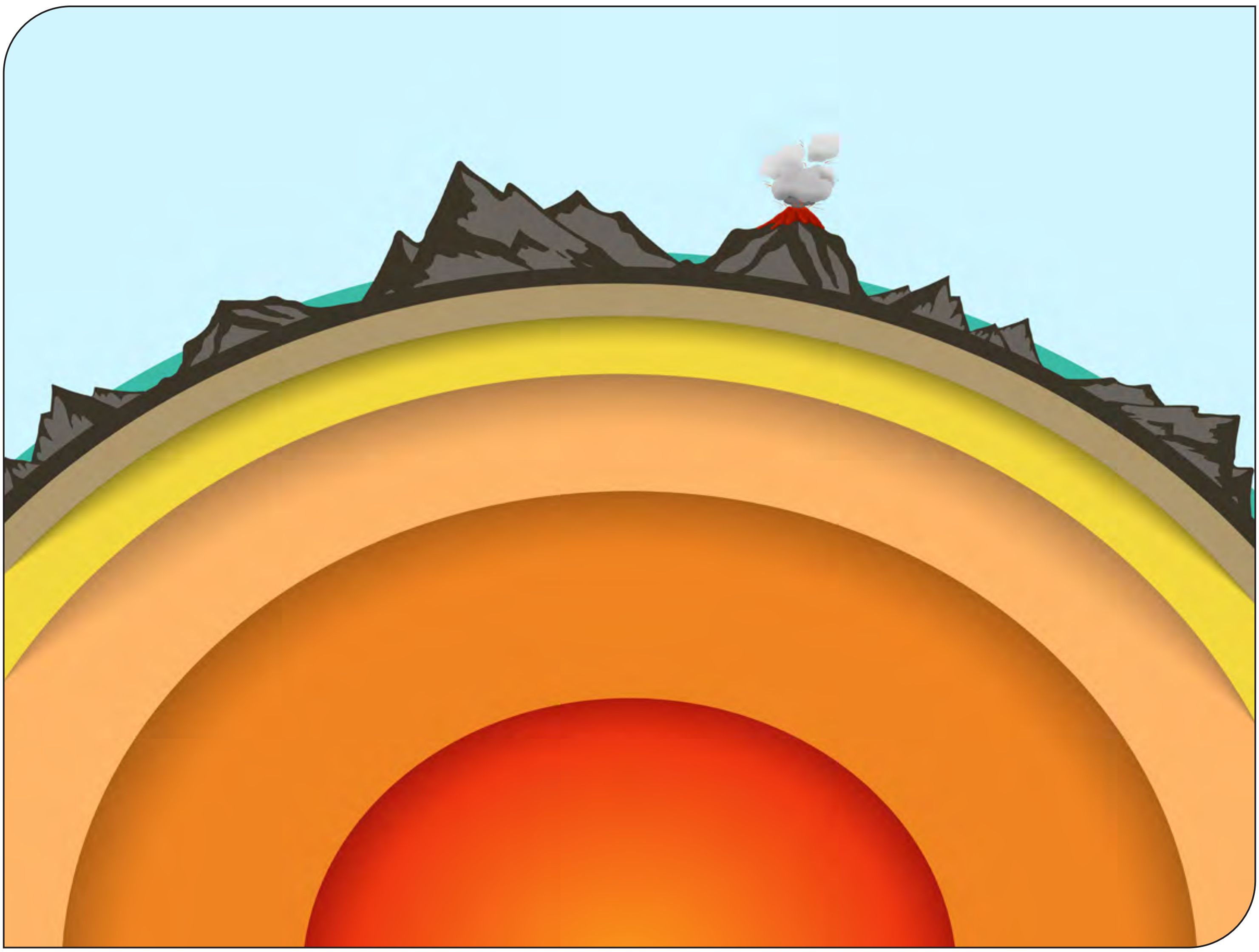
CEREAL CITY SCIENCE by BCAMSC

Teacher Guide and Student Journal
Sample Activity and Planning Pages

History of Earth
MSENG1



A Middle School Unit supporting Next Generation Science Standards and Michigan Science Standards

