Chemistry
Unit 7
Baltimore's Hills

BALTIMORE CITY
PUBLIC SCHOOLS

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Acknowledgements

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Unit Overview — Duration: 4 Weeks

UNIT STORYLINE SNAPSHOT

Anchoring Phenomenon: Baltimore has more hills than people expect.
Where did the hills come from?

Performance Task: Develop a page for the Visit Baltimore website that explains why Baltimore has so many hills.

What builds mountains?	What breaks down mountains?	What moves mountains?	Where are the mountains now?
What global processes create mountains and the rocks within them?	***What chemical and physical processes break down rocks?***	***How are rocks moved from one place to another?***	***Where does the material that was mountains end up?***

Students will observe the topography around their schools, in the region, and at continental-to-global scales. They will recognize that there are many high places, hills, mountains, and other features. Students will extend their learning from unit 6 by learning how the forces that move matter inside the Earth are also responsible for moving the surface through plate tectonics. Using Geo-Blox, students will explore the major tectonic regions and processes to gain the understanding that mountains form through volcanism above subduction zones, through deformation from collisions, and from isostatic uplift. They also learn about the chemical processes that result in distinctive igneous and metamorphic rocks; minerals; and their associated properties. Students will apply their knowledge to local and regional landforms and consider the consequences of uplift processes for Earth systems.

Students will consider weathering and erosion processes (physical, chemical) along with the significant role people play in shaping the physical landscape. They design and conduct investigations of physical weathering and chemical weathering on natural and urban materials (brick, concrete, marble and granite) and subsequently on surface water. Students will then investigate how the chemical materials released into water by weathering can be detected in our local waterways and the possible consequences of this altered chemistry. Next, students will revisit the regional landscape to identify places that demonstrate key ideas about weathering (ridges where resistant rock types occur, valleys where easily dissolved carbonate rocks occur), as well as places where deposition occurs. The unit concludes with the examination of deposition in the Chesapeake Bay through physical deposition in floodplains and deltas, and chemical deposition (e.g., limestone through shell growth). (Teacher notes and background information can be found in the Unit 7 Planning folder.)

Unit Goals

1. Create a model that depicts the development of the hills within Baltimore
2. Write an explanation to describe the visual representation of the model in words. Explain how the constructive and destructive processes produced the areas topography
3. Use appropriate scientific vocabulary and evidence to explain the phenomenon.

What students figure out at the end of the unit:

1. How plate tectonics cause the surface of the earth to change and build mountains.
2. How weathering breaks down mountains.
3. How erosion transports materials.
4. How and where deposition places materials.

Put another way:

If students understand…		Then, students can explain…
Plate tectonics • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. • Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.		How mountains are built by plate collision and volcanic eruption • Relationships in components of the geosphere and how changes in one area can cause a response in another area. • Specific internal processes, mainly volcanism, mountain building or tectonic uplift, are causal agents in building up Earth's surface over time • The rate at which the features change is related to the time scale on which the processes operate. Features such as continental positions may form or change slowly due to processes that act on long time scales and features such as volcanic mountains form or change rapidly due to processes that act on short time scales. • Moving continents cause changes in the surface of the earth along plate boundaries • Convergent, Divergent, and Transform boundaries each cause unique changes in the surface of the Earth • Earth system processes produce different types of minerals and rocks dependent on system condition.
Weathering • The abundance of water on the Earth's surface is central to the planet's dynamics. • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.		How mountains are broken down • Specific surface processes, mainly weathering and erosion, are identified as causal agents in wearing down Earth's surface over time • Mechanical effects of water on Earth materials that can be used to infer the effect of water on Earth's surface processes • The expansion of water as it freezes, which can be used to infer the ability of water to break rocks into smaller pieces.

		• Chemical effects of water on Earth materials that can be used to infer the effect of water on Earth's surface processes. • Water as a component in chemical reactions that change Earth materials
Erosion and Deposition • 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 dissolve and transport materials.		How materials are moved from where they were broken • The solubility of different materials in water, which can be used to infer chemical weathering and recrystallization; Where and how materials end up in their final locations. • Stream transportation and deposition models, which can be used to infer the ability of water to transport and deposit materials • The role of flowing water to pick up, move and deposit sediment;

Next Generation Science Standards

Targeted NGSS Performance Expectations…

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-ESS2-2: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]

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).]

Dimensions from the NGSS Performance Expectations….

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
SEP 2 HS3: **Developing and Using Models** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. SEP2 HS6: **Developing and Using Models** Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems. SEP 3 HS1: **Planning and Carrying Out Investigations** Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible variables or effects and evaluate the confounding investigation's design to ensure variables are controlled. SEP 4 HS1: **Analyzing and Interpreting Data** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. SEP 6 HS4: **Developing and Using Models** Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. SEP 7 HS5: **Engaging in Argument from Evidence** Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.	ESS2.A HS1: **Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. ESS2.B HS2: **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.C HS1: **The Roles of Water in Earth's Surface Processes** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. ESS2.BHS3: **Plate Tectonics and large-Scale System Interactions** Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.	CCC 1 HS4: **Patterns** Mathematical representations are needed to identify some patterns. CCC 1 HS5: **Patterns** Empirical evidence is needed to identify patterns. CCC2 HS2: **Cause and Effect** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. CCC 3 HS2: **Scale, Proportion, and Quantity** Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. CCC 4 HS1: **Systems and System Models** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. CCC 4 HS3: **Systems and System Models** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. CCC 5 HS2: **Energy and Matter** Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. CCC 6 HS2: **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.

SEP 8 HS5: **Obtaining, Evaluating, and Communicating Information** Communicate scientific and/or technical information or 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).		**Stability and Change** CCC 7 HS1 - Much of science deals with constructing explanations of how things change and how they remain stable. **Stability and Change** CCC7 HS2 - Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Disciplinary Core Idea Progressions

DCI	K-2	3-5	6-8	9-12
ESS2.A	• Wind and water can change the shape of the land.	• Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. • Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.	• All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.	• Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. • 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. • The geologic 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.
ESS2.B	• Maps show where things are located. One can map the shapes and kinds of land and water in any area.	• The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth.	• Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.	• Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. • 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. • 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.C	• Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.	• Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.	• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. • The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. • Global movements of water and its changes in form are propelled by sunlight and gravity. • Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.	• The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

Crosscutting Progressions

DCI	K-2	3-5	6-8	9-12
CCC 1 – **Patterns**	• Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.	• Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products. • Patterns of change can be used to make predictions • Patterns can be used as evidence to support an explanation.	• Macroscopic patterns are related to the nature of microscopic and atomic-level structure. • Graphs, charts, and images can be used to identify patterns in data. • Patterns in rates of change and other numerical relationships can provide information about natural systems. • Patterns can be used to identify cause-and-effect relationships.	• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Empirical evidence is needed to identify patterns. • Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. • Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. • Mathematical representations are needed to identify some patterns.
CCC 2 – **Cause and Effect: Mechanism and Prediction**	• Simple tests can be designed to gather evidence to support or refute student ideas about causes. • Events have causes that generate observable patterns.	• Cause and effect relationships are routinely identified, tested, and used to explain change. • Events that occur together with regularity might or might not be a cause and effect relationship.	• Cause and effect relationships may be used to predict phenomena in natural or designed systems. • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. • Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Systems can be designed to cause a desired effect. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Changes in systems may have various causes that may not have equal effects.

CCC 3 – **Scale, Proportion, and Quantity**	• Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). • Standard units are used to measure length.	• Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. • Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.	• Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. • Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. • Phenomena that can be observed at one scale may not be observable at another scale. • The observed function of natural and designed systems may change with scale. • Scientific relationships can be represented through the use of algebraic expressions and equations.	• The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. • 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). • Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. • Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. • Patterns observable at one scale may not be observable or exist at other scales.
CCC 4 – **Systems and System Models**	• Systems in the natural and designed world have parts that work together. • Objects and organisms can be described in terms of their parts.	• A system can be described in terms of its components and their interactions. • A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.	• Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. • Models are limited in that they only represent certain aspects of the system under study.	• 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. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. • Systems can be designed to do specific tasks.
CCC 5 – **Energy and Matter: Flows, Cycles, and Conservation**	• Objects may break into smaller pieces and be put together into larger pieces, or change shapes.	• Energy can be transferred in various ways and between objects. • Matter is made of particles. • Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems.	• Matter is conserved because atoms are conserved in physical and chemical processes. • Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). • Within a natural system, the transfer of energy drives the motion and/or cycling of matter. • The transfer of energy can be tracked as energy flows through a natural system.	• In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. • The total amount of energy and matter in closed systems is conserved. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. • Energy drives the cycling of matter within and between systems.
CCC 6 – **Structure and Function**	• The shape and stability of structures of natural and designed objects are related to their function(s).	• Different materials have different substructures, which can sometimes be observed. • Substructures have shapes and parts that serve functions.	• Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.	• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. • 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.

CCC 7 – **Stability and Change**	• Things may change slowly or rapidly. • Some things stay the same while other things change.	• Change is measured in terms of differences over time and may occur at different rates. • Some systems appear stable, but over long periods of time will eventually change.	• Stability might be disturbed either by sudden events or gradual changes that accumulate over time. • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. • Small changes in one part of a system might cause large changes in another part. • Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.	• Much of science deals with constructing explanations of how things change and how they remain stable. • Systems can be designed for greater or lesser stability. • Feedback (negative or positive) can stabilize or destabilize a system. • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Science and Engineering Practices Progressions

DCI	K-2	3-5	6-8	9-12
SEP 2 – **Developing and Using Models**	Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. • Distinguish between a model and the actual object, process, and/or events the model represents. • Compare models to identify common features and differences. • Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). • Develop a simple model based on evidence to represent a proposed object or tool.	Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Identify limitations of models. • Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events. • Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. Develop and/or use models to describe and/or predict phenomena. • Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. • Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Evaluate limitations of a model for a proposed object or tool. • Develop or modify a model— based on evidence – to match what happens if a variable or component of a system is changed. • Use and/or develop a model of simple systems with uncertain and less predictable factors. • Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. • Develop and/or use a model to predict and/or describe phenomena. • Develop a model to describe unobservable mechanisms. • Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena and move flexibly between model types based on merits and limitations. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze system
SEP 3 – **Planning and Carrying Out Investigations**	Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • With guidance, plan and conduct an investigation in collaboration with peers (for K). • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.	Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K– 2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. • Evaluate appropriate methods and/or tools for collecting data.	Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. • Conduct an investigation and/or evaluate and/or revise the experimental design to produce data	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

	• Evaluate different ways of observing and/or measuring a phenomenon to determine which way can answer a question. • Make observations (firsthand or from media) and/or measurements to collect data that can be used to make comparisons. • Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal. • Make predictions based on prior experiences.	• Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. • Make predictions about what would happen if a variable changes. • Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success.	to serve as the basis for evidence that meet the goals of the investigation. • Evaluate the accuracy of various methods for collecting data. • Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. • Collect data about the performance of a proposed object, tool, process or system under a range of conditions.	• 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. • Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. • Select appropriate tools to collect, record, analyze, and evaluate data. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.
SEP 4 – **Analyzing and Interpreting Data**	Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations. • Record information (observations, thoughts, and ideas). • Use and share pictures, drawings, and/or writings of observations. • Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems. • Compare predictions (based on prior experiences) to what occurred (observable events). • Analyze data from tests of an object or tool to determine if it works as intended.	Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. • Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. • Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings. • Analyze data to refine a problem statement or the design of a proposed object, tool, or process. • Use data to evaluate and refine design solutions.	Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. • Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships. • Distinguish between causal and correlational relationships in data. • Analyze and interpret data to provide evidence for phenomena. • Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible. • Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials). • Analyze and interpret data to determine similarities and differences in findings. • Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success.	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. • Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data. • Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. • Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.
SEP 6 – **Constructing**	Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and	Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in	Constructing explanations and designing solutions in 6–8 builds on K– 5 experiences and progresses to include constructing explanations and designing	Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple

Explanations and Designing Solutions	ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. • Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem. • Generate and/or compare multiple solutions to a problem	constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. • Identify the evidence that supports particular points in an explanation. • Apply scientific ideas to solve design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. • Construct an explanation using models or representations. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) 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. • Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events. • Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system. • Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. • Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and retesting.	and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • \Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
SEP 7 – **Engaging in Argument from Evidence**	Engaging in argument from evidence in K–2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s). • Identify arguments that are supported by evidence. • Distinguish between explanations that account for all gathered evidence and those that do not. • Analyze why some evidence is relevant to a scientific question and some is not. • Distinguish between opinions and evidence in one's own explanations. • Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument. • Construct an argument with evidence to support a claim.	Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • Compare and refine arguments based on an evaluation of the evidence presented. • Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation. • Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions. • Construct and/or support an argument with evidence, data, and/or a model. • Use data to evaluate claims about cause and effect.	Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. • Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. • Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. • Make an oral or written argument that supports or refutes the advertised performance of a	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. • Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. • Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

	• Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.	• Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and	device, process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints. Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	• Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).
SEP 8 – **Obtaining, Evaluating, and Communication Information**	Obtaining, evaluating, and communicating information in K–2 builds on prior experiences and uses observations and texts to communicate new information. • Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s). • Describe how specific images (e.g., a diagram showing how a machine works) support a scientific or engineering idea. • Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question and/or supporting a scientific claim. • Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas.	Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods. • Read and comprehend grade appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence. • Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices. • Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices. • Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. • Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.	Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods. • Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s). • Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings. • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. • Evaluate data, hypotheses, and/or conclusions in scientific and technical texts in light of competing information or accounts. • Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.	Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. • Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. • Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. • Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. • Communicate scientific and/or technical information or 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 (i.e., orally, graphically, textually, mathematically).

Content Overview

This section contains links to resources supporting the topics covered within the Unit.

Lesson 1 – Unit Introduction

- Plate Tectonics (Bozeman Science)
- Theory of Plate Tectonics and Types of Plate Boundaries (CK12.org)
- Mountain Building (CK12.org)
- Plate Tectonics (National Geographic)
- Plate Tectonics Basics (Earth Rocks!)

Lesson 2 – Exploring Landform Patterns- Global Scale

- Understanding Plate Motions (USGS)
- "Hotspots": Mantle Thermal Plumes (USGS)
- Plate Tectonics and California Geology (Earth Rocks!)

