									Science and Engineering Practices (SP / EP)							
Inv	**Inv Title**	**Part**	**Part Summary**	**Sessions**	**Content**	**NGSS Performance Expectations Addressed**	**Disciplinary Core Ideas (Framework)**	**Crosscutting Concepts**	**Asking questions (SP) / Defining problems (EP)**	**Developing and using models**	**Planning and carrying out investigations**	**Analyzing and interpreting data**	**Using mathematics and comp. thinking**	**Constructing explanations (SP) / Designing solutions (EP)**	**Engaging in argument from evidence**	**Obtaining, evaluating, and communicating information**
1	Earth Is Rock	**1**	**What's the Story of This Place?** Students consider the history of Earth and begin to think about rock and landforms as a source of evidence for Earth's past. An Earth tour provides a sense of the variety of landforms on the planet.	3	● Earth's surface has a variety of different landforms and water features. ● Every place on Earth's surface has a unique geologic story. ● Rocks hold the clues to the story of a place.	MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. (Foundational)	**ESS2.A: Earth materials and systems** • 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. (MS-ESS2-2)		**SP**							**SP**
1	Earth Is Rock	**2**	**Grand Canyon Rocks** Students learn about the human history of the Grand Canyon, including some of the first scientific expeditions into the canyon. They examine rock samples from two sites in the canyon and learn how to identify limestone, sandstone, and shale.	3	● Every place on Earth's surface has a unique geologic story. ● Rocks hold the clues to the story of a place. ● Limestone, sandstone, and shale are rocks found in the Grand Canyon that can be identified by their characteristics.	MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. (Foundational)	**ESS1.C: The history of planet Earth** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4)	**• Patterns:** Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. **• Scale, proportion, and quantity:** 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.	**SP**		**SP**	**SP**				**SP**
1	Earth Is Rock	**3**	**Correlating Grand Canyon Rocks** Students compare the rocks at two sites in the Grand Canyon. They discover that the layers can be correlated between the two sites, indicating that the rock layers extend great distances throughout the Colorado Plateau.	2	● Rocks hold the clues to the story of a place. ● Limestone, sandstone, and shale are rocks found in the Grand Canyon that can be identified by their characteristics.	MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. (Foundational) MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. (Foundational)	**ESS1.C: The history of planet Earth** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4) **ESS2.C: The roles of water in Earth's surface properties** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)	**• Patterns:** Patterns can be used to identify cause and effect relationships. Graphs, charts, and images can be used to identify patterns in data. **• Cause and effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **• Scale, proportion, and quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.		**SP**		**SP**		**SP**		
2	Weathering and Erosion	**1**	**Stream Table** Students observe erosion and deposition in a stream table and see how earth materials can be sorted by water.	2	● Most landforms are shaped by slow, persistent processes that proceed over the course of millions of years: weathering, erosion, and deposition.	MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	**ESS2.A: Earth materials and systems** • 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. (MS-ESS2-1) • 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. (MS-ESS2-2) **ESS2.C: Thr roles of water in Earth's suface pocesses** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)	**• Cause and effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **• Scale, proportion, and quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. **• Systems and system models:** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.		**SP**		**SP**		**SP**		**SP**

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2	Weathering and Erosion	**2**	**Weathering** Students create sand and consider how rocks experience abrasion and other forms of physical weathering. Further relationships are drawn between erosional forces and the sorting that occurs in nature.	3	● Rock can be weathered into sediments by a number of processes, including frost wedging, abrasion, chemical dissolution, and root wedging. ● Most landforms are shaped by slow, persistent processes that proceed over the course of millions of years: weathering, erosion, and deposition. ● Particles of earth material can be categorized and sorted by size: clay, silt, sand, gravel, pebble, cobble, and boulder.	MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	**ESS2.A: Earth materials and systems** • 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. (MS-ESS2-1) • 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. (MS-ESS2-2) **ESS2.C: The roles of water in Earth's surface processes** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)	**• Cause and effect:** Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. **• Scale, proportion, and quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.		**SP**	**SP**	**SP**		**SP**		**SP**
