Conceptual Story: STC/MS *CATASTROPHIC EVENTS*

The Earth is a dynamic planet. Catastrophic events such as hurricanes, earthquakes, and volcanic eruptions characterize the dynamic nature of Earth and occur in predictable places across the globe. Severe weather can affect human lives and property. Understanding the components and patterns of Earth systems, including the solid Earth, the hydrosphere, and the atmosphere, helps us to understand the nature of catastrophic events and why they occur on Earth.

Lesson 1
Storms Pre-assessment

Focus Question(s): What is an example of a catastrophic event? Where do catastrophic events occur?

Using a world map, students record their ideas of where catastrophic events occur on the Earth and describe why they occur there.

Lesson 2
Introducing Storms

Focus Question(s): What do we know about the causes and effects of storms? How does a vortex tube serve as a model of a storm? What causes the vortices in the atmosphere?

Students identify circular movement in storms and use a model of a vortex to develop an understanding of the forces involved.

1.2 Structure of Systems: Systems; Components and Patterns of Earth Systems
1.3 Changes in Systems: Hydrosphere and Atmosphere

AAAS Atlas:
Structure of Matter: States of Matter (p. 59)
Processes That Shape the Earth: Changes in the Earth's Surface (p. 51)
Systems (p. 133)

Energy from the sun reaches Earth in the form of radiant energy. Three different things happen to the radiant energy the Earth receives from the sun. Some is reflected back into space, some is absorbed by the atmosphere, and some is absorbed by Earth's land and water surfaces. Once energy is absorbed, heat can be transferred by radiation, conduction, or convection. Different surfaces (i.e., land vs. water) absorb the sun's energy at the same rate but radiate heat at different rates, resulting in the uneven heating of the Earth's atmosphere and air masses with different densities. As warm air rises and cool air sinks, convection currents are set in motion that results in winds and storms.

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Lesson 3
Uneven Heating of Earth's Surfaces

Focus Question(s): How does the sun's energy interact with the Earth's surface? How do different surfaces on the Earth absorb and retain the sun's energy? What are the effects of the differential heating of the Earth's surface?

Students observe, graph, and analyze the heating and cooling rates of soil and water.

Lesson 4
Heat Transfer and the Movement of Air

Focus Question(s): What is the effect of temperature on an air mass? What is the relationship between the temperature of air and its moisture content? What is the influence of the sun on a storm system?

Students investigate the effects of surface temperature on the temperature of the air above a land mass and above the surface of a body of water.

Lesson 5
Convention Currents

Focus Question(s): Why does the wind blow? How are air temperature and winds related? How do convection currents transfer energy from one place to another?

Students conduct investigations that demonstrate what happens when air masses of different temperature and humidity meet.

1.1 Properties of Systems: Energy Sources and Kinds
1.2 Structure of Systems: Systems; Energy Transfer and Transformation; Components and Patterns of Earth Systems;
1.3 Changes in Systems: Hydrosphere and Atmosphere

AAAS Atlas:
The Universe: Gravity (p. 43)
Systems (p.133)
The Earth: Weather and Climate (draft)

The movement of water from the hydrosphere, to the atmosphere, and back to Earth's surfaces is all about convection. As warm air rises and cools to its dew point, water vapor in the air condenses and forms tiny drops of water around dust particles in the atmosphere. When millions of these drops come together, a cloud forms. Convection is at work again when colder, denser seawater at the poles sinks and moves along the ocean floor toward the equator, while warmer, less dense water at the equator rises and moves toward the poles along the surface. These two events form a continuous convection current that circulates ocean water. Most surface currents in the ocean are the result of friction between the windblown air and the water surface causing the water to move. Strong wind-driven surface currents are responsible for upwelling and bringing high concentrations of nutrients to the surface. The rotation of the Earth as well as its tilt on its axis adds to the complexity of earth's dynamic systems.

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Lesson 6
Cloud Formation

Focus Question(s): How does the sun's energy drive the water cycle? How is temperature and air pressure involved in cloud formation?

Students model and describe evaporation, condensation, and the air pressure under which clouds form. They analyze weather maps, classify fronts, and identify high and low pressure systems.

Lesson 7
Convection in the Ocean

Focus Question(s): What causes ocean currents? Why are polar temperatures lower than equatorial temperatures?

Students investigate the effects of water temperature on the way water moves, the effect of wind on surface currents, and analyze the effects of ocean currents on global climate.

Lesson 8
Storms Assessment

Focus Question: Did you get the past 7 lessons?

Students determine the cause of rotation for a suspended helix exposed to a light source, using concepts and skills addressed throughout the unit of lessons. They also complete a written assessment.

1.2 Structures of Systems: System; Energy Transfer and Transformation
1.3 Changes in Systems: Hydrosphere and Atmosphere

AAAS Atlas: **The Earth**: Weather and Climate (draft)

Conceptual Story: STC/MS *CATASTROPHIC EVENTS*

Lesson 9
Introduction to the Anchor Activity

Focus Question(s): What risks from natural catastrophic events exist for people living in the Seattle area? How might these risks be reduced or eliminated?