Lesson 3 – Evidence of Plate Boundaries

- Convergent Plat Boundaries (The Kahn Academy)
- Plate tectonics and People (USGS)
- Plate Tectonics Global Impacts (Earth Rocks!)

Lesson 4 – The History of North America, Maryland, Baltimore

- Historical Perspective (USGS)
- Geologic Evolution of Eastern North America PowerPoint

Lesson 5 – Global Composition

- Earth Chemistry PowerPoint

Lesson 6 – Chemistry of Rock Types

- Geology (Bozeman Science)
- The Rock Cycle (BC
- The Rock Cycle (The Kahn Academy)
- Igneous Rocks (USGS)
- Metamorphic Rocks (USGS)
- Sedimentary Rocks (USGS)
- Silicate Minerals (BC Open Books)
- Identifying Igneous Rocks (Earth Rocks!)

Lesson 7 – Agents of Change

- Weathering and Erosion (CK12.org)

Lesson 8 – Physical Weathering Day 1

• Mechanical Weathering (CK12.org) • Honeycomb Weathering of Limestone Formations (USGS)
Lesson 9 – Physical Weathering Day 2
Lesson 10 – Physical Weathering Day 3
• Pothole Formation (Maryland State Highway Administration)
Lesson 11 – Chemical Weathering
• Chemical Weathering (CK12.org)
Lesson 12 – Weathering and Water Quality: Salinity in Streams Day 1
• How to Use Land Cover Data as an Indicator of Water Quality (NOAA) • Stream Health (Maryland DNR)
Lesson 13 – Weathering and Water Quality: Salinity in Streams Day2
Lesson 14– Weathering, Erosion and Deposition in the Local environment
• What is the difference between weathering and erosion? (Virginia DOE) • Weathering, erosion, landforms and regolith. Teacher notes and student activities (Geosciences Australia) • Weathering and Sedimentation (Earth Rocks!)
Lesson 15 – Landforms and Physical Deposition
• Landforms from Erosion and Deposition Study Guide (CK12.org) • Deposition by streams (CK12.org)
Lesson 16 – Chemical Deposition
Lesson 17 – Final Activity Day 1
• Storyboards in education (Bruce Montes)
Lesson 18 – Final Activity Day 2

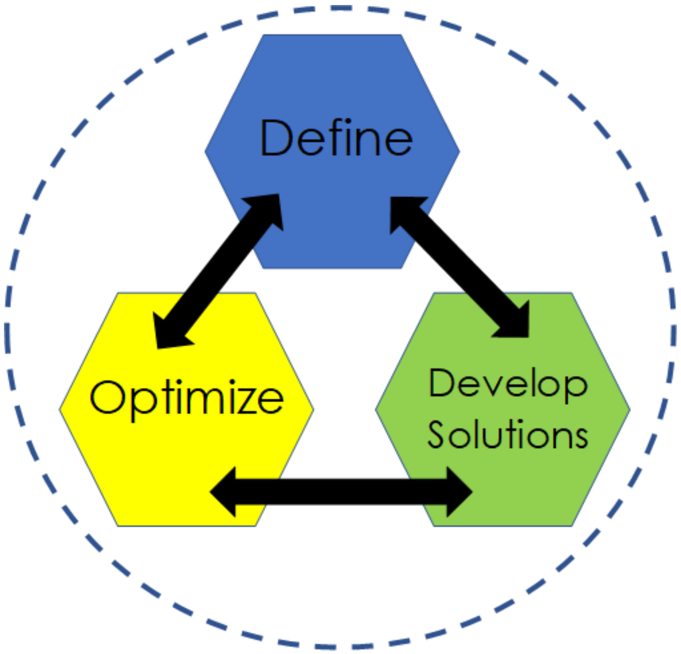
Unit Storyline

Storyline	Phenomena-driven Questions	Investigate and Build Knowledge through Practices	Incrementally Build Models that Explain Phenomenon
Build	Are there hills/mountains in Baltimore?	Students organize and analyze data that represent measurements of topographic features and describe what each data set represents.	Mountains grow and shrink over time. Depending on age and location, the relative size varies on a geographic scale.
	What processes build hills and mountains?	Engage in argument from evidence	Specific internal processes build mountains and create volcanoes over time, each boundary changes the land in unique ways.
	What evidence do we have?	Communicate scientific information	
	What is Maryland's tectonic history/How did we end up here?	Use a model to illustrate and/or predict the relationships between the components of a system	The motion of the continents and collision of tectonic plates have built the mountains within Maryland. This happens over long periods of time.
	How can the highest point in Maryland be both taller and shorter than Nihoa Volcano in Hawaii?	Analyze Data/Graphing	How can the highest point in Maryland be both taller and shorter than Nihoa Volcano in Hawaii?
	What types of rock have formed under our feet?	Obtaining, evaluating, and communicating information	The process of mountain building creates rocks of different composition and properties dependent on the conditions under which they formed.
Break	What can move/change mountains?	Evaluate the claims, evidence, and/or reasoning to determine the merits of arguments	Weathering, Erosion, Deposition are processes that break, move, and drop the material from mountains.
	How does Freezing water break down mountains?	Develop a model of physical weathering by observing the expansion of water as it freezes to illustrate and/or predict how freezing water can cause rocks to crack or break apart.	Water, through frost/ice wedging, can break apart the rocks of a mountain.
	How does moving water break down mountains?	Revise the physical weathering, model to include observed evidence from a rock tumbler which demonstrates the abrasive power of flowing water with sediment and its ability to wear down rocks.	Water, which can carry and move large and small matter (such as rocks, gravel, sand and silt), can wear down rocks in a river through abrasion.

	How does water break down other rock materials?	Communicate the process of physical weathering from water by creating a story-board that illustrates and explains the process that forms a pot-hole in the streets of Baltimore.	Water breaks down natural and manmade rocks through physical weathering processes.
	How do chemical processes break down mountains?	Design an investigation of the impact of acidic rain/water on rock.	How do chemical processes break down mountains?
Move	How do we measure chemical weathering? (two-day activity)	Analyze data regarding the mineral content of water and make an evidence supported argument from the data.	Dissolved matter from the rocks of a mountain, or manmade rocks, can be moved from their original location by flowing water.
	Where do we find evidence of weathering, erosion, and deposition in the local environment?	Observe the local environment to identify evidence of weathering, erosion and deposition.	Matter moves from one location and is deposited in another.
Drop	Where does the moving material go?	Create a model to illustrate the process of deposition and the impact of particle size on the movement of materials.	Large materials, such as boulders and rocks, are not able to be carried as far by flowing water as smaller particles of materials, such as gravel, sand and silt.
	What happens to dissolved materials?	Conduct experiments to observe the impact of Carbon Dioxide on lime-water to determine the impact on chemical deposition and report findings.	Dissolved minerals can be chemically deposited in the ocean either directly or through biological processes.
Final Project	Where did the hills come from?	Communicate scientific information by creating a visual model of the process of building and wearing away the mountains in Baltimore to form the hills found today.	Final Model which incorporates the information and understanding as developed throughout the unit.

Grades 9-12 Engineering Design

This is the Next Generation Science Standards 2019 version of the Engineering Design Process (EDP). This version is an iterative cycle of design that focuses on three areas across grade bands.



Define- Attend to a broad range of considerations in criteria and constraints for problems of social and global significance
Develop solutions- Break a major problem into smaller problems that can be solved separately
Optimize- prioritize criteria consider tradeoffs, and assess social and environmental impacts as a complex solution is tested and refined

EL Support

When you have specific prompts/questions in the lesson that students are to respond to either orally or in writing

Ask English learners to respond to prompts/questions. You should model and practice your expected response before asking a student to do so in a small group or independently. For beginning level students expect a word/phrase, and intermediate/advanced students expect simple sentences to complex discourse on the topic.

When you have specific prompts/questions in the lesson that students are to respond to either orally or in writing

It is important to model and practice using the new terms in context with English language learners. English learners need to learn not just the term but how it functions grammatically and syntactically in English in order to be able to use the term appropriately. Allow time for students to practice using the term before class discussions, readings or expecting them to use it in their writing. For beginning level students expect a word/phrase, and intermediate/advanced a simple to complex sentence on the topic.

When asking teachers to allow students to listen to texts read to them

For students at lower proficiency levels that may struggle listening to extended texts in English, you may want to provide a note taking sheet, where they can draw and label the portions of the text you want them to use later. For example, you may ask them only to pay attention to the second paragraph and not focus on trying to listen to the entire text right away. English learners with a higher proficiency may benefit from drawing and labeling their ideas to answer the outcome for the reading.

When teachers ask students to read independently

When students have a proficiency level 1-3 in reading, you will need to chunk the readings and provide a clear goal for how you expect the student to use the reading, either orally or in their writing. When students have a proficiency level 4-5, you will want to model and provide directions as to your expectations for how they are to use the reading in discussions or in their writing.

When teachers are expecting students to work collaboratively

When asking students to work collaboratively, model, and practice your expectations for what students should be saying, reading, listening to, or writing in order to appropriately contribute to the work and assignment expectations.

Recommended Instructional Supports

Supports	Strategies	Examples
Building Background	• Link concepts to students' background experiences • Make explicit links between past learning and new concepts • Consider cultural relevancy	***Culturally Relevant*** Keep in mind some English Learners may have begun developing mathematical concepts in their home language in which they may write or understand the numbering system in a different way. This is a great opportunity to honor the various ways different cultures express and write numbers while explicitly teaching how to represent numbers in English.
Listening	• Active listening guides • Reduced vocabulary load • Provide written notes • Provide visuals • Monitor responses • Clarify or provide directions in the native language • Modify classwork, assessments, homework (true/false,	***Active listening guide with written notes*** English learners with an English proficiency level of 1 to 3 will benefit form a guided note-taking sheet. During the Interactive Read Aloud, provide students with a note-taking sheet that includes illustrations and diagrams from the text that will be highlighted during the reading. This will support English learners by focusing their listening on the key language and content of the lesson.

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	reduced responses) • Allow verbal and non-verbal responses (gestures) • Extended time • Bilingual dictionary	
Speaking	• Graphic organizers • Reduced vocabulary load • Provide written notes • Provide visuals • Sentence frames and sentence starters • Model appropriate responses • Monitor responses • Clarify or provide directions in the native language • Modify classwork, assessments, homework (true/false, reduced responses) • Allow verbal and non-verbal responses (gestures) • Extended time • Bilingual dictionary	***Provide model response Sentence frames and sentence starters*** When asking English learners to respond to prompts or questions, you should model and practice your expected response before asking students to do so in a small group or independently. For students with an English proficiency level 1 to 2 expect a word or phrase, and for students with an English proficiency level 3 to 5 expect simple sentences to complex discourse on the topic. Provide sentence frames or starters to support students with an English proficiency level 1 to 2 in developing their response.
Learning Outcomes	• Explicitly state which language domains are addressed in the lesson: Listening, Speaking, Reading, Writing • Include language objectives with content objectives	***Language Objectives*** Content Objective: I can gather information and evidence from multiple media sources to learn about cultures. Language Objective: I can listen for information about a culture while watching a video.
Reading	• Graphic organizers • Reduced vocabulary load • Read to (entire or selected sections) • Break down reading into smaller chunks • Provide written notes • Provide visuals • Provide audio support • Monitor responses • Clarify or provide directions in the native language • Modify classwork, assessments, homework (true/false, reduced responses) • Allow verbal and non-verbal responses (gestures) • Extended time • Bilingual dictionary	***Break down into smaller chunks Provide audio support*** English learners with an English proficiency level 1 to 3 will need additional support when asked to read extended text independently. Chunk the reading and provide a clear goal for how you expect the student to use the reading, either orally or in writing. Provide access to audio resources for English learners to listen to the text if they struggle to read the text independently.
Translanguaging	• Take a translanguaging stance • Leverage students' native language to support English	***Native language support***

	language acquisition • Clarify or provide directions in the students' native language • Pair students that share a home language • Encourage students to discuss ideas and concepts in their native language prior to reporting out or writing in English	Model and practice your expectations for students when they answer the questions posed in this lesson. You may notice some students initially feel more comfortable using their home language. It is good practice to allow students to use their home language and then model and ask that they also use English. Consider pairing students who share the same home language so that they may discuss ideas and concepts in their native language prior to reporting out in English. You may need to assist with prompts for the terms as they transition to English. This is an excellent opportunity to value a student's home language, while providing scaffolds as they build the academic language necessary to fully participate in school in English.
Vocabulary Development	• Provide explicit vocabulary instruction • Provide visuals • Use the word in context • Provide native language support: bilingual dictionary, cognates, L1 partner • Consider multiple meaning words that may cause • confusion (i.e. table)	***Use words in context*** When pre-teaching vocabulary with the class, it is important to model and practice using the new terms in context with English learners. English learners need to learn not just the term but how it functions grammatically and syntactically in English in order to be able to use the term appropriately. Allow time for students to practice using the term before class discussions, readings or expecting them to use it in their writing.
Writing	• Graphic organizers • Reduce the writing load (sentence frames and sentence starters) • Reduced vocabulary load • Provide visuals • Provide audio support • Monitor responses • Clarify or provide directions in the native language • Modify classwork, assessments, homework (true/false, reduced responses) • Allow verbal and non-verbal responses (gestures) • Extended time • Bilingual dictionary	***Reduced Writing Load*** Consider English proficiency level in setting expectations for writing. Expect English learners with an English proficiency level 1 to produce single words or phrases. Provide these students with a framed paragraph and visual word bank to support them in completing the writing task. Expect English learners with an English proficiency level 2 to 3 to produce short and some expanded sentences. Provide these students with sentence frames and sentence starters to support them in completing the writing task. Expect English learners with an English proficiency level 4 to 5 to produce short, expanded and some complex sentences.
Assessments	• Reduce vocabulary load • Include visuals • Clarify or provide directions in the students' native language • Provide extended time • Read to (entire or selected sections) • Bilingual dictionary • Reduce the writing load (sentence frames and sentence starters) • Provide audio support	***Reduce vocabulary load Include visuals*** When assessing English learners with an English proficiency level 1 to 3 you will need to provide scaffolds and supports to reduce the linguistic load needed for them to access the content. It will be beneficial to provide students with a visual word bank of key vocabulary as a reference.

