HIGH SCHOOL CHEMISTRY: EARTH'S SURFACES

Standards Bundle:

Standards are listed within the bundle. Bundles are created with potential instructional use in mind, based upon the potential for related phenomena that can be used throughout a unit.

HS-ESS2-5 Plan and carry out an investigation of the properties of water and its effects on Earth's materials and surface processes (erosion, water pollution, etc.). (SEP: 3; DCI: ESS1.B, ESS2.A, ESS2.D; CCC: Cause/Effect) [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide 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).]

HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that cause changes to other Earth systems. (SEP: 2; DCI: ESS2.A, ESS2.B; CCC: Stability/Change) [Clarification Statement: Examples should include climate feedback, 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-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. (SEP: 7; DCI: ESS3.A, ETS1.B; CCC: Energy and Matter) Alignment may include HS-ETS1-3 [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

Content Overview

This section provides a generic overview of the content or disciplinary core ideas as an entry point to the standards.

Mechanical weathering is the process of breaking rocks into smaller pieces. Rocks and the surface of the land are always changing and do so with the help of water. This happens by the processes of erosion, deposition of sediment, abrasion, and frost wedging. Rain exerts force on the land beginning the process of erosion. Moving water also can carve away rocks over time as well as the soil and is the signature feature of erosion. Igneous rocks, sand, and mud can be carried as sediment by rivers and streams and deposited in layers which eventually form sedimentary rock. Students can use a stream table to observe the ability of water to carry sediment and deposit it in various places downstream. Frost wedging occurs when water makes its way into cracks from the surface of the land. As the water freezes, it expands in size causing great pressure to occur and as a result cracks in the ground and on the surface. These processes all fall under the umbrella of mechanical weathering. Chemical weathering is the process of breaking rock down into new substances. Chemical weathering that can occur with the help of water is rusting in rocks. Rocks with an iron content, exposed to oxygen and water, will go through the process of oxidation and this is visible as the rock turns reddish brown. Burning fossil fuels increases the nitrogen, sulfur, and carbon content of the atmosphere. When these compounds combine with water, acids are produced and combine with water droplets to form acid rain. This acid rain causes profound chemical weathering effects in living systems as well as rocks, especially limestone and marble. Lastly, water can dissolve minerals in the rock, changing them. When water is present in rocks, it can lower the melting temperature of the rock.

When changes occur in one system it often affects another system. These changes can be observed in glacial ice, soil, and humidity. There are two types of feedback systems: positive and negative. A positive feedback system is a cyclical process in which the effect is amplified through the process. A negative feedback system is also a cyclical process; however, the initial factor is decreased. As the increase in global temperature occurs, the temperature of the water increases, melting glacial ice. The decrease in glacial ice reduces the ability of the ice to reflect the sun, thereby causing an additional rise in ocean temperature. This is an example of a positive feedback system. Many examples of positive feedback systems and negative feedback systems can be identified and studied in nature.   Data collected over the last centuries can provide evidence of these feedback systems.

There will always be a need for energy and mineral resources, but the cost of extracting those will change over time. As new designs for the extraction of energy and minerals arise, it is important to identify the benefits, costs, and strengths. Areas to explore could be agriculture, mining, and pumping petroleum and natural gas.

Phenomena

Phenomena can be used at varying levels of instruction. One could be used to anchor an entire unit, while another might be more supplemental for anchoring just a unit. Please remember that phenomena should allow students to engage in the SEP and use the CCC/DCI to understand and explain the phenomenon.

- Stalagmites and stalactites can be seen inside caves.
- Jewel Cave and Wind Cave in South Dakota are fascinating to geologists.
- The Grand Canyon has several types of rock formations. Looking closely at photographs can help identify the specific type of weathering.
- Many important monuments that do not stand the test of time are the Roman Colosseum, the Ulysses S. Grant Memorial, the Statue of Liberty, and the Sphinx.
- The Badlands of South Dakota are popular for tourists.
- Runoff on agricultural land is typically more pronounced in the spring.
- Potholes and cracks in the roadways form more in the spring than in the fall.
- The glacial lakes in Northeast South Dakota can produce flooding in the area.
- Houses built on hills often must have additional structures uphill from the house.
- There is a lot of sedimentation downstream from a beaver dam.
- River rocks are smoother than field rocks.
- A rock tumbler produces smooth stones that can be made into jewelry.

