence of Science, Engineering, and Technology</u>** · 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.
Science and Engineering Practices
Engaging in Argument from Evidence · Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. -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. **<u>Connections to Nature of Science</u>** **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.

Grade Band Endpoints: By the end of grade 12
By the end of grade 12: Radioactive decay within Earth's interior contributes to thermal convection in the mantle. **K-12 Endpoint Progression**
Activities
Required activities: Convection current model: student investigation into the phenomenon of convection. Students produce a diagram and explanation of the phenomenon. Suggested activities: ● Model how energy is introduced into the planet and properly show how that energy affects changes in the geology or environment either in short term or long term results. ● Model of Faults – Tectonic plate modeling ● Earthquake and volcano tracking correlation with plate boundary investigation ● Dating Popcorn – popping corn to help model radioactive decay ● Earth Caching - Geo Caching activity ● Soil Color- investigate soil color relating to composition ● Earth Gravestone Project- measuring weathering of marble ● Magnets at the Earth's Core- classroom modeling of shifts in magnetic north and south ● Sink Holes in a Cup – modeling groundwater erosion creating empty space ● Pulse of the Classroom – modeling vibrations for tracking earthquakes ● Model of Faults – Tectonic plate modeling

Modifications to Content/Differentiation	
Students in need of support	**Students in need of deeper engagement**
-To include suggestions regarding depth of coverage *-Minimum depth of coverage* -Tectonic plates - rock density - continental landforms (mountains, volcanoes) - fault lines - Volcanism - radioactivity	*To include suggested extensions to investigations* *-Increased depth* - Seismic monitoring -Hot spots - Half-life calculations - Volcanic monitoring
- To include suggestions regarding depth of coverage *- Minimum depth of coverage* - How the planet is heated internally - Where the magnetic field comes from and benefits - Where energy is a factor into the surface conditions (weather) and circulation of air, water and moisture on the planet. - Understanding climate zones around the planet.	*- To include suggested extensions to investigations* *- Increased depth* - Density of air or water column affecting convection patterns - Predicting weather due to changes in patterns and energy. - How changes to composition of the atmosphere have affected heat capacity, weather and precipitation patterns.

Assessments
Suggested assessments: ● Traditional assessment: multiple choice and free response questions, or ● The above project(s) using the eight science and engineering practice standards, or ● A combination of traditional assessment with project, or ● Other format of teacher’s choice.

<table>
<tr><td colspan="2">

Unit 3-B:

THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES

Supporting Question*:*
How do the properties and movements of water shape Earth's surface and affect its systems?

</td></tr>
<tr><td colspan="2">

Suggested Content– Vocabulary in **Bold**

</td></tr>
<tr><td colspan="2">

Unit 3-B: The Roles of Water in Earth's Surface Properties

- 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 including;
- water's exceptional capacity to absorb, store, and release large amounts of energy;
- transmit sunlight; **thermal absorption** which varies seasonally and longitudinally affecting climate and ecosystems
- expand upon freezing; **frost wedging** as a destructive force that erodes mountains changing geologic features
- **erosion** and **deposition** of materials that shapes landforms such as **canyons, rivers, tributaries, water tables, rills, creeps and rock peeling.**
- **Sinkholes, cavern development through chemical and physical erosion.**
- Effects of rivers and waterways on river bank erosion
    - Corresponding development of **oxbow lakes, canyons and valleys.**
- Effects of **Glaciation** as an erosional force.
    - Development of **kettle lakes, till, cirques, moraines, aretes, outwash plains and drumlins.**

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

Disciplinary Core Ideas

</td><td>

Observable features of student performance

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

· 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

</td><td>

HS-ESS2-5
1. Identifying the phenomenon to be investigated
    a. Students describe the phenomenon under investigation, which includes the following idea: a connection between the properties of water and its effects on Earth materials and surface processes.

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

melting points of rocks. HS-ESS2-5/ ESS2.C	2. <u>Identifying the evidence to answer this question</u> a. Students develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data, including: i. Properties of water, including: a) The heat capacity of water; b) The density of water in its solid and liquid states; and c) The polar nature of the water molecule due to its molecular structure. ii. The effect of the properties of water on energy transfer that causes the patterns of temperature, the movement of air, and the movement and availability of water at Earth's surface. iii. Mechanical effects of water on Earth materials that can be used to infer the effect of water on Earth's surface processes. Examples can include: a) Stream transportation and deposition using a stream table, which can be used to infer the ability of water to transport and deposit materials; b) Erosion using variations in soil moisture content, which can be used to infer the ability of water to prevent or facilitate movement of Earth materials; and c) The expansion of water as it freezes, which can be used to infer the ability of water to break rocks into smaller pieces.