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Teaching Tips

These icons will appear throughout the unit to indicate different teacher tips and reminders during the lessons.

This icon indicates an important note for teachers to consider prior to teaching.

This icon indicates a reference to the DQB, anchor charts, and classroom models.

This icon indicates a wet-lab activity.

This icon indicates an opportunity to do outdoor activities.

This icon highlights a Green School activity that connects to our Environmental Literacy Standards.

This icon indicates an opportunity for student discourse.

This icon indicates a computer-based activity.

Lesson Sequence

Lesson 1: Unit Introduction

Duration: 45 Minutes

Lesson Overview

Students will explore the concept that there are mountains of varying heights and ages across the Earth's surface. They will investigate the relationship between mountain height and age using **data analysis and mathematical representations to determine patterns** and use this data as evidence to support a claim. Students will then consider the current characteristics of the mountains of Baltimore to determine the **conditions that affect stability and control the rates of change** and consider what these factors mean in terms of the origin of the hills within the Baltimore region.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Engaging in Argument from Evidence SEP 7 HS5 - Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence. **Analyzing and Interpreting Data** SEP 4 HS1 - 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.	**Plate Tectonics and Large-Scale System Interactions** ESS2.B HS3 - Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.	**Patterns** CCC 1 HS4 - Mathematical representations are needed to identify some patterns.

Instructional Delivery (Representation/Engagement)	Sample Assessments (Expression)

Essential Question: *Are there hills/mountains in Baltimore?*
• **Opening Activity:** Introduce the driving phenomenon for the unit.
  ○ Ask students access the website: Baltimore Marathon & Half Marathon, 5K, Team Relay, Baltimore, MD USA and read through the reviews of the Baltimore Marathon.
  ○ Distribute Sticky-notes and have students note the commonly mentioned items from the reviews.
  ○ Have students post organize their notes by categories on the board and discuss the key comments.
    ○ **Teacher Notes**: While there are a number of commonalities, a regular theme is that there are a lot of hills along the marathon's path. This is what you want to focus on in this lesson.
  ○ Introduce the **Design Challenge** at this time.
• **Mountain Comparison:** Extend the discussion by asking students, where are the hills located in Baltimore and where are mountains around the world. Then ask them to look up the mountains to share out with the class.
  ○ Ask students to list as many mountains as possible.
    ▪ Have students write them on sticky notes and post at the front of the room.
    ▪ Ask a student to read from the sticky notes.
  ○ Where is the highest mountain… [Use the coordinates to find them on Google Earth]
	These are opportunities or options to check students understanding.
	
	How does Mountain height vary with age?
	A. Taller Mountains tend to be older than shorter mountains.
	B. Taller Mountains tend to be younger than shorter mountains.
	C. Taller Mountains tend to be the same age as shorter mountains.
	D. There is no relationship between mountain height and age.
	Answer: B

    - in the world? (Everest, Nepal: 27.9881° N, 86.9250° E)
    - in North America? (Denali, Alaska: 63.0692° N, 151.0070° W)
    - in the contiguous 48? (Mount Whitney, California: 36.5785° N, 118.2923° W)
    - in Maryland? (Hoye-Crest Backbone Mountain, Maryland: 39.2373° N, 79.4853° W)
      - **Teacher Note:** Links will only work if the default browser on your computer is set to Chrome**.**
  - Are there (still) mountains in Baltimore?
    - What mountains or hills are in Baltimore (Federal Hill, Mt. Vernon, Mt. Washington, etc.)?
    - What is the highest point in Baltimore? (Northwest corner along Reisterstown Rd. near Fallstaff Rd. - 39° 21' 39" N, 76° 42' 30" W) (> 480 ft)
    - The Mountain Infographic includes the mountains listed in this activity along with the Appalachian Mountains, Smokey Mountains, and the Alleghanian Orogeny.
      - Alleganian Orogeny shows the original height of the mountains of Baltimore.
- **Mountain height and age investigation:** Students will investigate the relationship between the age of mountains and their heights to introduce the idea that there are natural forces that change the surface of the Earth.
  - Use the PowerPoint, Mountain Height Mystery, for the following activities.
    - Show the list of mountains around the world and their heights.
    - Ask students to discuss "What could cause the height differences?" with their shoulder partner and then share their ideas with the class.
      - List student responses on the board. (hold for end of lesson)
    - Students continue working with their shoulder partner to investigate the relationship between height, age, and location by graphically analyzing the age and height data of mountains worldwide. Hand out the Mountain Mystery Student Sheet and the Mountain Mystery Data Set. Students should use the data to develop a scientific argument about any patterns observed.
      - The data can be found in an excel file (Mountain Mystery Data Set) if you have computers available for data analysis. The data is provided in two forms.
        - All mountains present-tab
        - Separated by region-tab
      - Give students graph paper (only one of the two listed below).
        - Mountain Mystery Traditional graph paper with Hawaii expansion
        - Mountain Mystery Logarithmic graph paper
    - After analysis and questions have been completed, have each group present their conclusions to the class.
- **Discussion prompt:** To conclude the activity, students will discuss their observations of the data and develop their thoughts about how and why the data looks as it does.
  - Using a fishbowl discussion, ask students "What do you think caused the pattern you observed in the data?".
    - **Teacher Note**: Students should get into two circles (interior and exterior). Students seated inside the "fishbowl" actively participate in the discussion by asking questions and sharing their opinions,

Journal Write: Defend the statement: Baltimore's Hills are much older than the Rocky Mountains.

Which of the following factors may have contributed to the mountains' rocks breaking and wearing away, making them shorter? Choose all that apply

A. Flowing water
B. Freezing water
C. Plants
D. Wind
E. Gravity
F. Rain

Answer: All of the above

while students standing outside listen carefully to the ideas presented. Students take turns in these roles, so that they practice being both contributors and listeners in a group discussion.

- **Mountain Mystery Anchor Chart Creation:** Students, with the assistance of the instructor, will work together to create an anchor chart of processes that change the surface of the Earth. This chart will be used to record student ideas and understandings as they develop throughout the unit.
    - To wrap up the topic, return to the list of causes of height differences, add any new ideas that developed from the fishbowl discussion.
        - Typical entries on this list will include processes that touch on both "building up" and "tearing down".
        - Create an anchor chart that illustrates the two processes around a mountain. This chart should be kept in the classroom and added to as students are introduced to the concepts of this unit.
            - Mountain Mystery Anchor Chart Student Form: for students to keep their own copy of the chart.
                - **Teacher Note:** This chart will be used in an ongoing basis throughout the unit for students to record, revisit, edit and modify their ideas on the processes that effect the height of mountains in Baltimore and beyond. At the end of the unit, the chart will be a resource for students as they complete the cumulating activity.
            - Sample charts: Mountain Mystery Anchor Chart, Mountain Mystery Process List
    - Let students know that they will be mapping these processes in a project at the end of the unit. See the Mountain Mystery Overview Document and Mountain Mystery Cumulating Activity Student Sheet.
        - **Teacher Note:** In the Resources folder you will find all of the project resources, including the Student Sheet, Comic Strip Template, and Rubric.
            - Refer to the project regularly throughout the unit.
- **Cumulating Discussion Question:** Students will apply the information addressed in the lesson to come to a data supported conclusion about their current environment.
    - Given the current height of the "mountains" of Baltimore, what can we conclude about them?
- **Homework:** Students will use the internet to find an article on the basics of Plate Tectonics and write a one paragraph synopsis of the process.

EL Support:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Provide written notes
- Provide visuals
- Sentence frames and sentence starters

Differentiated Instruction:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- To assist students with developing their initial model for the anchor chart employ the Think-Pair-Share strategy before adding ideal to the classroom chart.

Lesson Summary:

Students should have an idea of the following: The height of the mountain is inversely proportional to its age, older mountains are shorter, in relationship to the younger mountains. Students should begin their anchor chart of mountain growth and destruction that include initial factors that affect the changes in the mountains. Questions that students should be asking at this point include What created the mountains? and Where did they go?

Lesson 2: Exploring Landform Patterns – Global Scale

Duration: 45 Minutes

Lesson Overview

Students investigate how mountains are built by studying the eight boundary types by examining sets of GeoBlox, interactive simulations, and videos to create a summary chart. Students will focus on **cause and effect** in tectonic interactions while using **models** to **study systems that are too large and slow to observe directly** and use their collected data to **make and defend a claim based on evidence**.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Developing and Using Models SEP 2 HS3 - Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. **Engaging in Argument from Evidence** SEP 7 HS5 - Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.	**Plate Tectonics and Large-Scale System Interactions** ESS2.B HS2 - 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.	**Scale, Proportion, and Quantity** CCC3 HS2 - Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. **Cause and Effect** CCC2 HS2 - Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

Instructional Delivery (Representation/Engagement)	Sample Assessments (Expression)

Essential Question: *What processes build hills and mountains?*
• **Opening Activity:** Students will begin class by revisiting their mountain anchor chart. They will have the opportunity to add to/revise based on the previous day's work.
  ○ Post the : Mountain Mystery Anchor Chart, from lesson one and ask the students "Where did the mountains come from?".
    ▪ Give student groups sticky notes to record their ideas and have them post their best idea on the anchor chart.
    ▪ Have one student read off the statements to the class and discuss.
      • Classify/categorize the ideas into relevant groups.
    ▪ Introduce the plate tectonic motion and mountain building investigation.
	These are opportunities or options to check students understanding.
	
	Which types of boundaries build mountains by two plates colliding?
	A. Divergent
	B. Convergent
	C. Transform
	D. Hot Spots
	Answer: B

- **Investigation:** Students will investigate the different types of boundaries by rotating through stations that have GeoBlox models and online simulations available for examination. Through the stations, they develop understandings of what each type of boundary does and its impact on the surface of the Earth.
  - Students will work in groups for the station activity, Tectonic Boundaries Investigation GeoBlox, where they will utilize computer and physical models to examine the global processes that take place at tectonic boundaries.
    - **Teacher Notes**: Resources:
      - Teacher setup guide: Tectonic Boundaries Investigation Teacher Setup Guide
      - Station instructions: Tectonic Boundaries Investigation Station Guide Sheets
      - GeoBlox Links:
        - Divergent Ocean-Ocean Boundary
        - Divergent Continent-Continent Boundary
        - Convergent Continent-Ocean Boundary
        - Convergent Continent-Continent Boundary
        - Convergent Ocean-Ocean Boundary
        - Oceanic Hot Spot
        - Continental Hot Spot
        - Transform Boundary
  - **Discussion prompt:** Ask students to sketch a diagram that shows how changes to the subducting plate, in a convergent boundary, produces volcanoes on a different plate.
  - **Discussion prompt:** Ask students "How could we test if the San Andreas fault is moving even though it looks like it is not?"
- **Mountain Mystery Anchor Chart:** Return to the anchor chart and have students revise/add to it based on the concepts that they explored during the lesson.
  - Have students discuss, in groups, what should be added to the chart based on today's activity. Then have them add to/edit their personal charts and add vocabulary and concepts to the classroom Mountain Mystery Anchor Chart
- **GeoBlox Summative Activity:** In this summative activity, students will answer the question, "Which boundary do you think causes the greatest change to the Earth's surface?" in CER format referencing the information they collected in today's activity as a part of their evidence.
  - Students will complete the GeoBlox: What Do You Think? activity. (CER Rubric provided)
- **Homework:** Students may complete the GeoBlox: What Do You Think? worksheet if extra time is needed.

EL Support:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Graphic organizers
- Provide written notes
- Provide visuals
- Model appropriate responses

Journaling Activity: Use images/sketches to show the similarities and differences between Convergent Continent-Continent Boundaries and Convergent Continent-Ocean Boundaries.

What would you be most likely to find at a divergent boundary between two pieces of continental crust?

A. Mountains
B. Island Arc
C. Rift Valley
D. Mid-Ocean Ridge

Answer: D

CER:

Examine the photograph of the damage done to a sidewalk curb by a fault. The dashed lines show the location of the fault. In Claim, Evidence Reasoning format, identify the fault type and defend your choice.

Answer: Transform Fault

CER Rubric

Image Source: http://thescienceexplorer.com/nature/america-s-most-dangerous-fault-likely-rupture-next-30-years

• Monitor responses • Pair students that share a home language **Differentiated Instruction:** *Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.* • To support students in the Investigation, group students who have common learning styles. This activity could also be adapted to work with task cards. • For students who need support with writing their CER, provide a more detailed CER Graphic Organizer. Students can also color code their writing, having a different color for each component in the Claim Evidence Reasoning format.	**What would you be most likely to find at a convergent boundary between two pieces of continental crust?** A. Volcano B. Mountain C. Rift D. Island Arc Answer: B

Lesson Summary:

Students should have an idea of the following: There are eight boundary types between tectonic plates: Divergent Ocean-Ocean Boundary, Divergent Continent-Continent Boundary, Convergent Continent-Ocean Boundary, Convergent Continent-Continent Boundary, Convergent Ocean-Ocean Boundary, Oceanic Hot Spot, Continental Hot Spot, Transform Boundary. Each boundary has a different impact on the surface of the planet, many of which are "mountain building." Questions that students should be asking include those regarding deeper understanding of the boundaries and ones asking for proof that the tectonic processes are happening.

Lesson 3: Evidence of Plate Boundaries

Duration: 45 Minutes

Lesson Overview

Students will explore **empirical evidence to identify the pattern** of tectonic plates on the Earth **indirectly** by investigating the locations of earthquakes and volcanoes found on Earth. They will then take a stance and defend their claim, **regarding the process of volcanic eruptions, orally.** The class concludes with putting together an overall picture of the connection between plate tectonics, land and ocean floor formations and the chemistry of Earth's crust.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Obtaining, Evaluating, and Communicating Information SEP 8 HS5 - Communicate scientific and/or technical information or 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).	**Plate Tectonics and Large-Scale System Interactions** ESS2.B HS2 - 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. **The History of Planet Earth** ESS1.C HS1 - 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.	**Scale, Proportion, and Quantity** CCC 3 HS2 - Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. **Patterns** CCC 1 HS5 - Empirical evidence is needed to identify patterns.