Storyline

This section aims to decode not only the DCI connections, but also the SEP and CCC in a detailed account of how they possibly fit together in a progression for student learning, including both rationale and context for the bundle.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations ● 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)	**ESS2.C: The Roles of Water in Earth's Surface Processes** ● The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. **ESS2.A: Earth Materials and Systems** ● Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	**Cause/Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Stability/Change** ● Feedback (negative or positive) can stabilize

Analyzing and Interpreting Data ● Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) to make valid and reliable scientific claims or determine an optimal design solution. **Engaging in Argument from Evidence** ● Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, and ethical considerations).	**ESS2.D: Weather and Climate** ● The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's reradiation into space. **ESS3.A: Natural Resources** ● All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **ETS1.B: Developing Possible Solutions** ● When evaluating solutions, it is important to consider a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (Secondary) ● Breaking down problems into simpler components to develop potential solutions, considering a variety of constraints (cost, safety, reliability, aesthetics, societal impacts, etc.).	or destabilize a system. **Technology** ● New technologies can have deep impacts on society and the environment, including some that were not anticipated. ● Analysis of costs and benefits is a critical aspect of technology decisions.

Students plan and carry out investigations to provide evidence to show the relationship between water's properties and its effects on Earth's surfaces. 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. Investigations can be conducted to provide evidence of water's ability to mechanically and chemically weather rocks.

Students use tools, technologies, and models to analyze data to show that Earth's systems cause positive and negative feedback on that system or on other systems, which can in turn stabilize or destabilize the system. The foundation for Earth's global climate systems is electromagnetic radiation from the sun, its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's reradiation into space. Changes in any one of these areas can cause changes in other systems. These changes can be identified and tracked using data collected over time.

Students evaluate design solutions for real-world problems such as energy and mineral requirements. All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. Students can also use costs and risks to compare two competing design solutions for the same purpose. When evaluating solutions, it is important to consider a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. Using a cost-benefit analysis is critical when implementing new technologies and new designs.

Formative Assessment

Formative assessment is crucial because all learners benefit from timely and focused feedback from others. It promotes self-reflection, self-explanation, and social learning. It can also make learning more relevant. Each of the questions below might be used throughout the formative assessment process. Specific prompts may focus on individual practices, core ideas, or crosscutting concepts, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given bundle, standard, or lesson-level performance expectation.

SEP Planning and Carrying out Investigation

- Plan and carry out an investigation that tests water's ability to carry mud and sand and to deposit sediment downstream.
- Plan and carry out an investigation on the dissolving ability of water on different minerals.
- Plan and carry out an investigation on the effects of acid on weathering rocks.
- Plan an investigation to show water's effect on the viscosity of molten rock and magma.

SEP Analyzing and Interpreting Data

- Using a graph, analyze the average global temperature over time up to the present and link it to possible causes.
- Using a graph, analyze the change in surface area of arctic glaciers over time and propose a possible cause.
- Using a graph, analyze the change in wetland area and relate it to the change in humidity.
- Using diagrams and pictures, analyze the change in coastal surface over time.

SEP Engaging in Argument from Evidence

- Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
- Argue society's need for a particular type of energy or mineral resource based on evidence.
- Evaluate a design on the basis of strengths, associated economic, environmental, and geopolitical costs, risks, and benefits, reliability and validity of the evidence used to evaluate the design solutions, and constraints, including cost, safety, reliability, aesthetics, cultural effects environmental effects.
- Evaluate current practices of soil preparation in agriculture.
- Evaluate current practices in mining.
- Evaluate current practices in pumping petroleum and natural gas.

CCC Cause/Effect

- What causes the mechanical weathering of rocks?
- What causes the chemical weathering of rocks?
- How does the moisture content of the soil affect runoff?
- How does water affect the melting temperature of solids?
- How are the rates of weathering of rocks affected by wind, rain, ice, water, and vegetation?
- How does water affect Earth's surfaces?