History of Earth
MSENG1

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Developed and written by
Battle Creek Area Mathematics + Science Center
for

CEREAL CITY SCIENCE™
by BCAMSC

History of Earth

Pre-Activity Information Pages

Activities

Appendix

NEXT GENERATION SCIENCE STANDARDS

DISCIPLINARY CORE IDEAS/PERFORMANCE ASSESSMENTS	Activity
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) • Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. (HS.ESS1.C GBE), (secondary to MS-ESS2-3)	6, 7
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.	6, 7
MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and sea floor structures to provide evidence of the past plate motions.	6, 7
ESS2.A: Earth's 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)	1, 2, 3, 4
MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	1, 2, 3, 4
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)	1, 2, 5
MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and sea floor structures to provide evidence of the past plate motions.	1, 2, 5
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)	3
MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	3
ETS1.A: Defining and Delimiting Engineering Problems • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit the possible solutions. (MS-ESS2-2)	4
MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales	4

NEXT GENERATION SCIENCE STANDARDS

DISCIPLINARY CORE IDEAS/PERFORMANCE ASSESSMENTS	Activity
ETS1.B: Developing Possible Solutions • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. • Models of all kinds are important for testing solutions.	4
MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	4
ETS1.C: Optimizing the Design Solution • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated in the new design. • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.	4
MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	4

SCIENCE AND ENGINEERING PRACTICES/PERFORMANCE ASSESSMENTS	Activity
Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to provide evidence for phenomena. (MS-ESS2-3)	1, 5, 7
MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and sea floor structures to provide evidence of the past plate motions.	1, 5, 7
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including 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. (MS-ESS1-4, MS-ESS2-2)	1, 2, 5, 6, 7

*The Performance Expectations marked with an asterisk integrate traditional science content with engineering through a Practice and Disciplinary Core Idea.

NEXT GENERATION SCIENCE STANDARDS

SCIENCE AND ENGINEERING PRACTICES/PERFORMANCE ASSESSMENTS	Activity
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.	6, 7
MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	1, 2, 5
Developing and Using Models 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. • Develop and use a model to describe phenomena. • Develop a model to describe unobservable mechanisms.	1, 2, 3, 4, 5 6, 7
MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	1, 2, 3, 4
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.	6, 7
Connections to Nature of Science **Scientific Knowledge Is Open to Revision in Light of New Evidence.** • Science findings are frequently revised and/or reinterpreted based on new evidence. (MS-ESS2-3)	
MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and sea floor structures to provide evidence of the past plate motions.	1, 2, 5

CROSSCUTTING CONCEPTS/PERFORMANCE ASSESSMENTS	Activity
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. (MS-ESS1-4, MS-ESS2-2)	2, 5, 6
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.	6, 7
MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	2, 5
Patterns • Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. • Graphs, charts, and images can be used to identify patterns in data.	1, 6, 7
MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and sea floor structures to provide evidence of the past plate motions.	6, 7