2	Weathering and Erosion	**3**	**Soil** Students collect soil from their local environment and perform a simple test to determine which earth materials are found in the soil, answering questions about what happens to sediments that are not turned into sedimentary rocks.	3-4	● Most sediments move downhill until they are deposited in a basin. Sediments that do not form rock can become widely distributed over Earth's surface as soil. ● Particles of earth material can be categorized and sorted by size: clay, silt, sand, gravel, pebble, cobble, and boulder.	MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	**ESS2.A: Earth materials and systems** • 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. (MS-ESS2-1) • 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. (MS-ESS2-2) **ESS2.C: The roles of water in Earth's surface processes** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)	**• Patterns:** Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. Patterns can be used to identify cause and effect relationships. Graphs, charts, and images can be used to identify patterns in data.			**SP**	**SP**		**SP**		
3	Deposition	**1**	**Sandstone and Shale** Students consider how sediments accumulate in a basin, in a sorted fashion. They learn that substances in groundwater can form a cement, bonding sand particles together to form sandstone. Students then learn about shale formation.	2	● Sediments deposited by water usually form flat, horizontal layers. ● Sediments turn into solid rock (such as sandstone, shale, and limestone) through the process of lithification, which involves compaction, cementation, and dissolution. ● Sandstone is a sedimentary rock formed when particles of sand are cemented together. ● Shale is a sedimentary rock formed when clay and silt particles are compacted and cemented together.	MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	**ESS2.A: Earth materials and systems** • 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. (MS-ESS2-1) • 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. (MS-ESS2-2) **ESS2.C: The roles of water in Earth's surface processes** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)	**• Patterns:** Macroscopic patterns are related to the nature of microscopic and atomic-level structure. **• Scale, proportion, and quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.		**SP**		**SP**		**SP**		

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3	Deposition	**2**	**Limestone** Students test two oceanic materials to see what might be a component of limestone. They determine that shells contain calcite and are likely to be in limestone.	2	● Sediments turn into solid rock (such as sandstone, shale, and limestone) through the process of lithification, which involves compaction, cementation, and dissolution. ● Limestone is a sedimentary rock composed mainly of calcium carbonate, deposited in oceanic basins by physical, chemical, and biological processes.	MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	**ESS2.A: Earth materials and systems** • 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. (MS-ESS2-1) • 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. (MS-ESS2-2) **ESS2.C: The roles of water in Earth's surface proceses** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)	**• Cause and effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **• Systems and system models:** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. Models are limited in that they only represent certain aspects of the system under study. **• Energy and matter:** Matter is conserved because atoms are conserved in physical and chemical processes. **• Scale, proportion, and quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.		**SP**	**SP**	**SP**		**SP**	**SP**	**SP**
3	Deposition	**3**	**Interpreting Sedimentary Layers** Students learn about the principle of original horizontality, the principle of superposition, and uniformitarianism. They start to make inferences about past environments, based on evidence found in sedimentary rock layers.	2	● Sediments deposited by water usually form flat, horizontal layers. ● The relative ages of sedimentary rock can be determined by the sequence of layers. Lower layers are older than higher layers. ● The processes we observe today, such as weathering, erosion, and deposition, probably acted in the same way millions of years ago, producing sedimentary rocks.	MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.	**ESS1.C: The history of planet Earth** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4)	**• Patterns:** Patterns can be used to identify cause and effect relationships. **• Scale, proportion, and quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.		**SP**		**SP**		**SP**	**SP**	**SP**
4	Fossils and Past Environments	**1**	**Fossils** Students look for fossils in Grand Canyon rocks, then identify a new set of fossils. Using modern environments for reference, students apply the principle of uniformitarianism to infer the ancient environments that formed Colorado Plateau rock layers.	3	● A fossil is any remains, trace, or imprint of a plant or animal that was preserved in Earth's crust during ancient times. ● The fossil record represents what we know about ancient life and is constantly refined as new fossil evidence is discovered.	MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.	**ESS1.C: The history of planet Earth** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4) **LS4.A: Evidence of common ancestry and diversity** • The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MS-LS4-1)	**• Patterns:** Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. **• Cause and effect:** Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. **• Structure and function:** 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 and designed structures/systems can be analyzed to determine how they function.			**SP**	**SP**		**SP**		**SP**