Instructional Delivery (Representation/Engagement)	Sample Assessments (Expression)
Essential Question: *What evidence do we have?*	*These are opportunities or options to check students understanding.*

- **Opening Activity:** Engage the students by getting them out of their seats to vote on the question in this activity and defend their choice, as a group, in CER format. The key here is not a "right" answer, as both could rightfully be argued, but that they understand that change is taking place.
  - Show students any video of an erupting volcano.
  - Have them make observations of the eruption.
  - Pose the question: "Are we seeing land being created or destroyed?"
  - Have the class from groups for "created" and "destroyed" based on their answers.
  - Allow groups to discuss their choice and elect a spokesperson to state their evidence and reasoning.
  - Ask if anyone wants to change sides.
- **Where are the Plates? (Internet Activity):** With the idea that change takes place at plate boundaries, students will map the global boundaries based on activities such as volcanoes and earthquakes. To connect this activity to prior lessons, have students begin by identifying the locations of the mountains studied in lesson one.
  - Distribute the worksheet Mapping the Plates.
  - Refer back to Lesson three's boundaries and the Mountain Height Mystery PowerPoint (used in lesson 1) to engage prior knowledge.
  - Display the initial list of mountains and have students plot them on the map.
    - Ask students to volunteer to look up one mountain/mountain range each and identify its location for the class.
    - Project the worksheet map and have the students come up to mark each location on the map.
    - Class should record on their individual maps.
      - **Teacher Note:** Internet access is needed to complete this activity. Computers work better than phones.
    - **Discussion prompt:** What patterns do you observe in the location of the mountains? What other data would we need to expand the pattern/draw a conclusion?
  - Students will use the provided links to:
    - Find and map the locations of earthquakes and volcanoes to outline the tectonic plates
    - Show the motion directions of each plate
  - Students will use the collected data to identify the location of convergent, divergent, and transform boundaries.
  - Fishbowl Discussion
    - Divide students into two groups to make circles. The inside circle students will be divided into two teams with one prompt each for discussion. Have outside students take notes as they listen but allow those who wish to add comments to join in the discussion.
      - **Discussion prompt:** What patterns do you observe in the added data? What does the pattern of data allow you to conclude about the surface of the planet?
      - **Discussion prompt:** Why could we see the tectonic plate patterns by plotting them on a map but not with just our eyes if we were standing near one of the boundaries?
- **Rocks are Chemicals! Mini Lesson- Part 2:** In this mini lesson students will expand their understanding about the composition of the crust and what is different between the continental and oceanic crusts.

Based on our lesson, which of the following are commonly used to identify the edges of plate boundaries? Mark all that apply

A. Rivers
B. Volcanoes
C. Mountains
D. Lakes
E. Glaciers
F. Earthquakes

Answer: B, F

Journal Writing Prompt:
Describe or sketch the tectonic plates and indicate where locations of active earth quakes and volcanic activity near North America. What does this mean in terms of tectonic plate boundaries near the United States?

- Teacher and students review Earth Chem 2 PowerPoint – "Why are continents lighter rock than ocean floors?"
  - **Teacher Note:** Notes on key content are in the notes section of the slides.
- **Summary Activity:** To show what they have learned over the last two lessons, students will complete a graphic summarizing activity that will illustrate the processes they have learned about plate motion.
  - Students will summarize their findings from lessons three and four on the Plate Tectonic Summary worksheet.

Homework: 1.7- Billion- Year- Old Chunk of North America Found Sticking to Australia Close Reading Activity

EL Support:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Link concepts to students' background experiences
- Make explicit links between past learning and new concepts
- Graphic organizers
- Reduced vocabulary load
- Provide written notes

Differentiated Instruction:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- For students who need more time to process presented materials, a Flipped classroom model could be useful. Use Google Meets or another software to screencast the Mini lesson and post on Google Classroom for students to watch the night before to allow for processing time on the concept.
- For students who need support with writing their CER, provide CER Graphic Organizer. Students can also color code their writing, having a different color for each component in the Claim Evidence Reasoning format.

Lesson Summary:

Students should have an idea of the following: Tectonic plates are typically identified by the occurrence of earthquakes, the formation of volcanoes, and rift valleys. Motion of the plates can be tracked by the change in features on the surface, such as volcanic island chains, and shifted river beds. Questions students should be asking include "How do these processes effect Maryland/Baltimore/me?" and "How much have we moved over time?"

Lesson 4: The History of North America, Maryland, Baltimore

Duration: 45 Minutes

Lesson Overview

Students will use an online simulation of the Earth to **examine the modeled motion of the continents over eons,** record the change in conditions, and track the location of the land that is now Maryland to understand the current composition of the crust under Maryland and **predict its future motion and location.**

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Developing and Using Models SEP 2 HS3 - Develop, revise, and/or use a model based on evidence to illustrate and/or predict the	**Plate Tectonics and Large-Scale System Interactions**	**Scale, Proportion, and Quantity** CCC 3 HS2 - Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.

relationships between systems or between components of a system.	ESS2.B HS2 - 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.	

Instructional Delivery (Representation/Engagement)

Essential Question: *What is Maryland's tectonic history/How did we end up here?*

- **Opening Activity**: Use the information from the homework from Lesson Four to introduce the idea of continental drift.
    - Pose the question, "Who used to be our neighbor?", to the students. Allow students to answer with their reasoning.
    - Discuss the questions from the homework 1.7- Billion- Year- Old Chunk of North America Found Sticking to Australia Close Reading Activity.
- **Travel Through Time with North America-Internet Activity Time Scale Model:** Students will explore the effects of continental drift on the globe and on the land that is now Maryland by using an online simulation.
    - Students will use Earth Viewer to model the motion of tectonic plates over eons and track the location and conditions of the land that will become Maryland.
        - Have students use the Evolution of Continents v02 activity.
    - **Check for understanding:** Does the simulation (model) describe processes that are [faster/slower/the same speed] than the phenomenon as you might observe it in nature?
    - Using their collected information, students will write a CER to predict the future motion and location of Maryland.
- **Mini Lesson:** Using direct instruction, the teacher will help students solidify concepts about plate tectonics, continental drift, and their effects on the surface of Earth.
    - Geologic Evolution of Eastern North America Update PowerPoint
- **Homework:** Students complete any unfinished work from the lesson.

EL Support:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Link concepts to students' background experiences
- Make explicit links between past learning and new concepts
- Graphic organizers
- Reduce the writing load (sentence frames and sentence starters)
- Monitor responses
- Clarify or provide directions in the native language

Differentiated Instruction:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- For students who need support with writing their CER, provide CER Graphic Organizer. Students can also color code their writing, having a different color for each component in the Claim Evidence Reasoning format.

Sample Assessments (Expression)

These are opportunities or options to check students understanding.

Which of the following terms correctly identifies the modern understanding of how the continental and oceanic plates move around on the Earth?

A. Continental Drift
B. Convergent Boundaries
C. Plate Tectonics
D. Oceanic Hot Spots

Answer: C

What internal process is the driving force for the movement of the tectonic plates?

A. Conduction
B. Radiation
C. Nuclear Fusion
D. Convection

Answer: D

Journal Writing Prompt:

Write one paragraph that will explain, to a younger sibling, how Maryland used to be a part of the South Pole.

Lesson Summary:
Students should have an idea of the following: Over long periods of time the continents have moved large distances. Maryland, at one time was as far south as the south pole. For very slow processes, it is often helpful to use a model to watch the process in an observable time frame. Questions that students should be considering next include How does the plate motion impact the surface features? and Why are some areas higher than others?

Lesson 5: Global composition

Duration: 45 Minutes

Lesson Overview

Students will explore the difference between oceanic and continental plates and apply this information to explain the global-scale phenomenon noted in lesson 1 – that continents are high and ocean floors low. Students will begin to learn about the chemistry of the matter that makes up the Earth – the most abundant elements and molecules of the Earth and its layers using **models** that **scale down** the Earth processes to a **manageable scale**. **Teacher Resources:** Introduction to Chemistry of the Earth docx and Earth-Chemistry Connection pptx

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Developing and Using Models SEP 2 HS3 - Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Plate Tectonics and large-Scale System Interactions** ESS2.B HS2 - 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.	**Scale, Proportion, and Quantity** CCC 3 HS2 - Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.

Instructional Delivery (Representation/Engagement)

Essential Question: *How can the highest point in Maryland be both taller and shorter than Nihoa Volcano in Hawaii?*

- **Opening Activity:** Students will compare the altitude and measured height, from base to peak, of two mountains and discuss the differences in the data.
  - Have students look up the altitude of the Nioha Volcano in the Hawaiian island chain and the Hoye-Crest Backbone Mountain, Maryland which is the highest point in Maryland and record them on the board.
  - Project the height of each peak, as measured from the base to peak.
  - Have students discuss with their shoulder partner the discrepancy between the two sets of numbers and how they would explain them. Then share out to class.
    - **Teacher Notes: Mountain Data**

	Nihoa Volcano	Hoye-Crest in the Backbone Mountains, MD
Altitude-from Sea Level	892 ft	3,360 ft
Height- from base to summit	14,623 ft	3,360 ft

- **Rocks are Chemicals!:** Introduce the ideas of composition of the Earth with the hands-on simulation investigation.
  - Have students discuss and predict, with their seat partner, what element makes up most of the crust of the Earth. Record predictions on the board and hold for the end of class.

Sample Assessments (Expression)

These are opportunities or options to check students understanding.

Which type of crust is denser?
A. Continental
B. Oceanic

Journal Writing Prompt:
Sketch a diagram that depicts how the Nioha Volcano in Hawaii can be both "Taller" and "Shorter" than the Hoye-Crest of the Backbone Mountains in Maryland.

Which type of rock is more prevalent in the crust of the Earth?
A. Silicate
B. Non-Silicate

- Students will investigate with their seat partner the mineral composition of the Earth using the modeling Bead Activity *"What in the World?"*
  - **Teacher Note:** Be sure to review the teacher notes on the second page of the Bead Activity document prior to the class. You will need beads and bags.
- **Check for understanding prompt:** What is the ratio of silicates and non-silicates in the data you collected?

- **Rocks are Chemicals! Mini Lesson:** In this mini lesson students will learn about the composition of the crust and the differences between the continental and oceanic crusts.
  - Lead a review using the Earth Chem 1 PowerPoint – Why are continents high and ocean floors low?
    - **Teacher Note**: Please refer to the notes section of each slide that has the key points that students will need to emphasize in their notes.
- **Process and Mechanism Introduction:** Throughout the unit students will be asked to identify and explain the process and mechanisms of many phenomena. This portion of the lessons introduces them to these two interconnected concepts and begins the development of an anchor chart for the classroom as a permanent reference.
  - Introduce the concepts of process and mechanism to your students using the PowerPoint, Process and Mechanism.
    - **Teacher Note:** Historically, students have been able to identify the most basic process but are not able to describe how that process happened. This PowerPoint will help students to realize that each process has a mechanism and will describe in detail how the process happened. The sequence of examples become progressively more complex.
  - Post a Process and Mechanism Anchor Chart in the room and continually update throughout the unit.
    - **Teacher Note**: Begin with one or two examples – there are samples on the second page of the document. See the Mechanism & Process Resource PowerPoint for further examples.
- **Data Activity:** In this activity, students will expand on the ideas from their initial investigation to look at specific elements and their place in the composition of the Earth.
  - Students will examine and analyze data on the chemical composition of the crust of the Earth by completing Composition the Earth's Crust.
    - Students should be able to complete the first portion of the worksheet in class and complete the second part as homework.
  - **Discussion prompt:** "What does the pattern of data in this activity allow you to conclude about the composition of the Earth? What data from our earlier investigation supports your conclusion?"
- **Essential Question Reflection:** Students return to the question by discussing with their shoulder partner and revise their responses from the beginning of class and share out.
- **Homework:** Complete the Composition of the Earth's Crust activity.

EL Support:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Encourage students to discuss ideas and concepts in their native language prior to reporting out or writing in English

What two elements are the most prevalent in the Earth's crust. (mark both for the correct answer.)

A. Aluminum
B. Carbon
C. Gold
D. Iron
E. Oxygen
F. Potassium
G. Silicon
H. Sodium

Answer: E and G

• Bilingual dictionary • Provide visuals • Provide audio support • Monitor responses **Differentiated Instruction:** Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content. • Employ the Think-Pair-Share process with shoulder partners to encourage greater depth of discussion between students. Possibly have students do a quick jot of their "Think" ideas before moving on to the "Pair-Share" portion.	

Lesson Summary:

Students should have an idea of the following: Oceanic Crust sits lower than Continental crust due to the differing composition and density. The majority of the crust is composed of Oxygen and Silicon in the form of Silicate minerals. The two types of silicates are Mafic and Felsic. The Oceanic crust is mostly composed of Mafic minerals and the Continental Crust is mostly composed of Felsic minerals. Questions that students should be asking/considering at the end of the lesion include Are there more types of rocks? and What makes them different from each other?

Lesson 6: Chemistry of Rock Types

Duration: 45 Minutes

Lesson Overview

Students learn about the specific rocks beneath Baltimore **using an online interactive map.** They will be investigating both the chemical composition and uses, as well as times of formation. Using the fabric map and the internet, **students will create a display** to show **how the chemistry of rocks can show the history of the land** we now called Baltimore.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Developing and Using Models SEP 2 HS3 - Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. **Obtaining, Evaluating , and Communicating Information** SEP 8 HS5 - Communicate scientific and/or technical information or 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).	**Plate Tectonics and Large-Scale System Interactions** ESS2.B HS2 - 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 Tectonics and Large-Scale System Interactions** ESS2.B HS3 - Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. **The History of Planet Earth** ESS1.C HS1 - Continental rocks, which can be older than 4 billion years, are generally much	**Structure and Function** CCC 6 HS2 - 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.

older than the rocks of the ocean floor, which are less than 200 million years old.