UNIT AT A GLANCE

Activity	Time to Complete	Lesson Level Learning Goal	Phenomena	Summary: Students will . . .
1 Earthquakes Around the World	Preparation: 30 minutes Activity: 4 classes Lesson 1A : 55–60 min., 2 classes Lesson 1B: 55–60 min., 2 classes	Develop an initial model of how earthquakes occur. Analyze real data to find patterns to figure out where most earthquakes occur and what causes earthquakes.	**Recent earthquake** **San Francisco Earthquake videos**	• Make observations of earthquakes in the San Francisco area and other recent earthquakes. • Record observations and questions from videos. • List questions about earthquakes and how and why they happen. • Map recent earthquakes using real-time data.
2 What Are Plate Tectonics?	Preparation: 20 minutes Activity: 6 classes Lesson 2A: 55–60 min., 2 classes Lesson 2B: 55–60 min. Lesson 2C: 55–60 min. Lesson 2D: 55–60 min., 2 classes	Develop a model to explain the effect of collisions due to tectonic plates made of different rock.	**Earthquake videos**	• Review their initial ideas from the What We Think chart. • Put together a tectonic plate jigsaw puzzle. • Raise questions about the effect of the motion and rubbing of the tectonic plates against one another. • Conduct research and take notes about the location of earthquakes and the layers of Earth. • Use a web simulation to show plate boundaries, earthquakes, and volcanoes. • Use a model to role-play the motion of Earth's layers and the movement of the tectonic plates. • Make observations of basalt and granite specimens • Use clay to develop a demonstration model of the effect of the motion of plates.
3 Change the Face of the Land	Preparation: 20 minutes Activity: 4-5 classes Lesson 3A: 55–60 min., 2 classes Lesson 3B: 55–60 min., 2–3 classes	Revise a model to explain the effect of an underwater earthquake that leads to a tsunami.	**Video of tsunami wave**	• Read and take notes from the book *Earthquakes*, by Seymour Simon. • Research a recent tsunami and compare information with other research groups. • Determine the "must haves" for the *Tsunami Product Descriptor*.

UNIT AT A GLANCE

Students Figure Out How to:	Practice/Crosscutting Concepts	Assessment
• Develop a model that explains what caused the earthquakes to happen in San Francisco and other areas. • Develop anchor questioning charts. • Share models and ideas in a Science Talk. • Develop a list of questions and a driving question board using the What We Think chart. • Interpret earthquake locations based on real-time data. • Revise earthquake models based on patterns in data.	**Asking Questions and Defining Problems** **Developing and Using Models** **Analyzing and Interpreting Data** **Constructing Explanations and Designing Solutions** **Cause and Effect** **Systems and System Models**	**Formative Assessment** initial models questions Science Talk Journal Entry mapping of earthquakes
• Use a tectonic plate jigsaw model to explain why the location of earthquakes occurs in a pattern. • Evaluate and communicate information from text that helps explain why the location of most earthquakes occurs in a pattern. • Revise earthquake models to include new information about the cause of the motion of the plates. • Use information from reading, simulations, logic, and reasoning to construct explanations. • Develop a model of the layers of Earth to explain how the layers are related to the movement of tectonic plates. • Relate their ideas from observations of basalt and granite to develop a presentation model of the effect of the plates moving together, rubbing, and pulling apart.	**Developing and Using Models** **Obtaining, Evaluating, and Communicating Information** **Constructing Explanations and Designing Solutions** **Cause and Effect** **Stability and Change** **Systems and System Models** **Scale, Proportion, and Quantity**	**Formative Assessment** Activity Pages Science Talk class chart **Summative Assessment** revised models Journal Entry consensus model
• Obtain information from text to compare with earthquake models and ideas about tsunamis. • Develop a model that explains the cause and effect of a tsunami. • Make revisions to models based on new information. • Develop a demonstration model of a tsunami.	**Obtaining, Evaluating, and Communicating Information** **Developing and Using Models** **Cause and Effect**	**Formative Assessment** initial models **Summative Assessment** demonstration models Activity Pages Product Descriptors