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4	Fossils and Past Environments	**2**	**A Long Time Ago** A 46-m time line of Earth's history is rolled out in front of students to help convey the vastness of geologic time. Students creat time lines of their own lives for comparison.	2	● Geologic time extends from Earth's origin to the present. ● Earth's history is measured in millions and billions of years.	MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.	**ESS1.C: The history of planet Earth** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4) **LS4.A: Evidence of common ancestry and diversity** • The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MS-LS4-1)	• **Patterns:** Macroscopic patterns are related to the nature of microscopic and atomic-level structure. • **Scale, proportion, and quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. Phenomena that can be observed at one scale may not be observable at another scale.		**SP**		**SP**	**SP**			**SP**
4	Fossils and Past Environments	**3**	**Index Fossils** Index fossils are introduced as a tool to correlate rock layers, based on age. Students correlate several Colorado Plateau sites, then add the formation of the Grand Canyon rock layers to their time lines.	4-5	● The fossil record represents what we know about ancient life and is constantly refined as new fossil evidence is discovered. ● Index fossils allow rock layers to be correlated by age over vast distances.	MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.	**ESS1.C: The history of planet Earth** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4) **LS4.A: Evidence of common ancestry and diversity** • The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MS-LS4-1)	• **Patterns:** 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. • **Scale, proportion, and quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. • **Stability and change:** Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.				**SP**	**SP**	**SP**		**SP**
5	Igneous Rocks	**1**	**Earth's Layers** Students study a new set of rocks that are not sedimentary. They identify some characteristics that differentiate these rocks from sedimentary rocks, namely the presence of crystals. Students study the layers of Earth to see what heat source might melt rocks.	1	● Earth is composed of layers of earth materials, from its hard crust of rock all the way down to its hot core. ● Heat inside Earth melts rock; melted rock can cool and form igneous rocks.	MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	**ESS2.A: Earth's materials and systems** • 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. (MS-ESS2-1) • 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. (MS-ESS-2)	• **Patterns:** Graphs, charts, and images can be used to identify patterns in data.	**SP**		**SP**	**SP**				**SP**
5	Igneous Rocks	**2**	**Salol Crystals** Students use salol to model the cooling of igneous rocks and design an experiment to test the effect of cooling rate on crystal formation. They find that slower cooling leads to larger crystal formation and apply that relationship to the environments in which igneous rocks form.	3	● Molten rock cools quickly on the surface of Earth and can be identified by small mineral crystals. Molten rock that cools more slowly inside Earth forms larger mineral crystals.	MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	**ESS2.A: Earth's materials and systems** • 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. (MS-ESS2-1) • 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. (MS-ESS-2)	• **Patterns:** Macroscopic patterns are related to the nature of microscopic and atomic-level structure. Patterns can be used to identify cause and effect relationships. • **Cause and effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems. • **Scale, proportion, and quantity:** Phenomena that can be observed at one scale may not be observable at another scale.		**SP**	**SP**	**SP**		**SP**		**SP**

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5	Igneous Rocks	**3**	**Types of Igneous Rocks** Students consider a larger sample set of igneous rocks and determine which rocks are intrusive or extrusive, based on crystal size.	2	● Molten rock cools quickly on the surface of Earth and can be identified by small mineral crystals. Molten rock that cools more slowly inside Earth forms larger mineral crystals.	MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	**ESS2.A: Earth's materials and systems** • 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. (MS-ESS2-1) • 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. (MS-ESS-2)	**• Cause and effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems.			**SP**	**SP**				
6	Volcanoes and Earthquakes	**1**	**Mapping Volcanoes and Earthquakes** Students map volcanoes. When the class combines the data, specific patterns appear, such as the ring of volcanoes around the Pacific Ocean. Students map earthquakes and discover that the pattern generally matches that of volcanoes. They start to consider why that might be the case.	2	● Volcanoes and earthquakes occur along plate boundaries.	MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.	**ESS3.A: Natural resources** • Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1) **ESS3.B: Natural hazards** • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)	**• Patterns:** Patterns can be used to identify cause and effect relationships. Graphs, charts, and images can be used to identify patterns in data. **• Cause and effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **• Scale, proportion, and quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.	**SP**			**SP**	**SP**			**SP**