	iv. Chemical effects of water on Earth materials that can be used to infer the effect of water on Earth's surface processes. Examples can include: a) The solubility of different materials in water, which can be used to infer chemical weathering and recrystallization; b) The reaction of iron to rust in water, which can be used to infer the role of water in chemical weathering; c) Data illustrating that water lowers the melting temperature of most solids, which can be used to infer melt generation; and d) Data illustrating that water decreases the viscosity of melted rock, affecting the movement of magma and volcanic eruptions. b. In their investigation plan, students describe how the data collected will be relevant to determining the effect of water on Earth materials and surface processes. 3. <u>Planning for the Investigation</u> a. In their investigation plan, students include a means to indicate or measure the predicted effect of water on Earth's materials or surface processes. Examples include: i. The role of the heat capacity of water to affect the temperature, movement of air and movement of water at the Earth's surface; ii. The role of flowing water to pick up, move and deposit sediment;

	iii. The role of the polarity of water (through cohesion) to prevent or facilitate erosion; iv. The role of the changing density of water (depending on physical state) to facilitate the breakdown of rock; v. The role of the polarity of water in facilitating the dissolution of Earth materials; vi. Water as a component in chemical reactions that change Earth materials; and vii. The role of the polarity of water in changing the melting temperature and viscosity of rocks. b. In the plan, students state whether the investigation will be conducted individually or collaboratively. 4. <u>Collecting the data</u> a. Students collect and record measurements or indications of the predicted effect of a property of water on Earth's materials or surface. 5. <u>Refining the design</u> a. Students evaluate the accuracy and precision of the collected data. b. Students evaluate whether the data can be used to infer the effect of water on processes in the natural world. c. If necessary, students refine the plan to produce more accurate and precise data.

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.
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. o 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.

Grade Band Endpoints
By the end of grade 12: The planet's dynamics are greatly influenced by water's unique chemical and physical properties. **K-12 Endpoint Progression**
Activities
Suggested activities: ● Erosion/stream bed modeling ● Sea Salinity- investigate how salinity relates to temperatures ● Fresh vs Salt Water – compare and investigate properties of fresh vs salt water ● Make a Cave – model cave/empty space development. ● Chemical deposition investigation. ● Explore Porosity- explore how empty space affects liquid carrying capacity of soil. ● Glacier Slide—modeling glacial movement due to freeze/thaw process

- ID Watersheds – investigating potential watersheds in town area using topographical maps

Modifications to Content/Differentiation	
Students in need of support	**Students in need of deeper engagement**
-*To include suggestions regarding depth of coverage* - *Minimum depth of coverage* - Properties of water - Erosional features of streams - Land features created by water (caves, sinkholes, waterfalls, oxbow lakes).	-*To include suggested extensions to investigations* -*Increased depth* - Potential to expand upon and investigate how salinity and/or pH changes the properties of water and changes the capacity of water to erode materials, thermal/freeze capacity, effects on biologicals.

Assessments

Suggested assessments:

- Traditional assessment: multiple choice and free response questions, or
- The above project(s) using the eight science and engineering practice standards, or
- A combination of traditional assessment with project, or
- Other format of teacher’s choice

Unit 4: Mineralogy **CORE IDEA:** **How does the chemistry of the planet affect its geology** **(Approximate instruction time for this unit is 20 class periods)**	
Earth's surface is a complex and dynamic set of interconnected systems—principally the geosphere, hydrosphere, atmosphere, and biosphere—that interact over a wide range of temporal and spatial scales. The solid material of the planet is affected by these on short and long time scales. The chemistry of the bonds between elements and compounds grant minerals and rocks their properties which then affect how the systems of the planet are constantly changing. The materials involved have not changed but constantly interact and form various minerals, types of stone or remain intact as elements. Students will learn the different types of rocks, minerals and differentiate them based on their characteristics. These characteristics affect the erosional time on geologic formations over time and the environments themselves.	
Component Ideas	**Performance Expectations**
Unit 4-A Composition of the material of the planet Supporting standards: **ESS2-1 Composition Composition of the material of the planet.** [Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.] [Assessment Boundary: Assessment does not include the identification and naming of minerals.]	- HS- ESS1-6, HS- ESS2-3, HS-Ess2-6, HS- ESS2-5, HS--ESS1.c, HS--ESS2.b, HS--PS4.b, HS--ESS2.A, HS- PS1-1, HS-PS1-3, HS-PS2-6

ESS2-C: THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES Supporting question: How does water shape Earth's solid matter? [Clarification statement: Emphasis on how the presence of water changes mineral composition and characteristics as well as play a role in the rock cycle.] **ESS2-B: PLATE TECTONICS AND LARGE-SCALE SYSTEM INTERACTIONS** Supporting question: How do rocks and minerals get recycled? [Clarification statement: Emphasis on how the heat, pressure and time change minerals and their characteristics along with are a role in the rock cycle.]	