Students will define "risk" and relate it to natural catastrophic events. They select a topic of study for the project.

Lesson 10
Earthquakes Pre-assessment

Focus Question(s): What is an earthquake? What are the constructive and destructive effects of earthquakes? What do you know about catastrophic events that you can apply to earthquakes?

Students brainstorm the possible causes and effects of earthquakes. Students view a video about earthquakes.

1.2 Structure of Systems: Systems
1.3 Changes in Systems: Processes and Interactions in Earth Systems; Hydrosphere and Atmosphere

AAAS Atlas:
Processes That Shape the Earth: Plate Tectonics (p. 53)
Changes in Earth's Surface (p. 51)
Systems (p. 133)

The sudden breaking of rock along a fault in the Earth's crust causes earthquakes. This breaking produces vibrations that release energy in the form of seismic (P and S) waves that travel outward in all directions from the earthquake focus. P (primary or compression) waves and S (secondary or shear) waves travel at different speeds and along different paths and can be recorded at different seismograph stations around the globe. Behavior of waves through the earth allows us to determine the distance from a recording station to an epicenter. With data from at least three stations, the epicenter of an earthquake can be calculated. Using seismograph data, a pattern emerges of earthquake locations around the Earth.

Lesson 11
Earthquake Waves

Focus Question(s): What are the characteristics of a wave? What are the similarities and differences in P and S waves? How do earthquake waves affect structures?

Students observe the formation and movement of waves in water. They use a spring to simulate different kinds of waves. They correlate the waves modeled by the spring with earthquake waves. They use the spring to model possible damaging effects of earthquake waves.

Lesson 12
Recording Earthquake Waves

Focus Question(s): How does a seismograph record wave action? Why is it desirable to have a global network of seismographic stations?

Students use a model seismograph to record vibrations. They use actual seismograms to analyze wave patterns. They use triangulation to determine the epicenter of an earthquake.

Lesson 13
Plotting Earthquakes

Focus Question(s): Where on earth are earthquakes likely to occur? What can the patterns in earthquake locations tell us about the structure of the Earth?

Students plot the locations of earthquakes on a world map. They analyze the plotted data and look for patterns.

1.1 Properties of Systems: Motion of Objects; Wave Behavior
1.2 Structure of Systems: Systems; Energy Transfer and Transformation

AAAS Atlas:
Processes That Shape the Earth: Plate Tectonics (p. 53)
Motion: Waves (p. 65)

Knowing how P and S waves move differently through the Earth allows us to infer the structure of the Earth's interior. At certain depths, the speed and path of the P and S waves change. S waves aren't transmitted through liquid. P waves are slowed and deflected, but not stopped by the liquid outer core. These changes mark the boundaries of the layers of Earth. The pattern of earthquakes at the surface allows us to infer that the Earth's crust is broken into plates. Plates are under tension and pressure which cause colliding, sliding, and separation. Supporting evidence of the moving plate model of the Earth includes the fossil record, matching coastlines of the continents, and rock evidence such as paleomagnetism, and matching formations across oceans and rifts. The engine that drives this movement of the plates at the surface comes from the heat within the Earth's interior. Radioactive decay in the core provides heat for convection currents in the mantle, which cause the plates of the Earth's crust to move.

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Lesson 14
Earth's Structure

Focus Question(s): What is the structure of the Earth? How do earthquakes help us in visualizing the interior of the Earth?

Students examine the interior structure of common objects. They learn how scientists study the Earth's interior. They learn about changes in the motion of waves as they move through different substrates. They learn the structure of the earth's interior.

Lesson 15
Plate Boundaries

Focus Question(s): What evidence is there to support the theory of plate tectonics? What energy source drives the movement of the oceanic and continental plates? How do rocks respond to the forces caused by plate tectonics?

Students use models to simulate the movement and interaction of plates. They locate plate boundaries on a globe using topographic clues. They classify materials as brittle or ductile. They use a model to simulate a fault and factors that influence the force needed to rupture a fault.

Lesson 16
Mantle Convection

Focus Question: Why do the earth's plates move?

Students use rheoscopic fluid to model convection currents in the Earth's mantle. They identify the convection of the mantle as the engine for plate movement. They recognize the role of mantle convection in the formation of ridges and trenches.

Lesson 17
Earthquake Assessment

Focus Question(s): What is an earthquake? What evidence do we have for the cause of earthquakes? What impact on humans can earthquakes have? How can we mitigate that impact?

Students design and conduct an investigation to determine the effect of soil structure on the way buildings respond to shaking. They use knowledge and data interpretation skills to complete a written assessment.

1.1 Properties of Systems: Waves Behavior; Energy Sources and Kinds
1.2 Structure of Systems: Energy Transfer and Transformation; Components and Patterns of Earth Systems
1.3 Changes in Systems: Physical and Chemical Changes; Processes and Interactions in Earth Systems

AAAS Atlas:
Scientific Inquiry: Scientific Theories (p. 21)
Systems (p.133)
Motion: Waves (p. 65)

Conceptual Story: STC/MS *CATASTROPHIC EVENTS*

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Lesson 18
Volcanoes Pre-assessment

Focus Question(s): What are some of the risks posed by a possible volcanic eruption? What is the role/responsibility of scientists in deciding whether to issue an alert?