6	Volcanoes and Earthquakes	**2**	**Moving Continents** Students are introduced to Wegener's theory of continental drift and consider how it might be related to what is causing volcanoes and earthquakes at specific locations on Earth. Students learn about plate boundaries. They explain how plate boundaries might support Wegener's theory and explain the location of volcanoes and earthquakes.	1	● Volcanoes and earthquakes occur along plate boundaries. ● Earth's crust and solid upper mantle make up Earth's plates. Plates can be the size of continents or larger or smaller.	MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.	**ESS2.B: Plate tectonics and large-scale system interactions** • 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. (MS-ESS2-3)	**• Patterns:** Patterns can be used to identify cause and effect relationships. Graphs, charts, and images can be used to identify patterns in data. **• Cause and effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **• Stability and change:** 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.				**SP**		**SP**		**SP**
6	Volcanoes and Earthquakes	**3**	**Plate Tectonics** Students learn more about the layers of Earth, and convection is introduced. Students explain how plates might induce convection, and they investigate the type of plate-boundary interactions that could result. A short video and a reading help students bring all the pieces together to understand the theory of plate tectonics.	3-4	● Earth's plates "float" on top of the layer of viscous, semisolid earth material below—the asthenosphere. ● The asthenosphere is a heated, semisolid, semifluid material that flows due to convection currents. ● Plate movements result in plate-boundary interactions that produce volcanoes, earthquakes, and continental drift.	MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.	**ESS1.C: The history of Planet Earth** • Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. (MS-ESS2-3) **ESS2.A: Earth materials and systems** • 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. (MS-ESS2-2) **ESS2.B: Plate tectoonics and large-systems interactions** • 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. (MS-ESS2-3) **ESS3.B: Natural hazards** • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)	**• Systems and system models:** Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. **• Energy and matter:** Within a natural (or designed system), the transfer of energy drives the motion and/or cycling of matter. **• Stability and change:** Stability might be disturbed either by sudden events or gradual changes that accumulate over time.	**SP**	**SP**				**SP**		**SP**

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7	Mountains and Metamorphic Rocks	**1**	**Plate Models** Students use plate models to simulate interactions at plate boundaries that result from plates moving in different ways. They review what they have learned by watching animations of plate movements. They consider the relationship between mountain locations and plate boundaries.	3	● Interactions between tectonic plates at their boundaries deform the plates, producing landforms on Earth's surface. ● Mountains form as a result of plate interactions.	MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.	**ESS1.C: The history of Planet Earth** • Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. (MS-ESS2-3) **ESS2.B: Plate tectonics and large-scale interactions** • 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. (MS-ESS2-3)	**• Cause and effect:** 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. **• Systems and system models:** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. **• Energy and matter:** Within a natural (or designed system), the transfer of energy drives the motion and/or cycling of matter. **• Stability and change:** Stability might be disturbed either by sudden events or gradual changes that accumulate over time.		**SP**				**SP**		**SP**
7	Mountains and Metamorphic Rocks	**2**	**Metamorphic Rocks** Students observe and describe a number of metamorphic rocks and consider how they might form. Focusing on heat and pressure, students observe a candy model for metamorphic-rock formation. They compare rocks to identify the source rocks for specific metamorphic rocks. They organize what they have learned about rocks to develop the rock cycle.	4-5	● When plates interact, high heat and immense pressure can change rock into new forms of rock (metamorphic rock). ● The rock cycle describes how rock is constantly being recycled and how each type of rock can be transformed into other rock types.	MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.	**ESS2.A: Earth materials and systems** • 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. (MS-ESS2-1) • 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. (MS-ESS-2)	**• Patterns:** Patterns can be used to identify cause and effect relationships. **• Cause and effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **• Systems and system models:** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. **• Energy and matter:** Within a natural (or designed system), the transfer of energy drives the motion and/or cycling of matter.		**SP**		**SP**		**SP**	**SP**	**SP**

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8	Geoscenarios	**1**	**Introduction to the Project** Students get a tour of the four geoscenario locations. Each team of students views an online introductory tour specific to their topic and answers questions as a group.	1	● Geologic processes help tell the story of a physical place. ● Evidence and observations of a site's geology provide clues to tell the geologic story.	MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	**ESS3.A: Earth materials and systems** • Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1) **ESS3.B: Natural hazards** • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2) **ESS3.C: Human impacts on Earth systems** • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4) **ESS3.D: Global climate change** • Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)	**• Cause and effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems.	**SP**							**SP**