NGSS Performance Expectations 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 affecting how minerals form and change.[Clarification Statement: Emphasis is on how large scale factors of heat, pressure, water content and time affect the chemical composition and properties of rocks] [Assessment Boundary: Including demonstrating understanding of what drives the rock cycle on this planet.] **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 cycling of rock. Assessment could include understanding of the Bowden reaction graph.] **HS-ESS2-4** Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes to minerals and topography

Clarification Statement: Rock cycle has occurred since the start of the planet, 4.5 billion years ago. As temperatures fluctuate, the elements in minerals break down and exchange bonds, changing those compounds and their properties.
Assessment Boundary: Assessment of the results of changes as igneous and sedimentary rocks form and are transformed into metamorphic rocks over time.

HS-ESS2-5.
Plan and conduct an investigation of the properties of water and its effects on Earth materials and affects the properties of those materials. [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 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 could include demonstrating how water content changes chemical bonds and melt temperatures of minerals.]

HS-ESS2-6.
Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling how organic material decomposes and/or is fossilized and adds to the stratification of rock layers along with the properties of sedimentary rock.]

HS-PS2-6.
Communicate scientific and technical information about why the molecular-level structure is important in the geometry and functional properties of minerals.* [Clarification Statement: Emphasis is on the bonding geometry and resulting chemistry of minerals which defines the crystallization geometry and inherent properties.] [Assessment Boundary: Assessment is limited to provided molecular structures of basic minerals.]

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: Understanding of chemical bonding based on electron patterns helps in understanding how bonds help in strengthening or weakening crystal geometry.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]

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.]

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.]

Unit 4- Mineralogy

(HS-ESS2 1-6, , HS-PS1 1-3, HS-PS2-6)

Supporting Question*:* How does the chemistry of the planet affect its geology

Suggested Content– Vocabulary in **bold**

- Exploration of **melting, crystallization, weathering, deformation, and sedimentation**, which act together to form **minerals** and rocks through the cycling of Earth's materials also affects the properties of a type of rock.
- Exploration how **Sedimentary, Igneous and Metamorphic** rock properties are foundational to the geologic processes and formations on this planet.
- Exploration of properties of rocks and minerals to understand their classification.
    - Introduction to: **hardness, density, color, magnetism, conductivity, crystal geometry, appearance and fracture vs cleavage.**
- Exploration around the chemical bonding that occurs within an mineral element or a complex compound mineral and the resulting properties from those bonds.
- The lower the **viscosities** and **melting points** of rocks as a factor to consider in the **Bowden reaction series** for crystallization of rock or in metamorphosing rock into a different mineral composition.

Disciplinary Core Ideas	**Observable features of student performance**
- The planet is made up of all of the elements on the periodic table. These elements are either found as primary minerals or are secondary as part of a chemical bond for a complex mineral. **HS-ESS2 1-6, HS-PS1 1-3** - Temperature, pressure, time all are components of the rock cycle which change elements and minerals on the planet. Rocks and minerals are moved, displaced, broken down and recycled all over the planet in various states and phases. **HS-ESS2 1-6, HS-PS1 1-3** - Sedimentary rocks develop as a result of deposition and concentration of material (in/organic) over time. The properties of the rock are due to the types elements and minerals that make it up and the conditions exposed to it over time. **HS-ESS2 1-6, HS-PS1 1-3** - Igneous rock is a result of convection currents under the crust as that material cools off and from minerals being exposed to heat. The properties of the rock are due to the types elements and minerals that make it up and the conditions exposed to it over time. **HS-ESS2 1-6, HS-PS1 1-3** - Metamorphic rock is a result of material being exposed to pressure, heat and time which change how the chemical bonds and elements exchange from their prior state. The properties of the rock are due to the types elements and minerals that make it up and the	**HS-ESS2-2** 1. Organizing data a. Students organize data that represent measurements of Density, atomic weight, hardness, reactivity, magnetics, conductivity, and color to classify minerals.. b. Students describe what each data set represents. 2. Identifying relationships a. Students use tools, technologies, and/or models to analyze the data and identify and describe relationships in the datasets, including: i. Understanding melt and crystallization temperatures. ii. Organizing sets of properties and how the chemical bonding is associated. iii. Identify how hydration, temperature, pressure and time affect bonding and geometry of minerals. 3. Interpreting data a. Students use the analyzed data to describe an understanding how changes in time, pressure, hydration, pressure and temperature affect the rock cycle. b. Students use the analyzed data to describe a particular unanticipated or unintended effect of a selected mineral. c. Students include a statement regarding how variation or uncertainty in the data (e.g., limitations, accuracy, any bias in the data resulting from choice of sample, scale, instrumentation, etc.) may affect the interpretation of the data.