Instructional Delivery (Representation/Engagement)

Essential Question: *What types of rock have formed under our feet?*

- **Opening Activity - Sort the rock samples (photos):** The opening activity introduces the idea that there are many different types of rocks and that they are classified by their properties. Students will be asked to create groups from rock samples (pictures of Maryland rocks) and explain their grouping/classification process.
  - Place students in groups of three or four.
  - The student groups will be given a set of pictures of rocks that are in the Baltimore region.
  - Students are to sort rock into "like" grouping and then organize the rock in an order that they develop themselves (ex: Lightest to darkest, crystal size, etc.).
  - Have the students do a class gallery walk with one spokesperson remaining at each station to explain their organizational process.
    - Materials:
      - Rock sample photos with an id number: Rock Sort Pics and Key PowerPoint
      - You will need to make enough of the pictures for one set per group. These will work best if they are in color.
- **Creating a Timeline:** Students, individually or in pairs, will use ArcGIS interactive map to research one of the rock types found in the greater Baltimore area. They should determine the chemical composition, rock type classification (igneous, metamorphic, sedimentary, etc.) and age of the rocks. As a class, students will create and display a timeline of the rock types (sequential or scaled—to be determined by the teacher based on skill level and time constraints of the class) and use the string to mark the location of each rock type on the map.
  - Geologic Timeline and Rock Type Map Activity
    - **Teacher Note:** Do not hand out the cards at the beginning of their research process. Only give cards to students after they show you that they have completed their research.
  - Materials needed:
    - Computers with internet access (or cell phones)
    - String
    - Baltimore rock fabric map
    - Tape
    - Map activity instruction sheets for students
    - Map activity rock cards for students
    - Mineral composition reference sheet (found at the end of Geologic Timeline and Rock Type Map Activity document)
    - Rock timeline reference sheet (for teacher) (found at the end of Geologic Timeline and Rock Type Map Activity document)
  - Student teams should present their information to the class as they place their card in the display. The students should have time to examine the completed display before moving on in the lesson.
  - Timeline/map sample image: Image 1, Image 2

Sample Assessments (Expression)

These are opportunities or options to check students understanding.

Journal Writing Prompt:
There is Volcanic rock within the boundaries of Baltimore city but there are no volcanoes here. What does the presence of this type of rock tell you about the history of the land on which our city is built?

Journal Writing Prompt:
List four features the geologists use to classify rocks into categories**.**
Answer: There are many that they could list. Some common ones include color, texture, and crystal size.

What type of rock is produced from an active volcano?

A. Metamorphic
B. Igneous
C. Sedimentary

Answer: B

- **Think Pair Share Discussion:** Using rocks that are native to the region, students will work collaboratively to develop an overview of the history of Baltimore.
  - Have students group up with one or two students from other rock groups to discuss and come up with a response for the following prompt. They may report out verbally or in written format.
  - **Discussion prompt:** Identify the different rock types found in Baltimore. What about each of these rock types tells a story about the history of the earth beneath our feet? What can we conclude about the mountains that were once here?
- **Connecting Plate Tectonics with Maryland's Rocks Mini Lesson:** Using direct instruction, the teacher will help students solidify concepts about rock types, their history and their chemical make-up.
  - Teacher and students review the PowerPoint Plate Tectonic Processes for Maryland.
- **Mountain Mystery Anchor Chart:** Students will have the opportunity to edit and up-date their Anchor Charts and adjust the class chart to match their improved understanding of the processes studied.
  - Have students revise their Mountain Mystery Anchor Chart based upon lessons five and six.
    - Add vocabulary and concepts.
    - Include descriptive mechanisms as well as processes.
  - Students revise the class anchor chart based on student input.

Homework: Foldable Rock Types activity

EL Support:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Graphic organizers
- Sentence frames and sentence starters
- Model appropriate responses
- Monitor responses
- Modify classwork, assessments, homework (true/false, reduced responses)

Differentiated Instruction:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Group students based on ability level or learning style.
- Timeline activity could be modified into a Task Card activity.

Lesson Summary:

Students should have an idea of the following: There are three major categories of rock: Igneous, Metamorphic, and Sedimentary. The land beneath Baltimore contains all three as well as areas of pure sediment. The Fall Line divides the city from the north-east corner to the south-west, with the north west section being composed primarily of Igneous and Metamorphic rock while the south-east portion is sediment and sedimentary rock. Evidence of the history of the land is in the rock. Questions to consider, how do rocks break down and change location to become sediment and sedimentary rocks?

Lesson 7: Agents of Change

Duration: 45 Minutes

Lesson Overview

In response to the question how do rocks break? down from Lesson 6, the focus of the lesson sequence shifts from building continents and mountains to wearing them away. Students will learn about the basics of weathering, erosion and deposition. They will have the opportunity to debate and defend claims as teams, describe **cause and effect relationships**, and **examine models** while classifying phenomena.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Developing and Using Models SEP 6 HS4 - Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.	**Plate Tectonics and Large-Scale System Interactions** ESS2.B HS2 - 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. **The History of Planet Earth** ESS1.C HS1 - 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.	**Cause and Effect** CCC 2 HS2 - Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

Instructional Delivery (Representation/Engagement)

Essential Question: *What can move/change mountains?*

- **Opening Activity:** Engage students' prior knowledge and interest by getting them out of their seats to playing 4 Corners. Have them vote with their feet on what agent they think caused the land feature shown on the PowerPoint slides.
  - Play Agents of Change 4 Corners with your students to see if they can identify what agents cause different land features.
    - Post the Agents of Change 4 Corners Signs Form C: "Friction", "Heating/Cooling" "Chemical Reactions", and "Gravity".
      - Alternative signs – simplified concepts Agents of Change 4 corners signs Form B "Gravity," "Water," "Wind," "Ice".
    - Show the slides in the Agents of Change PowerPoint.
      - The notes section of each slide has the agents most impacting the landscape.
    - Students move to the sign that they think is the most likely agent of change in the picture.
    - Have each group discuss their reasoning and have a spokesperson explain their evidence and reasoning to the rest of the class.
      Questioning prompt: How does [friction/heating-cooling/chemical reaction/gravity/water/wind/ice/etc.] affect the Earth's surface (such as a cliff or large rock)?
- **Weathering, Erosion and Deposition Mini-lesson:** Challenge student ideas about weathering erosion and deposition processes.
  - Weathering Erosion and Deposition PowerPoint

Sample Assessments (Expression)

These are opportunities or options to check students understanding.

Examine the image below.

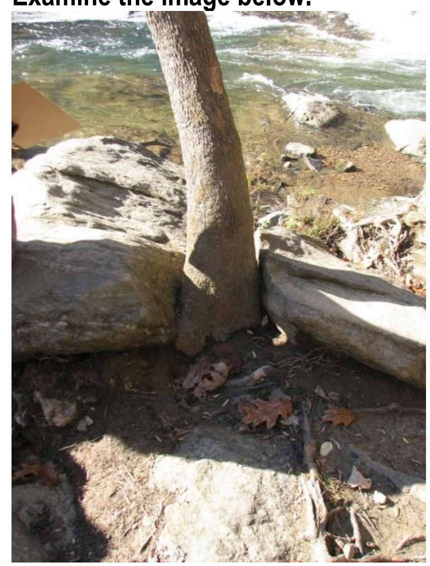

Image used by Permission of V.Anderson

- **Sorting Activity:** To solidify student understanding, students will work in groups to identify and sort examples of each process.
  - Complete the Weathering, Erosion, or Deposition Sort activity.
    - This is a group/partner activity.
    - Prior to class you may want to make reusable cards on cardstock.
    - Scaffolded Versions: Weathering, Erosion, or Deposition Sort V02
- **Expansion Activity:** Preparing for lesson eight, students will set up the Expansion Activity so that it can be frozen overnight.
  - Have students read and set up the expansion activity Brr…It's Cold in Here in preparation for lesson eight.
    - **Teacher Notes:** The water in the syringes needs to freeze overnight to measure expansion. You may want to add food coloring to the water to make it easier to see.
  - Students record the initial volume in the syringe and save the data for tomorrow.

Homework: Doing a photo treasure hunt, have students find evidence of "Agents of Change" in the area between school and home. Have them look for evidence of the most dramatic or powerful agent they can find. The weathering can be of human-made or natural materials**.** Have them take a picture and either send it to the teacher or bring it into class.

EL Support:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Pair students that share a home language
- Provide native language support: bilingual dictionary, cognates, L1 partner
- Modify classwork, assessments, homework (true/false, reduced responses)

Differentiated Instruction:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- For the Four-Corners activity: a possible "in seat" protocol would be to have students sit in groups and give them the 4 signs. Have each group discuss the image, come to a consensus, then hold up the sign that they agree upon. Afterwards have each group share their reasoning as above.
- For the mini-lesson content, the teacher could prepare a Flipped Classroom format and record the content for the students to watch the night before, or as review after class.

The Tree grew into a crack of the rock and caused the split. What is this process called?

A. Weathering
B. Erosion
C. Deposition

Answer: A

The actions of animals most commonly can cause the type of weathering known as ______.

A. Mechanical weathering
B. Chemical weathering
C. General weathering
D. Biological weathering

Answer A

Which of the following would probably cause the most damage to an abandoned building found in a jungle?

A. Plant growth and flowing water
B. Solar heat and acid rain
C. Wind and gravity
D. Freezing water and Ice

Answer: A

.

Lesson Summary:

Students should have an idea of the following: Weathering is a process that breaks down rocks. Erosion is a process that moves broken material. Deposition is the process that drops moved material in other locations. Water, gravity, and chemical processes are among the factors which are responsible for the processes. Questions students should be asking include How can water break rocks? and How do chemicals change rocks?

Lesson 8: Physical Weathering (1)

Duration: 45 Minutes

Lesson Overview

Students will experiment with factors that lead to the weathering process ice-wedging and develop a **cause and effect** understanding of how it contributes to the formation of potholes in our streets. By the end of the lesson sequence students will **"storyboard" the process of pothole formation** which will demonstrate their understanding of the concept. They will also complete the rock tumbler activity that **models** weathering of natural and urban materials. **Teacher's Notes:** This is topic requires a three day lesson set.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Developing and Using Models SEP 2 HS3 - Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. **Obtaining, Evaluating, and Communicating Information** SEP 8 HS5 - Communicate scientific and/or technical information or 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).	**The Roles of Water in Earth's Surface Processes** ESS2.C HS1 - The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.	**Cause and Effect** CCC 2 HS2 - Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

Instructional Delivery (Representation/Engagement)

Essential Question: *How does freezing water break down mountains?*

- **Opening Activity**: Students will, once again, identify the agent of change in images. This time the images will be ones that they took of the areas that they live in and submitted to their teacher. This is to show that agents of weathering, erosion, and deposition also effect more urban environments.
  - Using a teacher-created PowerPoint of students' photos, have students identify the cause of change in each image.
    - **Teacher Note:** You may use the Weathering in Baltimore Sample Slide resource if students did not find useable images.
  - Have the class vote for the most powerful or influential "super-agent" of destruction or weathering.
- **Focus on the Cracks:** To begin their direct study of weathering, using ice-wedging, students will examine the power of freezing water and how much it increases in size as it freezes.
  - Students complete the expansion activity Brr…It's Cold in Here.
    - Students observe, record and analyze the change in volume of the frozen water.
    - Allow the ice to melt as students analyze their data.
    - Once it has melted, students will record one last set of observations on the volume.
      - **Teacher Notes:** Save the discussion questions/data for after the mini lesson.
- **Frost/Ice Wedging Mini Lesson:** The teacher will facilitate a discussion on the process and mechanism of ice wedging in conjunction with the development of potholes in roads.
  - Show students a picture of a street pothole as a specific example of urban weathering.
    - Have student share their experiences with potholes.
      - When do they form?
      - Where do they form?

Sample Assessments (Expression)

These are opportunities or options to check students understanding.

Mechanical weathering produces ___________.

A. new materials
B. quartz
C. smaller particles
D. calcium carbonate

Answer: C

When water freezes in a crack the process is known as

A. Mass movement
B. Erosion
C. Frost Wedging
D. Corrosion

Answer: C

Journal writing prompt:

        - What is the worst you have ever seen/experienced?
    - Have students explain what they think causes potholes.
  - Show video: [Weathering and Erosion - Freeze Thaw Weathering (Lammas Science 1:20)]
    - Please note that the speed of the process in the video is greatly exaggerated.
  - **Questioning prompts:**
    - What property of water causes the pattern we observed in the syringe?
    - How can a small change in the volume of water have a big effect on the condition of a street or sidewalk?
- **Set-up Rock Tumbler Model of Weathering of Urban Building Materials – Part 1:** Pause the lesson on Ice Wedging to set up the Rock Tumbler activity. The teacher, along with the students, will be setting up the rock tumbler modeling demonstration as students complete Part 1 of the activity.
  - The teacher will let the students know that we need to allow the ice to finish melting in the syringes, so we are using this time to set up the activity for tomorrow's lesson.
  - Students complete Part 1 of the [Physical Weathering of Urban Building Materials: River Rock Simulation].
    - **Teacher Note**:
      - Materials for student use:
        - Balances
        - Rocks (some of each rock types)
      - Materials for teacher use:
        - Rock tumbler
        - Water
        - Grit
      - In terms of materials and logistics, your rock tumbler is designed to support 2 tumbling barrels. Depending on your class load, you will need to use 1 barrel per 2-3 classes.
      - Example:
        - Use the first barrel for your first two periods. Demonstrate the setup for both periods and start it tumbling after the second period. Then use the second barrel for the rest of your classes, and start it tumbling at the end of your last class.
        - Next morning, open the first barrel for your first class and save liquid for your second class to see. Have both classes analyze rock data using balances, et cetera.
        - Repeat the process with the second barrel for the rest of your classes.
      - Consult video for tips on how to set up the Tumbler: [River Rock Simulation].
      - **Logistics suggestion**: As students will need to rotate through the different rock stations, it might be a good idea to have this set up parallel to the pothole storyboarding activity. As students are working on their storyboards, have small groups "step out" of the activity to complete their measurements and observations. Then at the end of the period(s) set up the tumbler and set it turning after the appropriate period(s).