UNIT AT A GLANCE

Activity	Time to Complete	Lesson Level Learning Goal	Phenomena	Summary: Students will . . .
4 Measuring Earthquakes: Engineering	Preparation: 20 minutes Activity: 5–6 classes Lesson 4A: 55–60 min., 2 classes Lesson 4B: 55–60 min., 3–4 classes	Apply science ideas to design a tool to measure the strength of vibrations caused by an earthquake.	**Engineering Design Challenge:** **Plan, design, and build a model of a seismograph**	• Research the history of the seismograph. • Develop questions about what the seismograph is measuring. • Present an engineering product that measures shaking motion. • Demonstrate their engineering product and evaluate the designs of others.
5 Fossil Finds and the Pangaea Puzzle	Preparation: 20 minutes Activity: 6 classes Lesson 5A: 55–60 min., 2 classes Lesson 5B: 55–60 min. Lesson 5C: 55–60 min., 3 classes	Analyze fossil records and rock strata to find patterns to provide evidence of how Earth's tectonic plates moved great distances, collided, and moved apart over a long period of time.	**Fossils of the same kind are discovered on different continents, separated by a vast ocean.**	• Develop questions about the fossil find. • Become paleontologists and complete an assigned "fossil dig." • Combine information and data from the dig with other paleontologist groups. • Explore a continental drift jigsaw to model the movement of the continents over a long period of time. • Take notes from their observations from a video about Pangaea and continental drift.
6 Rocks, Fossils, and the History of Earth	Preparation: 20 minutes Activity: 7-8 classes Lesson 6A: 55–60 min., 2 classes Lesson 6B: 55–60 min., 3–4 classes Lesson 6C: 55–60 min., 2 classes	Identify patterns in organisms found in an analysis of fossil records to use as evidence that the plates were closer together in the past.	**Layers and strata of the Grand Canyon**	• Make observations and discuss ideas about the formation of the layers in the Grand Canyon. • Share and discuss initial models of the formation of the layers in the Grand Canyon. • Make observations of an illustration of the cross-section of the Grand Canyon. • Use different sediments to show how layers form. • Present their demonstration models. • Obtain information from the USGS website. • Read and take notes about stratification in Michigan from the book *Under Michigan*.

UNIT AT A GLANCE

Students Figure Out How to:	Practice/Crosscutting Concepts	Assessment
• Work in an engineering team to plan, design, and build a seismograph. • Use information obtained from resources about the history of the seismograph. • Demonstrate the seismograph and how it works.	**Developing and Using Models** **Engaging in Argument from Evidence** **Systems and System Models**	**Formative Assessment** Activity Pages "Must Haves" list **Summative Assessment** Science Talk seismograph devices seismograph presentations Activity Pages
• Develop an initial model of how they think the fossils of the same kind of organisms were discovered on continents that are separated by a vast ocean. • Analyze and interpret data from multiple fossil digs to construct an explanation for the fossil finds. • Use what they know about plant and animal survival to figure out the phenomenon. • Develop a theory to explain the fossil finds using their findings from the continental drift jigsaw. • Write a scientific explanation based on their findings.	**Developing and Using Models** **Asking Questions and Defining Problems** **Analyzing and Interpreting Data** **Constructing Explanations and Designing Solutions** **Scale, Proportion, and Quantity**	**Formative Assessment** initial models Science Talk revised models (1) Activity Pages **Summative Assessment** Journal Entry final (revised) models (2) Activity Pages
• Brainstorm and develop initial models that explain how the layers of the Grand Canyon formed. • Raise questions about the formation of the layers of the Grand Canyon. • Use information from the cross-section illustration of the Grand Canyon to add to and revise models. • Plan and build a demonstration model of how the layers of the Grand Canyon formed. • Use new information from text and diagrams on the USGS website to revise their models. • Compare the stratification in Michigan to layers of the Grand Canyon to construct an explanation.	**Developing and Using Models** **Asking Questions and Defining Problems** **Obtaining, Evaluating, and Communicating Information** **Constructing Explanations and Designing Solutions** **Cause and Effect** **Scale, Proportion, and Quantity** **Systems and System Models**	**Formative Assessment** initial models Science Talk Activity Page revised models What We Think chart **Summative Assessment** revised models What We Think chart Activity Pages

UNIT AT A GLANCE

Activity	Time to Complete	Lesson Level Learning Goal	Phenomena	Summary: Students will . . .
7 Fossil Dig	Preparation: 20 minutes Activity: 5-6 classes Lesson 7A: 55–60 min., 2 classes Lesson 7B: 55–60 min., 3–4 classes	Analyze how layers of rock and fossil records help to develop a time line of the history of Earth.	**Layers and strata of the Grand Canyon**	• Use a demonstration model to find out how groups of paleontologists combine information to develop a time line of the history of Earth. • Excavate two layers in a model of Earth layers to find fossils. • Compare fossil specimens to modern life-forms using the Fossil Observation chart. • Make observations of the identification of fossils from video. • Write and illustrate a story about the formation of a fossil and the evidence it provides of life on Earth millions of years ago.