conditions exposed to it over time. **<u>HS-ESS2 1-6, HS-PS1 1-3</u>** - Rocks can be classified based on their properties which are unique either to the element or the compound which makes up the mineral. **<u>HS-ESS2 1-6, HS-PS1 1-3</u>**	**HS-ESS2-4** 1. <u>Components of the model</u>: a. From the given model, students identify and describe the components of the model relevant for their mechanistic descriptions. Given models include at least one factor that affects the input of energy, at least one factor that affects the output and/or change in the rock/mineral. Factors are derived from the following list: i. Atmospheric composition (including amount of water vapor and CO2); ii. Atmospheric circulation; iii. Volcanic activity; iv. Ocean circulation; v. Changes in extent or type of vegetation cover; vi. Human activities. b. From the given model, students identify the relevant factors which drive development of a type of rock. 2. <u>Relationships</u> a. Students identify and describe the relationships between components of the given model, and organize the factors from the given model into three groups: i. Those that affect the input of energy; ii. Those that affect the output of matter b. Students describe the relationships between properties of minerals in the model as either causal or correlational. 3. <u>Connections</u>

	a. Students use the given model to provide a mechanistic account of the relationship between energy flow in Earth's systems and changes in elements and minerals, including: i. The specific cause and effect relationships between the factors and the effect on energy flow into and out of Earth's systems with resulting changes in geology. ii. The net effect of all of the competing factors in the rock cycle.

Crosscutting Concepts
Stability and Change · Feedback (negative or positive) can stabilize or destabilize a system. · Much of science deals with constructing explanations of how things change and how they remain stable and have certain properties. **Cause and Effect** · Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Energy and Matter** (HS-ESS2-6) · The total amount of energy and matter in closed systems is conserved. **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.

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. (HS-ESS2-2)

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.
  - o 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.

Scientific Knowledge is Based on Empirical Evidence

· Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

Developing and Using Models

o 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).

- o Use a model to provide mechanistic accounts of phenomena.
- o Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

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).
  - o Arguments may also come from current scientific or historical episodes in science.
  - o Construct an oral and written argument or counter-arguments based on data and evidence.

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;
  - o A range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms;
  - o Computational tools for statistical analysis to analyze, represent, and model data.
  - o Simple computational simulations are created and used based on mathematical models of basic assumptions.

· Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

Grade Band Endpoints
By the end of grade 12: Students will be able to demonstrate understanding of the factors which affect the cycling of rock on this planet between three types of rocks and minerals. Students will also be able to classify rocks and minerals based on their specific properties. **K-12 Endpoint Progression**
Activities
Suggested activities: - Mineral melt temperatures lab - Bowden melt and crystallization series exploration - Density calculations - Mineral identification lab to include introduction to and application of; hardness, density, color, magnetism, conductivity, crystal geometry, appearance and fracture vs cleavage. - Construction and application of rock cycle model - Fossilization identification.

Modifications to Content/Differentiation	
Students in need of support	**Students in need of deeper engagement**
- *To include suggestions regarding depth of coverage* - *Minimum depth of coverage* -Classifying minerals -Classifying types of rocks -Demonstrate understanding of the driving processes of the rock cycle.	- *To include suggested extensions to investigations* - *Increased depth* -Applied understanding of the environment which sedimentary, igneous and metamorphic rocks form in. -Apply understanding of a Bowden reaction - Apply how temp, water, pressure affect the chemical bonding of minerals and then affects their properties.

Assessments
Suggested assessments: ● Traditional assessment: multiple choice and free response questions, or ● The above project(s) using the eight science and engineering practice standards, or ● A combination of traditional assessment with project, or ● Other format of teacher's choice

Suggested Timeline and pacing… subject to further review and alignment with book and labs. Units should be intended to be completed in each quarter but are not required.	
Unit one- Astronomy	**20 days**
Unit two- Atmosphere and Weather	**25 days**
Unit three- Physical Forces and Formations	**25 days**
Unit four- Mineralogy	**20 days**