Why are potholes more likely to form when temperature hover right around $0^{o}C$ ($32^{o}F$) instead of when temperatures are dangerously cold?

Homework: Students will complete Part 2 of the Physical Weathering of Urban Building Materials: River Rock Simulation activity.

EL Support:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Modify classwork, assessments, homework (true/false, reduced responses)
- Clarify or provide directions in the students' native language
- Pair students that share a home language
- Provide visuals
- Monitor responses
- Allow verbal and non-verbal responses (gestures)

Differentiated Instruction:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- As this is a three-day lesson set, post an agenda that covers the activities for the three days.
- This day's activities could easily be set up as learning stations.

Lesson Summary:

Students should have an idea of the following: Water expands when it freezes. When this expansion happens within the space of a crack in rock or pavement causes the crack to widen. When the water thaws it shrinks to its original volume. When more water fills the cracks and freezes once again the crack will widen further. This process is known as ice or frost wedging and is a component of the formation of potholes in our streets. Students should be asking about what other types of forces cause pot holes? Does water do anything else to the road?

Lesson 9: Physical Weathering (2)

Duration: 45 Minutes

Lesson Overview

Students will experiment with factors that lead to the weathering process ice-wedging and develop a **cause and effect** understanding of how it contributes to the formation of potholes in our streets. By the end of the lesson sequence students will **"storyboard" the process of pothole formation** which will demonstrate their understanding of the concept. They will also complete the rock tumbler activity that **models** weathering of natural and urban materials. **Teacher's Notes:** This is the second scheduled day to complete this topic

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Developing and Using Models SEP 2 HS3 - Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. **Obtaining, Evaluating, and Communicating Information** SEP 8 HS5 - Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development	**The Roles of Water in Earth's Surface Processes** ESS2.C HS1 - 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	**Cause and Effect** CCC 2 HS2 - Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. **Systems and System Models** CCC 4 HS1 - Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	transport materials, and lower the viscosities and melting points of rocks.	

Instructional Delivery (Representation/Engagement)

Essential Question: *How does moving water break down mountains?*

- **Opening Activity**: Engage students' prior knowledge and experience by viewing images of damage done by water weathering and erosion.
    - Review pictures of weathering caused by running water in Baltimore and dramatic ones around the world (potholes, canyons, etc.).
        - Water Weathering PowerPoint
- **Expansion Activity Discussion Questions:** Return to the Expansion activity from Lesson 8. Have the students check the volume of the melted syringes and record the data. Students will then use their observations, calculations and the information from the mini lesson to complete the discussion questions in the expansion activity to wrap up this portion of the lesson.
    - Have students complete the discussion questions at the end of Brr…It's Cold in Here.
    - **Discussion prompt:** Is the evidence presented today sufficient to conclude that water causes potholes? Why or why not?
- **Rock Tumbler Model of Weathering of Urban Building Materials – Part 2:** Today you will open the rock tumbler so that the students can see the effects of water weathering on rocks. As you do this, be sure to save your "discard water" for your other classes to see. A key point that you will want to emphasize is that this is not directly "dissolving". The weathering here is due to repeated impacts of the rocks chipping off small particles thus smoothing the rocks.
    - With your class:
        - Review hypotheses predictions
        - Remove rocks and collect data
            - Materials needed:
                - paper towels
                - balances
                - strainer
                - basin/beakers
                - rinse water
        - Analyze and interpret the results
    - Complete pre/post storyboard diagrams showing the changes that took place in the rock tumbler.
        - Physical Weathering of Urban Building Materials: River Rock Simulation
        - **Teacher Note**:
            - In terms of materials and logistics, your rock tumbler is designed to support 2 tumbling barrels. It is suggested that, depending on your class load, you use 1 barrel for 2-3 classes.
            - Example:

Sample Assessments (Expression)

These are opportunities or options to check students understanding.

What property of water is the basis of the frost wedging process?

A. Water's high specific heat
B. Water's ability to dissolve multiple substances
C. Water's pH
D. Waters tendency to expand when freezing.

Answer: D

Journal Writing Prompt:
Explain, through a combination of words and images, how the water in a river is able to break down land smooth the large rocks found within its borders.

Journal Writing prompt:
Water is not the only medium that carries abrasive components over rock surfaces. Examine the image of a feature found in Arches National Park.

- Refer to the example from the previous lesson.
- Consult the video for tips on how to set up the tumbler: River Rock Simulation.
- **Clean Up:** *Do not* pour the sediment-laden liquid down the drain. It will cause significant clogging. Ask the assistant principal in charge of science where to dump the barrel contents outside.

- **Mountain Mystery Anchor Chart:** Students will have the opportunity to edit and update their anchor charts and adjust the class chart to incorporate their improved understanding of the processes studied.
  - Have students revise their Mountain Mystery Anchor Chart
    - Add vocabulary and concepts.
    - Include descriptive mechanisms as well as processes.
  - Revise class anchor chart based on student input.

Homework: Students will complete the video worksheet Pothole Homework to prepare for tomorrow's activity.

EL Support:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Graphic organizers
- Reduce the writing load (sentence frames and sentence starters)
- Reduced vocabulary load

Differentiated Instruction:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- As this is a three-day lesson set, post an agenda that covers the activities for the three days.
- This day's activities could be set up as learning stations.

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Explain how you think this arch formed in this dessert environment. What were the abrasive components? How were they carried to the stone? What other forms of weathering may have aided in the formation of this feature?

Lesson Summary:

Students should have an idea of the following: River water facilitates wreathing of rocks by carrying abrasive particles and rolling stones against each other. When this happens, small pieces break off the larger stones shrinking, smoothing, and rounding them. The sediment is carried off by the flowing water. Different types of rock weather at different rates based on their composition and hardness. Students should be considering how these two processes work together to create potholes in the streets of Baltimore, and if other factors contribute to their formation.

Lesson 10: Physical Weathering (3)

Duration: 45 Minutes

Lesson Overview

Students will experiment with factors that lead to the weathering process of ice-wedging and develop a **cause and effect** understanding of how it contributes to the formation of potholes in our streets. By the end of the lesson sequence students will **"storyboard" the process of pothole formation** which will demonstrate their understanding of the concept. They will also complete the rock tumbler activity that **models** weathering of natural and urban materials. **Teacher's Notes. :** This is the third and final scheduled day for this concept.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)

Developing and Using Models SEP 2 HS3 - Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. **Obtaining, Evaluating, and Communicating Information** SEP 8 HS5 - Communicate scientific and/or technical information or 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).	**The Roles of Water in Earth's Surface Processes** ESS2.C HS1 - The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.	**Cause and Effect** CCC 2 HS2 - Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

Instructional Delivery (Representation/Engagement)	Sample Assessments (Expression)
Essential Question: *How does water break down other rock materials?* ● **Opening Activity**: Engage the students in a discussion on potholes in Baltimore by discussing the information from the videos that were assigned as homework. ○ Students will share their thoughts on the homework assignment. ● **Pothole Story Board:** Students are asked to summarize what they have learned about ice wedging and its effects on physical surfaces, such as roads, in the formation of potholes. They will storyboard the sequence of events, with full explanations of processes and mechanisms, in this activity. ○ Ask students to explain how ice-wedging and other physical weathering processes apply to pothole formation. ▪ Include effects of salt on road causing ice to melt. ○ After the discussion ask students to summarize what they learned about the formation of potholes by creating/drawing a storyboard/comic strip that illustrates and explains the steps of pothole formation using the Pothole Storyline. ▪ **Teacher Note:** Encourage students to put in as much detail as possible and include both processes and mechanisms for each step/action. ▪ **Scaffolded Versions of Activity Sheet:** Pothole Storyline with Mechanisms, Pothole storyline with mechanisms and word bank ○ Have students do a Gallery Walk using sticky notes to give feedback to their peers regarding their storyboards. Have students focus their feedback on the level of detail and the presence of identified and explained process and mechanisms. ○ Students return to their storyboard and edit/update their model based on the feedback they received from their peers. ● **Mountain Mystery Anchor Chart:** Students will have the opportunity to edit and update their anchor charts and adjust the class chart to incorporate their improved understanding of the processes studied. ○ Have students revise their Mountain Mystery Anchor Chart.	*These are opportunities or options to check students understanding.* **Journal Writing Prompt:** Explain how the forces that cause potholes to form in the streets of Baltimore impacted the ancient mountains that are now the hills of Baltimore. **Journal Writing Prompt:** Listed below are factors that can contribute to weathering. Select two from the following list and explain how each helps potholes to form. A. Freezing water B. Flowing water C. Roots under streets D. Salt on Roadways, E. Heavy trucks/traffic F. Water Main Breaks G. Snow Plows.

- Add vocabulary and concepts.
- Include descriptive mechanisms as well as processes.
- Revise class anchor chart based on student input.

EL Support:
Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Reduced vocabulary load
- Provide visuals
- Sentence frames and sentence starters
- Monitor responses

Differentiated Instruction:
Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- As this is a three-day lesson set, post an agenda that covers the activities for the three days.
- Utilize the scaffolded resources provided for the Pothole storyboard activity.

Lesson Summary:

Students should have an idea of the following: Physical weathering breaks objects into smaller pieces but does not change the identity of the object. Water is a major component of Physical weathering due to its ability to expand when it freezes and through flowing water aiding in abrasion. These two processes are a significant component in the formation of potholes in city streets as well as the natural landscape. Questions they should be considering, at this point, include how can weathering change the composition of the rocks?

Lesson 11: Chemical Weathering

Duration: 45 Minutes

Lesson Overview

Students develop an **explanation of how chemical weathering effects the natural environment** and complete a laboratory simulation of the effect of acid rain (simulated by vinegar) on sedimentary rock (simulated by chalk). Students will be asked to **design their investigation** and **analyze collected data** to deliver their results and conclusions afterward.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Planning and Carrying Out Investigations SEP 3 HS1 - Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible variables or effects and evaluate the confounding investigation's design to ensure variables are controlled. **Analyzing and Interpreting Data** SEP 4 HS1 - Analyze data using tools, technologies, and/or models (e.g., computational,	**Earth materials and Systems** ESS2.A HS1 - Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	**Stability and Change** CCC 7 HS1 - Much of science deals with constructing explanations of how things change and how they remain stable.

mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Instructional Delivery (Representation/Engagement)

Essential Question: *How do chemical processes break down mountains?*

- **Opening Activity:** Engage students' prior understandings of the idea of acid rain with this opening discussion/brainstorming session and its connections to weathering. Remember, chemical weathering involves chemical changes in physical materials (rocks, etc.) due to interactions with water and/or acids, or oxidation.
  - Ask students to recall what they know about acid rain.
    - How does it form?
    - Why are we concerned about acid rain?
    - What are the impacts of acid rain, particularly in urban areas?
  - Students share what/where they should look to determine how much acid rain is affecting Baltimore.
  - Pass out sticky-notes and have students write their estimate of the average pH of rain in Baltimore. Post to the board.
    - **Teacher Note:** Draw a pH scale on the board and have students put their sticky-notes on the scale where they think the pH of acid rain would be.
  - Share the highest and lowest estimates.
- **Analyzing Rain Data:** In this investigation students will analyze Maryland rain data to determine pH trends.
  - Students will determine both the average pH and the pH range of rain in our region.
    - **Teacher Note:** This activity uses excel data. It may be completed with students at individual computers, or as a guided activity from one screen, or offline with data printouts.
  - Students complete the exercises and answer questions in the Precipitation Chemistry Data Worksheet.
    - Provide students with rain data from the Precipitation chemistry NTN – Beltsville MD file (see the graph on the 3rd tab) from the National Acid Deposition Program (NADP) site in Beltsville, MD.
    - Students determine both the range and average pH of rain in our region.
    - Ask students to raise their hands if their estimates of the average rain pH were correct.
    - Ask students to raise their hands if their estimates fell within the range of typical acid rains.
    - Ask students to determine what reactions could occur if acidic rainwater falls on concrete in Baltimore.
      - How will that change the pH of the water running into our storm drains and streams?
      - Consider what you learned about local rain pH in designing and interpreting the study.
- **Chemical Weathering Lab** (teacher resources are in this link): Students will develop their own research protocols for this investigation on how acid rain (simulated by vinegar) effects local rocks (simulated by chalk). Students choose their own variables and data collection methods before beginning the activity.
    - **Teacher Note:** Video resource for set-up tips for the activity: Chemical Weathering Lab Activity.
  - Divide students up into groups of no more than three students.
  - Hand out the Lab investigation Proposal A Worksheet to each group.

Sample Assessments (Expression)

These are opportunities or options to check students understanding.

All of the following are causes of physical weathering except:

A. Plant Growth
B. Running Water
C. Wind
D. Acid Rain

Answer: D

Journal writing prompt:
Biological weathering occurs when Plants and animals are responsible for the breakdown of rocks and other materials. This can be caused when plants and animals secrete acids that eat away at rocks, such as lichens and Piddock Shells, the rock surfaces are broken down. At other times plants can break apart the rocks simply by growing larger within a small space and causing a larger crack to form. Other organisms burrow into surfaces opening up holes which allow for the weather to affect the interior of the object.

Explain how Biological weathering could be classified as both chemical and physical weathering.

Rusting is a form of chemical weathering. Rust is formed when oxygen in the air reacts with which of the following?

A. Iron
B. Salt
C. Copper
D. Marble

- Students use the Lab Investigation Proposal A to design an investigation based on the guiding question, "What determines how much rocks are affected by acid rain?" Be sure to sign off on their protocol before allowing each group to begin their investigation.
    - Available materials include:
        - balances
        - LabQuests
        - pH sensors
        - vinegar (acetic acid)
        - water
        - chalk (a soft sedimentary rock)
        - granite rock samples
- Students must complete all but "The Actual Results" box before they get the instructor sign-off and receive their materials.
    - Their plan should include safety measures.
- Students carry out their investigation and record their data on the lab worksheet and their results in "The Actual Results" box of the Laboratory Investigation Proposal A.
- Students analyze their data and construct an explanation.
- Students should share what they learned with the other groups.