CCC Stability/Change

- How is the global temperature changing slowly over time?
- How is the surface area of glaciers changing over time?
- How is the concentration of carbon dioxide in the ocean changing over time?
- How is the concentration of carbon dioxide in the atmosphere changing over time?
- How is the concentration of greenhouse gases changing in the atmosphere?
- How is the topsoil of agricultural land in South Dakota changing over time?
- How is the coastal regions landscape of the United States and other countries changing over time?
- How can changes in one system cause instability in that system?
- How can changes in the landscape be slowed or prevented?

CCC Technology

- How can technology improve the design for the extraction of energy or a mineral in the United States?
- How can technology be useful in creating a cost-benefit analysis for a product or process?
- How can technology increase the safety and reliability of a designed product or process?

Performance Outcomes

These are statements of how students use knowledge and are similar to the standards in how they blend DCI, SEP, and CCC, but at a smaller grain size. These are potential outcomes for instruction as it plays out in lessons and activities in the classroom. It is important to also think of these as smaller outcomes that build toward the larger goal of mastering the standards.

- **Describe the relationship between** *a property of water and its effect on* Earth's materials and surface processes.
- **Plan an investigation to collect qualitative and quantitative data** on the heat capacity of water, the density of water in its solid and liquid states, and the polarity of water due to its structure.
- **Plan an investigation to observe** *energy transfer that causes the patterns* of temperature, the movement of air, and the movement and availability of water at Earth's surface.
- **Plan and carry out an investigation to observe** *the mechanical effects of water* on Earth's materials and infer the effect of water on Earth's surface processes.
- **Plan and carry out an investigation to observe** stream transportation and deposition using a stream table and describe water's ability to transport and deposit materials.
- **Plan and carry out an investigation to observe** erosion using variations in soil moisture content, and its *effects on* the movement of Earth's materials.
- **Plan and carry out an investigation to observe** the expansion of water as it freezes, *and its effects on* rocks.
- **Plan and carry out an investigation to observe** the solubility of different materials in water and describe water's ability to weather and recrystallize.
- **Plan and carry out an investigation to observe** water's role in iron rusting and infer the role of water in chemical weathering.

- **Plan and carry out an investigation to collect data illustrating** *that water lowers* the melting temperature of most solids and infer melt generation.
- **Plan and carry out an investigation to collect data illustrating** *that water decreases* the viscosity of melted rock, affecting the movement of magma and volcanic eruptions.
- **Students organize data that represent measurements** *of changes in* the hydrosphere, cryosphere, atmosphere, biosphere, or geosphere in response to a change in Earth's surface.
- **Use tools, technologies, and/or models to analyze the data and identify** *the relationship between the changes in* one Earth's system and changes in another Earth's system *(or within).*
- **Use tools, technologies, and/or models to analyze the data and identify** *the relationship between the changes in one system and changes* in climate.
- **Analyze data to identify the** *effects of human activity and specific technologies on Earth's systems*.
- **Using data, describe** the mechanism for a positive feedback system that occurs on Earth.
- **Using data, describe** the mechanism for a negative feedback system that occurs on Earth.
- **Describe the nature of a problem that a design solution addresses and identify the solution** *that has the most preferred cost-benefit ratios.*
- **Identify evidence for** a design solution, including society's need for an energy or mineral resource, the cost of extracting or developing the energy reserve or mineral resource, the costs and benefits of the given design solutions, and the *feasibility, costs, and benefits* of recycling or reusing the mineral resource.
- **Evaluate the given design solutions,** including the relative strengths of the given design solutions, based on associated economic, environmental, and geopolitical costs, risks, and benefits, the reliability and validity of the evidence used to *evaluate the design solutions*, and constraints, including cost, safety, reliability, aesthetics, cultural effects environmental effects.
- **Use logical arguments based on an evaluation** *of the design solutions, costs and benefits, empirical evidence, and scientific ideas to support one design over another in* energy production and other resource extraction.
- **Describe how** *a decision on the "best" solution may change over time as engineers and scientists work to increase the benefits of design solutions while decreasing costs and risks in* energy production and other resource extraction.