Students analyze the destructive and constructive effects of volcanoes after watching two short videos. They learn how scientists work to reduce risks associated with volcanic eruptions. They explore the causes, effects, locations and interrelationships of seven different catastrophic events.

1.2 Structure of Systems: Systems
1.2.1 Changes in Systems: Processes and Interactions in Earth Systems

AAAS Atlas:
Processes That Shape the Earth: Changes in the Earth's Surface (p. 51)
Systems (p. 133)

One of the constructive effects of volcanoes is the formation of new land. Special regions of the Earth have molten magma just beneath the crust. Magma is less dense than the rock around it, so it is very slowly forced upward towards Earth's surface. Lava can spew out onto the land or ocean floor, creating volcanic mountains and islands. The viscosity of magma depends on its composition and temperature. If an eruption contains runny magma, it spreads out; if it contains sticky magma, it does not flow far before it solidifies; if it contains thick magma, trapped gases shatter the rock within the volcano into small pieces. Magma viscosity is responsible for different landforms.

Lesson 19
Forming New Land

Focus Question: How do magma and lava influence surface changes on the earth?

Students simulate magma and lava flow using two different substances, and consider the constructive influences of volcanic materials on land formations. They formulate working definitions of the words "magma" and "lava" based on their simulation experiences.

1.1.1 Properties of Systems: Properties of Substances; Energy Sources and Kinds
1.2 Structure of Systems: Systems
1.2.1 Changes in Systems: Physical and Chemical Changes; Processes and Interactions in Earth Systems

Lesson 20
Viscosity

Focus Question(s): How does lava viscosity affect the shape of a volcano?

Students investigate the viscosity of several liquids. They analyze how adding a solid to a liquid or increasing the temperature of a liquid can change its viscosity. They examine how the viscosity of lava affects the formation of volcanoes. They classify photographs of volcanoes and analyze why the volcanoes are not all the same shape and size.

AAAS Atlas:
Processes That Shape the Earth: Changes in Earth's Surface (p. 51)
Systems (p 133)

Igneous rocks are formed from magma and lava. Rocks tell a story about how they formed and where they came from. Magma is cooled slowly beneath the Earth's crust form igneous rock with large crystals. Lava that flowed onto the Earth's surface and cooled quickly, form igneous rock with fine crystals or no crystals at all. Rocks on the earth are weathered and eroded and eventually may form new rocks. This process is called the rock cycle.

Lesson 21
Igneous Rocks and Crystallization

Focus Question: What are three properties used for classifying igneous rock?

Students examine five igneous rock samples (igneous rocks are formed when cooling molten rock crystallizes under or on the earth's surface) using a magnifier, and classify the samples on the basis of color, mineral composition, and texture.

1.1 Properties of Systems: Nature and Properties of Earth Materials
1.2 Structure of Systems: Systems
1.3 Nature of Systems: Processes and Interactions in Earth Systems

Lesson 22
Exploring Igneous Rock Formation

Focus Question(s): What is an igneous rock and how are they formed? How does igneous rock crystal formation identify the conditions under which the rock was formed?

Students explore rates of crystallization and hypothesize how three of the igneous rock samples may have formed. They read to learn more about the "rock cycle."

AAAS Atlas: Processes That Shape the Earth: Changes in Earth's Surfaces (p. 51)

Volcanic eruptions may release great quantities of ash, which, in turn, can pose great environmental and personal dangers. It can block sunlight, smother crops, and coat people's lungs. The properties of ash can tell us what it is made of and how far it traveled. Ash in the atmosphere can cause global climate change.

Lesson 23
Properties of Ash

Focus Question(s): What is volcanic ash? What are six properties of volcanic ash? What are the risk factors associated with these properties of volcanic ash?

Students analyze the properties of volcanic ash including appearance, texture, hardness, buoyancy, magnetism, and density. They consider potential effects on people, property, and the environment.

1.1 Properties of Systems: Properties of Substances; Nature and Properties of Earth Materials
1.2 Structure of Systems: Systems
1.3 Nature of Systems: Processes and Interactions in Earth Systems; Hydrosphere and Atmosphere

Lesson 24
Ash Fall and Weather

Focus Question(s): What factors can influence the distribution of ash after volcanic eruption? What are the beneficial and detrimental effects of ash fall?

Students design their own investigations to simulate the eruption of volcanic ash. They collect data on ash fall and draw conclusions about the effects of weather on ash fall. They examine the constructive and destructive effects of ash fall on humans, the environment, and global weather.

AAAS Atlas:
The Earth: Weather and Climate (draft)

Lesson 25
Volcanoes Assessment

Focus Question: What did you learn?

Students design and carry out an investigation in which they explore the effects of ash fall on the temperature of the earth's surface. Students must control variables, set up a data table to collect temperature and time data, record observations, graph data, and draw conclusions that relate to concepts and skills addressed throughout the module.