- **Mountain Mystery Anchor Chart:** Students will have the opportunity to edit and up-date their anchor charts and adjust the class chart to incorporate their improved understanding of the processes studied.
    - Have students revise their Mountain Mystery Anchor Chart.
        - Add vocabulary and concepts.
        - Include descriptive mechanisms as well as processes.
    - Revise class anchor chart based on student input.

Homework: Pass out the Acid Rain CER worksheet. Students respond individually to their guiding question (What determines how much rocks are affected by acid rain?) with a written argument including:

- a claim.
- a description of the supporting evidence from their investigation.
- and an explanation of their reasoning.

EL Support:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Modify classwork, assessments, homework (true/false, reduced responses)
- Provide written notes
- Provide visuals
- Clarify or provide directions in the native language

Differentiated Instruction:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Even though students are designing their own lab, be prepared to give explicit instructions to support students who need more structure. These can include guidelines for how the procedures should be written, specific

Answer: A

components that must be present, peer/teacher review of procedures, requirements for stated safety procedures, etc.
- For students who need support with writing their CER, provide CER Graphic Organizer. Students can also color code their writing, having a different color for each component in the Claim Evidence Reasoning format.

Lesson Summary:

Students should have an idea of the following: Chemical weathering changes the chemical composition of the matter being weathered. This can happen through dissolution by water or by chemical reactions. Oxidation processes, such as rusting are classified as chemical weathering. Chemical reactions with acids, such as those found in acid rain and other water sources and those produced by living organisms, also are factors in chemical weathering. Students should be wondering where the weathered materials, both chemical and physical, go once broken down from the original rock.

Lesson 12: Weathering and Water Quality: Salinity in Streams (1)

Duration: 45 Minutes

Lesson Overview

Students will examine how scientists measure chemical weathering through the chemical composition of runoff in streams. They will analyze local stream data and use that data to **make and defend a claim** regarding **the impact of impermeable surfaces (such as cement) on water quality. Teacher Note:** You have two scheduled days for this topic.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Engaging in Argument from Evidence SEP 7 HS5 - Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.	**Earth materials and Systems** ESS2.A HS1 - Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	**Cause and Effect** CCC 2 HS1 -

Instructional Delivery (Representation/Engagement)

Essential Question: *How do we measure chemical weathering?*

- **Opening Activity:** Through a vocabulary exploration, students will be exposed to the basic concepts of watersheds and run-off through this activity using Frayer models.
  - Place students in groups of five for the whole lesson.
  - Students will complete Frayer Models PDF for the five vocabulary terms. Students may use whatever resources the instructor has available to complete the models.
    - Watershed
    - Impervious
    - Pervious
    - Storm drain
    - Limestone
    - **Teacher Note:** The PDF file has multiple versions of the model, scaffolded for your students. Use as appropriate for your individual students.
- **Baltimore Region Watershed Sort:** Students will examine the level of development in watersheds based on satellite images and rank them from least to most developed.

Sample Assessments (Expression)

These are opportunities or options to check students understanding.

Examine the chart below. Identify each pH reading as either acidic (A), Basic (B) or Neutral (N)

pH Reading	A, B, or N
7	
3.5	
8.2	
6.3	
4.8	
5.2	

When looking at Ca^{2+} ion concentration, which of the following correlations matches your data?

- Student groups will be presented with satellite images of five watersheds.
    - Watershed Satellite Images slides
- Based on the images, students are to sequence the watersheds from least to most developed/ concentration of impervious surfaces.
- **Questioning Prompt:** What patterns do you observe in the images presented? How did you organize them? Why?

- **Water Quality Effects:** Students will predict the impact that impermeable surfaces, such as concrete, have on the water quality within a watershed.
    - Each group make a prediction on pH and dissolved calcium content.
        - **Focus Questions:**
            - Which watershed site will produce the highest pH in the stream water?
            - Which will produce the greatest calcium ion pollution in the stream?
            - Is there a relationship?
        - **Prior knowledge questioning prompt:** "What range of pH is acidic? Basic?"
    - Have each group write their predictions on sticky notes and then post on the board.
- **Analyze Data on Long-term Stream Chemistry:** Students will analyze local watershed data to determine the impact that impermeable surfaces have on the calcium ion concentration and pH of water in streams.
    - Student do the Water Quality Analysis Data Activity.
    - Each member of the group will graph the calcium ion concentration measured at one of the five watershed sites. (These are the same five sites from the satellite images.)
    - As a team, the students will compare their graphs with respect to patterns, similarities, and differences.
    - After examining the five graphs students will answer discussion questions in the activity.
    - Save pH graph analysis section for Lesson 13.

EL Support:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Provide visuals
- Monitor responses
- Modify classwork, assessments, homework (true/false, reduced responses)
- Allow verbal and non-verbal responses (gestures)

Differentiated Instruction:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

To scaffold the Data Activity the teacher can give the student only one column of data, or have a pre-numbered graph grid, or chunk the activity by using task cards.

A. High Ca^{2+} ion concentration with low percentage of pavement
B. High Ca^{2+} ion concentration with high percentage of pavement
C. No correlation between Ca^{2+} ion concentration and percentage of pavement.

Answer: A

Rain that contains harmful chemicals caused by burning fossil fuels is called __________.

A. hydration rain
B. acid rain
C. oxidation rain

Answer: B

Lesson Summary:

Students should have an idea of the following: pH is a measure of acidity of water. pH less than 7 is considered acidic. The ground cover in an area can affect the acidity of the water in the watershed area. Concepts students should still be thinking about include the impact on pH caused by runoff, what type of development has the most impact on pH, how does the concentration of calcium ion in the water correlate with the pH changes?

Lesson 13: Weathering and Water Quality: Salinity in Streams (2)

Duration: 45 Minutes

Lesson Overview

Students will examine how scientists measure chemical weathering through the chemical composition of runoff in streams. They will analyze local stream data and use that data to **make and defend a claim** regarding **the impact of impermeable surfaces (such as cement) on water quality.** **Teacher Note:** This is your second scheduled day for this topic, a continuation of lesson 12.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Engaging in Argument from Evidence SEP 7 HS5 - Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.	**Earth materials and Systems** ESS2.A HS1 - Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	**Cause and Effect** CCC 2 HS1 -

Instructional Delivery (Representation/Engagement)

Essential Question: *How do we measure chemical weathering?*

- **Opening Activity:** Engage students by reviewing the concepts from lesson 12.
  - Teacher created interactive review of previous day's topics, such as Kahoot! or Quizlet
- **Examine Data on pH:** Students will analyze the data they graphed in lesson 12 and compare it to pH data for the same streams.
  - Students return to the same groups they were in during the previous lesson and review the data on long-term stream chemistry.
  - Students will examine the long-term pH data graph and compare it to their Ca^{2+} ion data and complete the discussion questions.
    - **Teacher Note:** Water quality activity pH graph reference sheet
  - **Questioning prompt:** What has caused the patterns you have observed in stream chemistry? How do you know that this is the cause? What would you predict if the farm at McDonogh built a parking lot for their visitors to use?
- **Conclusions:** Students will present their findings from the data analysis activity to the class, through a gallery walk, and give feedback to their classmates.
  - Groups will examine their initial hypothesis.
  - Each student group will write their claim, evidence, and reasoning on chart paper and present their findings. They should include information on:
    - Calcium vs. pH comparison
    - Source of calcium ions in the streams
    - Environmental impact/concerns
    - Suggestions for mitigating impact on the environment

Sample Assessments (Expression)

These are opportunities or options to check students understanding.

Journal Writing Prompt:
The calcium ion content found in the rainwater runoff from a large cement parking lot would be due, in large part, to:

A. Physical Weathering
B. Chemical Weathering

Justify your answer.

Answer: B

Journal Writing Prompt:
If acid rain is a main culprit in the chemical weathering of cement surfaces, and stronger acids do more damage, why is the stream data showing lower levels of acid (higher pH)?

- **Questioning prompt:** Is the evidence presented sufficient to conclude that paved surfaces change the chemistry of our streams? If not, what additional evidence is needed?
- Class Gallery Walk
  - Give students sticky notes to leave comments and constructive suggestions as they walk around the room.

Homework: Students will complete "Permeable Surfaces and the Law" writing activity.

Sources of Evidence of Three-Dimensional Student Learning: Student teams will produce clear, data supported claims regarding the impact of impermeable surfaces on water quality and receive constructive peer-feedback on their claim, evidence, and reasoning.

EL Support:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Graphic organizers
- Reduce the writing load (sentence frames and sentence starters)
- Reduced vocabulary load
- Provide visuals
- Extended time
- Bilingual dictionary

Differentiated Instruction:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- For the conclusion presentation/gallery walk, allow students to design the format of their presentation. Allow variation in format, design, and materials as long as the required content is present and relevant.

Lesson Summary:

Students should have an idea of the following: Calcium ions in the water of streams is due to chemical weathering of hard surfaces, such as paved streets. The concentration of calcium ions can be used to measure the level of chemical weathering. Highly paved areas produce more calcium ions that areas with little or no paved surfaces. Higher concentrations of calcium ions correlate with higher pH readings, thus lower levels of acid in the water. Students should be asking Where do we see these processes in our environment?

Lesson 14: Weathering, Erosion, and Deposition in the Local Environment

Duration: 45 Minutes

Lesson Overview

Students will apply their knowledge of the **cause and effect relationships** of weathering erosion and deposition to their local environment in this lesson. As weather permits, student will go outside to **collect and analyze evidence** of weathering in the "Schoolyard Weathering and Erosion Treasure hunt."

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Analyzing and Interpreting Data SEP 4 HS1 - Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable	**The Roles of Water in Earth's Surface Processes** ESS2.C HS1 - The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to	**Cause and Effect** CCC 2 HS2 - Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

scientific claims or determine an optimal design solution.	the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.	

Instructional Delivery (Representation/Engagement)

Essential Question: *Where do we find evidence of weathering, erosion, and deposition in the local environment?*

- **Opening Activity Photo Slideshow**: Challenge students to identify erosion and deposition as they watch a slideshow.
  - Show Baltimore's Weathering and Deposition Photos slideshow.
  - As the slide show proceeds, students should record how many images they see of erosion and how many images they see of deposition. In some cases, the image may show both processes.
  - Play the slide show once or twice then discuss the results as a class.
  - **Discussion Prompt:** How could you tell which images showed erosion and which images showed deposition?
- **Evidence of Weathering in the Schoolyard/Neighborhood:** In this activity students will move from images to real-world experiences by going outside to find and document examples of weathering and erosion.
  - Students go outside to examine the area around the school and gather data regarding weathering and erosion.
    - Worksheet: Schoolyard Weathering and Erosion Treasure Hunt
  - Upon returning to the classroom have students discuss their observations of patterns and cause and effect with their shoulder partner.
    - Share analysis with class.
  - **Discussion prompt:** What comparisons did you make? What kinds of weathering or erosion did you find?
- **Examine Maps and Other Visualizations of Weathering in the Baltimore Region:** With the guidance of the teacher, students will expand their view from local to regional. They will examine the effects of weathering in Baltimore, and Maryland as a whole.
  - Go through the PowerPoint presentation MD Landforms and Weathering to review reasons why some Maryland rocks weather more easily than others.
    - **Discussion Prompt:** What evidence presented here supports the claim that different rock types weather differently and shape the topography of Maryland?
- **Mountain Mystery Anchor Chart:** Students will have the opportunity to edit and update their anchor charts and adjust the class chart to incorporate their improved understanding of the impact of weathering and rock type.
  - Add vocabulary and concepts to your Mountain Mystery Anchor Chart.
    - Include descriptive mechanisms as well as processes.

Homework: Read over your Mountain Mystery Overview Document and begin gathering materials for Lesson 17 and Lesson 18.

EL Support:

Sample Assessments (Expression)

These are opportunities or options to check students understanding.

Journal Writing Prompt:

Which of the three processes, that we looked for outside, did you observe the greatest amount of evidence for? Why do you think that is? What about the area around your school would make this the most prevalent process?

Journal Writing Prompt

Examine the photo below:

This image of a rusted fence shows evidence of weathering and deposition. Identify and explain each as shown in the photo.

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Link concepts to students' background experiences
- Reduced vocabulary load
- Provide written notes
- Provide visuals

Differentiated Instruction:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Utilize Pear Deck to allow students to work through the MD Landforms and Weathering slides as their own pace and annotate their ideas directly on the slides.

Lesson Summary:

Students should have an idea of the following: Evidence of weathering includes broken items, such as sidewalks, curbs, rocks, cracks in the road, rusted items, etc. Evidence of erosion includes areas where the soil has been washed away, and on windy days students may see erosion if wind is blowing dust, dirt, leaves, etc. Evidence of deposition include areas where rust (or other types of oxidation) has stained nearby structures, piles of dirt or sand, etc. Evidence of physical weathering include the broken pieces that are still the same substance. Evidence of chemical weathering include oxidized products, such as rust. Students should be asking questions like here does it all end up once it leaves here?

Lesson 15: Landforms and Physical Deposition

Duration: 45 Minutes

Lesson Overview

Students will examine the **changes in matter within a simulated stream** to develop an understanding of the process of settling. Students will **analyze data and observations collected during class investigations** and apply their understanding to the natural world through student created models.

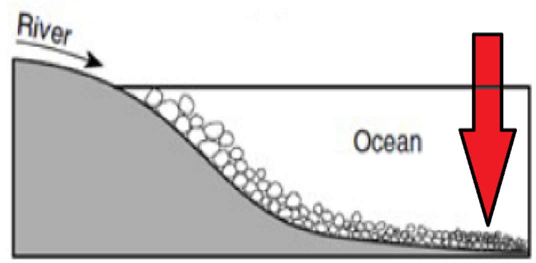
Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Analyzing and Interpreting Data SEP 4 HS1 - Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.	**The Roles of Water in Earth's Surface Processes** ESS2.C HS1 - The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.	**Energy and Matter** CCC 5 HS2 - Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Instructional Delivery (Representation/Engagement)	Sample Assessments (Expression)
Essential Question: *Where does the moving material go?* ● **Opening Activity- Erosion and Deposition Investigation:** Students investigate the settling rate/order of sediments in water by shaking containers with various sizes of rock, sand, and silt. ○ Have students do the Suspension/Settling activity.	*These are opportunities or options to check students understanding.* **Journal Writing Prompt**

- Students experiment with a mixture of silt, sand, and gravel to explore and observe the relationships between:
  - Water velocity (force of motion) and ability to carry particles in suspension
  - Particle size and settling rates
  - **Teacher Note:** If possible, save the jars from your final class of the day and let them set overnight. Allow students to examine the effects of longer-term settling at the beginning of class tomorrow.
- **Questioning prompt:**
  - How are the particles moving?
  - How do the different sized particles settle differently? Why?
  - How does shaking the jar at different speeds effect the moving particles?