UNIT AT A GLANCE

Students Figure Out How to:	Practice/Crosscutting Concepts	Assessment
• Work with other groups to combine information to develop a time line of the history of Earth. • Analyze information from a model fossil dig. • Use patterns in results from fossil digs to put together a time line of the history of Earth. • Determine limitations in the class model. • Use what they know about modern life-forms for comparison to fossils of ancient life-forms. • Obtain information from text and video to help compare ancient life-forms to modern life-forms. • Combine information from models, text, and video to write and illustrate a story about the formation of a fossil and the evidence it provides of life on Earth millions of years ago.	**Developing and Using Models** **Asking Questions and Defining Problems** **Constructing Explanations and Designing Solutions** **Obtaining, Evaluating, and Communicating Information** **Patterns**	**Summative Assessment** Science Talk Activity Page class time line Journal Entry

Earthquakes Around the World

Teacher Background Information
The unit begins with a look at an earthquake that has occurred recently and then explores one of the most devastating and tragic natural disasters in the United States, the 1906 earthquake in San Francisco. There were more than 3,000 deaths, and the city was destroyed. The students will watch before and after videos of the city and then create a What We Think About Earthquakes chart and work toward answering their questions about earthquakes. The initial question students investigate is "Where do earthquakes most often occur?" Students plot real data about the location and magnitude of earthquakes around the world. Students plot the occurrences of earthquakes using real data from the United States Geological Society website. The purpose of plotting earthquake events is to create a detailed picture of earthquakes that occurred worldwide over one year and analyze any possible patterns in the data. The data also provides the opportunity to ask the question "Why do earthquakes occur most often in these areas?", which leads to the discussion of Earth's tectonic plates in following activities.

Students begin their mapping skills by identifying the continents and major bodies of water on a wall map and then discuss longitude and latitude coordinates. Longitude determines direction east and west and is measured in respect to the prime meridian in Greenwich, England. Latitude determines the north and south angular distance from the equator. After students have practiced their mapping skills, they begin to map the data for earthquakes around the world for one full year. Students recognize earthquake-prone areas and then question, "Why do these areas on Earth experience more earthquakes than other areas?"

The movement of the tectonic plates of Earth's crust causes earthquakes. The National Earthquake Information Center records approximately 20 earthquakes each day. Earthquakes with a magnitude between 2 and 4 occur on a daily basis. Earthquakes below a 2 occur more frequently but are not recorded or plotted for this activity. Approximately 9,000 very minor earthquakes, below a 3 in magnitude, occur every day! On a yearly basis, there are approximately 49,000 earthquakes that measure 3 to 3.9 in magnitude, 6,200 earthquakes that measure 4 to 4.9 in magnitude, 800 that measure 5 to 5.9 in magnitude, 120 that measure 6 to 6.9 in magnitude, 18 that measure 7 to 7.9 in magnitude, and finally, 1 annual earthquake on Earth that measures 8 or higher in magnitude. The number and magnitude of yearly earthquakes worldwide is high-interest and surprising data for students. The data also provide further evidence of the ever moving and changing planet Earth.

ESTIMATED TIME
Lesson 1A: 55–60 minutes, 2 classes
Lesson 1B: 55–60 minutes, 2 classes

LESSON LEVEL LEARNING GOALS
Develop an initial model of how earthquakes occur.

Analyze real data to find patterns to figure out where most earthquakes occur and what causes earthquakes.

MATERIALS NEEDED
For each student:
- student pages

For each group of 4:
- chart paper/whiteboards
- markers
- sticky notes

For the class:
- Internet access

Teacher provides:
- chart paper/whiteboards
- markers
- sticky notes
- Internet access

ESS2.A: EARTH'S 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 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)

TEACHING TIP

The What We Think chart is an important tool for students to recognize the storyline and progression of their learning. It serves as a driving question board and activity summary board. Students have a record of the progression of their changing ideas and reference for past ideas and new ideas. The What We Did column is a record of the Science and Engineering Practices; the What We Figured Out column is a record of progress toward the Disciplinary Core Ideas (DCIs) and Crosscutting Concepts (CCC).