8	Geoscenarios	**2**	**Research and Writing** Each student reviews information from a specialist and contributes detailed evidence to the team's presentation. The group develops a time line of events related to their place or process. Students develop their presentation, based on the four guiding questions.	2	● Knowledge of uplift, plate tectonics, volcanism, weathering, erosion, and fossil evidence plus the principles of uniformitarianism, superposition, and original horizontality can help tell the story of a place.	MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.	**ESS3.A: Earth materials and systems** • Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1) **ESS3.B: Natural hazards** • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2) **ESS3.C: Human impacts on Earth systems** • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4) **ESS3.D: Global climate change** • Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)	**• Cause and effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **• Stability and change:** Stability might be disturbed either by sudden events or gradual changes that accumulate over time.	**SP/ EP**					**SP**		**SP**

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8	Geoscenarios	**3**	**Presentations** Teams split up so that two members explain the presentation to visiting groups, while the other two members visit other presentations, take notes, and ask questions. Then students switch roles. After they have visited all the presentations, the teams do a self-assessment and a peer assessment.	2	● Geologic processes help tell the story of a physical place. ● Knowledge of uplift, plate tectonics, volcanism, weathering, erosion, and fossil evidence plus the principles of uniformitarianism, superposition, and original horizontality can help tell the story of a place.	MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.	**ESS3.A: Earth materials and systems** • Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1) **ESS3.B: Natural hazards** • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2) **ESS3.C: Human impacts on Earth systems** • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3),(MS-ESS3-4) **ESS3.D: Global climate change** • Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)	**• Cause and effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **• Stability and change:** Stability might be disturbed either by sudden events or gradual changes that accumulate over time.	**SP**					**SP**	**SP**	**SP**
9	What Is Earth's Story?	**1**	**Revisit the Grand Canyon** Students use what they have learned about Earth's history and processes to interpret the rock evidence at the Grand Canyon and the geologic history of the Grand Canyon.	2	● Evidence that provides clues about Earth's geologic history comes from observing rocks, landforms, and other earth materials.	MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.	**ESS1.C: The history of Planet Earth** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4) **ESS2.A: Earth materials and systems** • 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. (MS-ESS2-1) • 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. (MS-ESS-2) **ESS2.B: Plate tectonics and large-scale interactions** • 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. (MS-ESS2-3) **ESS2.C: The roles of water in Earth's surface systems** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)	**• Patterns:** Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. Patterns can be used to identify cause and effect relationships. **• Cause and effect:** 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. **• Scale, proportion, and quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.		**SP**				**SP**		**SP**

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9	What Is Earth's Story?	**2**	**Review the Evidence** Students review evidence from the previous investigations and put together a list of evidence and inferences that help tell Earth's geologic story. They review the processes that drive the rock cycle and the constructive and destructive processes that shape Earth. They explore various careers in the geosciences.	2	● Evidence that provides clues about Earth's geologic history comes from observing rocks, landforms, and other earth materials. ● Scientists specialize in many different disciplines to collect and analyze evidence to help put together Earth's geologic history. ● Scientists use a number of different tools and techniques to analyze and synthesize evidence obtained from Earth to tell its story.	MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.	**ESS1.C: The history of Planet Earth** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4) **ESS2.A: Earth materials and systems** • 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. (MS-ESS2-1) • 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. (MS-ESS-2) **ESS2.B: Plate tectonics and large-scale interactions** • 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. (MS-ESS2-3) **ESS2.C: The roles of water in Earth's surface systems** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)	**• Systems and system models:** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.						**SP**	**SP**	