- **River Sediments Model:** Based on their observations, students will predict the order of sedimentation and create a pictorial model of sediments at a river outlet.
  - Hand out River Sediments Model Sheet and have them illustrate, based on their observational data, where they believe each sediment particle will drop out of the flowing water and end up on the diagram.
    - **Teacher Note:** At this point do not have them complete their explanation. That will be completed after the next activity.
- **Deposition Simulation:** After making their model, students will further test the motion of sediments using the Race of Deposition simulation. Then they will edit their models based on their new data.
  - In groups of 4, have students investigate deposition patterns in flowing water by completing the Race of Deposition activity.
    - In this activity, students will simulate where a river will drop sediments (heavy, light) as if flows downstream or into a lake or ocean.
    - **Teacher Note:**
      - Materials:
        - large marbles
        - steel balls
        - rubber balls
        - ping pong balls
        - straws
        - folded paper
    - Set-up notes are at the end of the activity packet.
  - After completing the data analysis for this activity, students return to their River Sediments Model Sheet and make any modifications/edits.
    - The edits/modifications should be in a second color.
  - Once students have edited their diagram, they should explain their final model the class.
- **How Tall were Baltimore's Mountains?** The teacher, or a student, will lead a class discussion on how scientists could reverse-engineer the size of ancient mountains from the volume of deposited materials left from weathering, erosion, and deposition.

In the settling activity, the lightest particles were on the top of the "pile." Yet in the river sediments model, these ended up the in the deepest part of the model, as indicated by the arrow.



Explain the apparent discrepancy? Why isn't the pattern the same?

- **Key Questions:**
    - Where are Baltimore's mountains now?
    - How can we estimate the height of the mountains that once stood where Baltimore is today?
- Using the Height of Baltimore's Mountains PowerPoint, the class discusses how scientists might determine the height and volume of Baltimore's mountains based on the estimates of the volume of coastal plain sediments and assumptions of mountain shape and density.

- **Mountain Mystery Anchor Chart:** Provide students with an opportunity to edit and update their anchor charts and adjust the class chart accordingly.
    - Students will add vocabulary and concepts to their Mountain Mystery Anchor Chart.
        - Include descriptive mechanisms as well as processes.

Homework: Complete the deposition CER found at the end of the Race of Deposition activity.

Sources of Evidence of Three-Dimensional Student Learning: Students will apply the data they collected and analyzed, regarding components of sedimentation, to a model that they create, critique, and update based on newly acquired information.

EL Support:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Reduced vocabulary load
- Provide written notes
- Provide visuals
- Monitor responses
- Allow verbal and non-verbal responses (gestures)

Differentiated Instruction:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Assign lab groups based on differing ability levels/mixed readiness groups with targeted roles.
- For students who need support with writing their CER, provide CER Graphic Organizer. Students can also color code their writing, having a different color for each component in the Claim Evidence Reasoning format.

Lesson Summary:

Students should have an idea of the following: Moving water carries sediments. It takes more energy to move large particles than small particles. Large particles, such as rocks, fall out of the flowing water fastest while smaller particles take longer to fall out and thus travel farther in the stream. At the mouth of a river the large rocks will collect first and the finer sediment moves further away from the opening and settles into the deeper waters. Students should be asking questions like what about the dissolved/chemically weathered material? Where is it going?

Lesson 16: Chemical Deposition

Duration: 45 Minutes

Lesson Overview

Students will **simulate the process of limestone formation** in a chemical deposition lab activity by blowing through limewater. The data and information that they gather through this process will be used to **revise their Mountain Mystery anchor chart** for the final time.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)

Developing and Using Models	Earth Materials and Systems	Systems and System Models
SEP2 HS3 - Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	ESS2.A HS1 - Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	CCC 4 HS3 - Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Instructional Delivery (Representation/Engagement)

Essential Question: *What happens to dissolved materials?*

- **Opening Activity What is Limestone?** Engage student's prior knowledge (6th and 8th grade instruction) of sedimentary rock types and limestone with this activity.
  - Have students search the internet for information on how limestone is formed.
  - Ask students to write one paragraph summarizing the process of limestone formation.
    - Possible modification: Allow students to write a bulleted list.
  - Ask students to share what they have found with the class.
- **Limestone Formation and Dissolution Lab Activity:** Students will investigate the formation of limestone by observing chemical deposition from lime water.
  - To begin, review chemical weathering that may have taken place in the rock tumbler.
  - Students will complete the Chemical Deposition and Limestone Laboratory activity.
    - **Teacher Note**:
      - Material Preparation:
        - Clear Cups
        - Straws
        - Lime water (Saturated solution)
        - Timer
        - Goggles
    - There are detailed teacher notes for the activity at the beginning of the Chemical Deposition and Limestone document and the video, Chemical Deposition Lab Video goes through the mechanics of the activity and other considerations for the students.
- **Chemical Deposition Forming Rocks in the Baltimore Region:** With the teacher's guidance, students will expand their focus to the regional level and learn about mineral depositions in the Baltimore region.
  - Teacher and students review PowerPoint Rock & Mineral Deposition showing interesting examples of chemical deposition at work in the region.

Homework: Complete lab write-up. Bring materials for your final activity project. Mountain Mystery Cumulating Activity Student Sheet.

Sources of Evidence of Three-Dimensional Student Learning: Students will write a well-constructed report for the laboratory investigation.

EL Support:

Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.

- Link concepts to students' background experiences
- Make explicit links between past learning and new concepts

Sample Assessments (Expression)

These are opportunities or options to check students understanding.

What is the chemical process called when solids form from a solution?

A. Sublimation
B. Deposition
C. Precipitation
D. Oxidation

Answer: C

What type of rock would Limestone be classified as?

A. Igneous
B. Sedimentary
C. Metamorphic

Answer: B

Return to the Table of Contents

- Active listening guides
- Reduced vocabulary load
- Clarify or provide directions in the native language

Differentiated Instruction:
Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.
- Assign lab groups based on differing ability levels/mixed readiness groups with targeted roles.

Lesson Summary:
Students should have an idea of the following: Chemicals dissolved in water can for solids. Animals can facilitate chemical deposition by creating shells. Chemical deposition is also the chemical process known as precipitation. Ions in solution can react to form solid materials. The deposited materials form sedimentary rocks such as limestone. Students should be considering how all of the information from the unit can be combined in their final project.

Lesson 17: Final Activity (1)

Duration: 45 Minutes

Lesson Overview
Over the final two lessons of the unit, students will create a cumulative project that will illustrate what they have learned about the processes of mountain building and destruction. In this project students will communicate the **process of mountain building and destruction through words and models** based on the Alleghanian Orogeny mountains that once towered over Baltimore.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Developing and Using Models SEP2 HS6 - Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.	**Earth Materials and Systems** ESS2.A HS1 - Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	**Stability and Change** CCC7 HS2 - Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Instructional Delivery (Representation/Engagement)	Sample Assessments (Expression)
Essential Question: *Where did the hills come from?* ● **Opening Activity: Mountain Mystery Anchor Chart:** Students will have the opportunity to make a final edit to their Anchor Charts and adjust the class chart to incorporate their improved understanding of the processes discussed in the unit. ○ Give students sticky-notes and have them add any processes, mechanisms, or vocabulary terms to the Class Anchor Chart that they feel is needed to complete the overall process of mountain growth and destruction. ▪ Have a student volunteer read out additions and verify that they are in the correct location. Have the class come to a consensus, for each sticky-note entry to determine if it is needed or if the it is already represented on the chart (remove redundancy). ○ **Questioning Prompt**: What would it look like if we stretched the anchor chart out over time? What might we see?	*These are opportunities or options to check students understanding.* Which of the following is the force that break down the Earth's crust into smaller particles? A. Transporting B. Erosion C. Weathering D. Deposition Answer C

Mountain Mystery Cumulating Activity: In this two-day activity students are asked to develop a page for the Visit Baltimore website that explains why Baltimore has so many hills. The development process should contain three items: 1) a poster-sized scientifically accurate comic strip storyline following the Earth's surface conditions and the processes that have changed those conditions over time in the Baltimore region, 2) a report detailing the conditions and processes listed in their storyline, and 3) a "pitch" for why we should care about the history of Baltimore's mountains. ○ Students will have this period and half of the next period to complete their project and be prepared to present it to the class. ▪ Resources: • Mountain Mystery Overview Document • Mountain Mystery Cumulating Activity Student Sheet • Mountain Mystery Cumulating Activity Comic Strip Template • Mountain Mystery Cumulating Activity Rubric **Homework:** Work on your written report and pitch for tomorrow. **EL Support:** Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content. • Reduced vocabulary load • Provide written notes • Provide visuals • Sentence frames and sentence starters • Modify classwork, assessments, homework (true/false, reduced responses) • Provide extended time **Differentiated Instruction:** Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content. • Allow students to choose the format for both their visual and verbal presentations.	**Journaling Prompt** How would a story-board or cartoon strip differ in structure and content from our anchor chart? What components should the class be including that might not be on the anchor chart? How could this be incorporated into a webpage design?

Lesson Summary:

Students should have an idea of the following: Mountains are built through tectonic processes such as colliding plates and volcanic eruptions. As mountains age they decrease in size due to weathering, erosion, and deposition. Physical weathering breaks up the mountain's rock while chemical weathering changes the composition of the rock through dissolution and chemical reactions. Erosion moves the materials away from the location of weathering. Deposition places the materials in a new location via physical or chemical processes. These processes, working in concert, formed the mountains of Maryland and the hills of Baltimore.

Lesson 18: Final Activity (2)

Duration: 45 Minutes

Lesson Overview

Over the final two lessons of the unit, students will create a cumulative project that will illustrate what they have learned about the processes of mountain building and destruction. In this project students will communicate the **process of mountain building and destruction through words and models** based on the Alleghanian Orogeny mountains that once towered over Baltimore. In this second day of the final activity, students will complete their projects and present them to the class..

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Developing and Using Models	**Earth Materials and Systems**	**Stability and Change**

SEP2 HS6 - Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.	ESS2.A HS1 - Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	CCC7 HS2 - Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Instructional Delivery (Representation/Engagement)	Sample Assessments (Expression)
Essential Question: *Where did the hills come from?* ● **Mystery Cumulating Activity:** In this two-day activity students are asked to develop a page for the Visit Baltimore website that explains why Baltimore has so many hills. The development process should contain three items: 1) a poster-sized scientifically accurate comic strip storyline following the Earth's surface conditions and the processes that have changed those conditions over time in the Baltimore region, 2) a report detailing the conditions and processes listed in their storyline, and 3) a "pitch" for why we should care about the history of Baltimore's mountains. ○ Students will have half of this period to complete their project and be prepared to present it to the class. ● **Presentations and Gallery Walk:** *Students will observe and evaluate each other's projects and give constructive feedback.* ○ Students will give their pitch to the class. ○ The class will complete a gallery walk of the different comic strips. Students will have sticky-notes to give praise and constructive feedback on each of the storyboards. **Homework:** Study for your unit exam. ***Sources of Evidence of Three-Dimensional Student Learning:*** Students create a visual representation of the mountain building and destruction process, utilizing the information that they have collected on their Mountain Mystery Anchor Chart. Then, students communicate it to the class with a verbal pitch and a comic strip story board. **EL Support:** Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content. • Clarify or provide directions in the students' native language • Reduce the writing load (sentence frames and sentence starters) **Differentiated Instruction:** Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content. • Allow students to choose the format for both their visual and verbal presentations.	*These are opportunities or options to check students understanding.* **Journaling Prompt** Of all of the projects presented, which one do you think did the best job of conveying the information in an accessible manner? Why did you choose this one? What could they have done to improve it?

Lesson Summary:

Students should have an idea of the following: Mountains are built through tectonic processes such as colliding plates and volcanic eruptions. As mountains age they decrease in size due to weathering, erosion, and deposition. Physical weathering breaks up the mountain's rock while chemical weathering changes the composition of the rock through dissolution and chemical reactions. Erosion moves the materials away from the location of weathering. Deposition places the materials in a new location via physical or chemical processes. These processes, working in concert, formed the mountains of Maryland and the hills of Baltimore.

Lesson 19: Review

Duration: 45 Minutes

Lesson Overview

Students will engage in teacher-designed activities to review and prepare for the unit exam.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)

Instructional Delivery (Representation/Engagement)	Sample Assessments (Expression)

• **Opening Activity:** Allow students to review with each other in preparation for the review activity.
  ○ Give students an opportunity to ask each other questions before beginning the prepared review activity.
• **Review Activity:** Using a teacher-created review activity, students will prepare for the unit exam.
  ○ Students use clickers, white boards, or cell phones to answer teacher-created/selected concept review questions.
  ○ Questions should include all topics from the unit.
Homework: Students study for Unit Assessment.
EL Support:
Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.
• Provide native language support: bilingual dictionary, cognates, L1 partner
• Graphic organizers
• Provide visuals
• Modify classwork, assessments, homework (true/false, reduced responses)
Differentiated Instruction:
Purposefully choose one or more of the following options based upon student needs or formative assessment data to have students process and engage with content.
• Review activities are excellent candidates for learning stations and task cards.
	These are opportunities or options to check students understanding.

Lesson 20: End of Unit Assessment

Duration: 45 Minutes

Lesson Overview

Students will take a district-created unit assessment that includes NGSS aligned item sets (multiple choice, data analyses and short response).

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)

Instructional Delivery (Representation/Engagement)	Sample Assessments (Expression)
• **Unit exam:** The unit assessment is found on Data Link.	*These are opportunities or options to check students understanding.*