TEACHING TIP

Throughout the activities in the Teacher Guide, specific student instructions from the Student Journal pages are given first and italicized. Additional information for the teacher follows the italicized instructions in plain print.

Specific student questions from the Student Journal are also italicized in the Teacher Guide.

Engage the Learner

The initial phase of the learning cycle is intended to introduce and activate prior knowledge about the cause of earthquakes with a focus on why and where they occur. Students develop initial models, raise questions, and determine how to investigate their ideas.

Advance Preparation

Make copies of the Parent Letter and Activities to Do at Home to be sent home.

Prepare for a space for Science Talk so all students are standing or sitting in a circle and have eye contact with one another. (See Science Talk and Developing Effective Questions in the appendix.)

Prepare a space for a What We Think Chart that includes the driving question and an activity summary table. Plan to have the chart visible throughout the activities.

Example: What We Think chart

What We Think	What Questions Do We Have and How Can We Find Out?	What We Did	What We Figured Out	How Does This Help Us to Figure Out the Phenomenon?
Student initial ideas about how earthquakes occur	Student initial questions about earthquakes (how, where, strength or magnitude, damage, etc.)	Description of what students did (related to the science and engineering practices)	New information as a result of the lessons	Application of new findings to phenomenon

Preview the earthquake websites and choose a recent earthquake for your class. Check for the latest earthquakes and related news reports and reactions to the shaking. Use the USGS site and national news for the latest information:

earthquake.usgs.gov/earthquakes/map

https://eos.org/articles/rare-earthquake-swarm-strikes-puerto-rico

Preview earthquake sites related to 1906 San Francisco earthquake:

(suggested video) https://www.youtube.com/watch?v=g5VXIp8Ux8c

https://www.youtube.com/watch?v=-gebK-F4D1k

https://www.youtube.com/watch?v=jiR7LnOkKug

https://www.youtube.com/watch?v=FOwWmt9NBM0

https://www.youtube.com/watch?v=Tm9kqImgsxQ

1989 San Francisco earthquake:

(suggested video) https://www.youtube.com/watch?v=p4LFu91Xrw0

https://www.youtube.com/watch?v=viE_yQNFvhM

Earthquake history of San Francisco:

http://www.earthquakesafety.com/earthquake-history.html

http://scedc.caltech.edu/recent/Maps/San_Francisco.html

Write one of the following headings each at the top of four pieces of chart paper to make classroom anchor posters.

Asking Clarifying Questions
Asking a Probing Question
Adding to an Idea
Respectfully Disagreeing with an Idea

Lesson 1A: A Shaky Day in San Francisco

Procedure

Engage the learner.

In trying to figure out where, how, and why earthquakes happen, students are more likely to be engaged and interested when exploring a recent earthquake, one that has occurred in their recent memory and in the news. As of the writing of this unit (January 2020), Puerto Rico experienced an earthquake on December 28, 2019, with a magnitude of 4.7. The aftershocks continued well into January 2020, with some measuring a magnitude as large as or larger than the original quake.

The flurry of seismic activity in Puerto Rico that began December 28 and continued aftershocks in January provides a phenomenon that can inspire a variety of questions for investigation throughout the unit. (See Advance Preparation.)

Show the information about the most recent earthquake.

Allow time for students to discuss their ideas about the recent earthquake. Display the What We Think chart and record students' initial ideas about how earthquakes occur and what they think is happening to make the area shake. Encourage students to share personal or family stories about earthquakes. Listen for early ideas about magnitude, and how and why earthquakes occur in different regions across the globe. Encourage and record all ideas at this time.

Show the video about the 1906 earthquake in San Francisco that you selected from the list above.

Have students refer to the Student Journal.

Record your ideas and questions about your observations of the San Francisco earthquake. Include key terms and ideas that you think are important to understanding the phenomenon.

Observations	*Questions*

Ask the students to make observations about San Francisco before and after the earthquake. Encourage them to describe the differences in the number of people, size and number of the buildings, etc.

HISTORY/SOCIAL STUDIES, SCIENCE, AND TECHNICAL SUBJECTS WRITING STANDARDS—GRADES 6–8

Text Types and Purposes
WHST.6–8.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

Range of Writing
WHST.6–8.10: Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

TEACHING TIP

Listen for ideas that relate to earthquakes as a weather-related event. Make note of students' ideas about the cause of earthquakes.

Make a note of their comments and refer to them again when raising questions.

CAUSE AND EFFECT

- Cause-and-effect relationships may be used to predict phenomena in natural and designed systems. (MS-ESS2-5), (MS-ESS3-4)
- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3)

DEVELOPING AND USING MODELS
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.

- **Develop and use a model to describe phenomena. (MS-ESS2-6)**
- **Develop a model to describe unobservable mechanisms.**

SYSTEMS AND SYSTEM MODELS

- Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within systems. (MS-ESS2-6)

TEACHING TIP
If your class is new to developing and using models to explain their thinking, take time to discuss the use of models to represent ideas that explain phenomena. Discuss how models can be used to make the unobservable components of a system visible. Allow time for the groups to discuss the components that they cannot see but are important in understanding their ideas. Do not lead their thinking at this time.

TEACHING TIP
Listen for the use of the term *magnitude* in student discussions about earthquakes. Make a note of how students used the term to use as a reference in the following lesson.

Show the video of the 1989 earthquake in San Francisco. Ask the students to share their observations about this earthquake. How was it similar to the 1906 earthquake? Different?

Divide the class into groups of four and allow time for students to discuss the phenomenon of earthquakes in San Francisco. Some students may have personal experiences to share. Encourage students to share their observations from the video and discuss their initial ideas of the cause of the quakes.

Facilitate the sharing of information and ideas by circulating among the groups and listening to their initial responses to the information. To help students elaborate on their observations and initial ideas, ask:

- What do you think is causing the earth to shake?
- What makes you think that?
- Does anyone have similar or different ideas about the cause of the quakes?
- Tell me what you already know about earthquakes and the cause of the shaking.
- Can someone describe an observation or idea everyone had in common after viewing the videos?

After the groups have shared information and concluded their brainstorming, ask them to read the prompt in the Student Journal. Ask students to work individually first, and develop a model of their thinking. Discuss the use of a model to describe unobservable mechanisms that work together to cause an earthquake. Ask students to be prepared to share their individual models and work as a group to develop one model that reflects the thinking of the group. Remind students that this is their initial thinking and that there are no wrong ideas at this time. Explain that if the group has different ideas, they should add the different ideas to their model and that it is not necessary for a complete consensus to be reached at this time.

Have students refer to the Student Journal.

Work with your group and use the space below to draw and label a model that explains what caused the earthquakes to happen in San Francisco. Include the unobservable mechanisms that help explain the phenomenon. Share your individual ideas with your group to develop a group model that includes ideas of all members.

When the groups have decided on how they want the model that represents their collective thinking to look, distribute chart paper or whiteboards and markers for them to develop a model to share with the class. Encourage groups to write questions that come up during the model development. Distribute sticky notes to each group and encourage students to write the questions about earthquakes on each sticky note (one question per note). Have them attach the questions to their model.

Circulate among the groups to monitor their progress and listen to their exchange of ideas. Do not offer suggestions or information at this time. Make a note of key ideas and questions to revisit during Science Talk. After the groups have had the opportunity to complete their initial models, ask them to display their models around the room.

In order to conduct friendly, nonthreatening critiques, as a class establish some guidelines and rules for their critiquing methods.

As a class, create four anchor posters that will guide the class throughout the unit when sharing ideas. Display the four charts with the questioning and critiquing categories. Have students suggest how they might start a question that asks a group to clarify, probe or dig deeper, or add to an idea, or disagrees with an idea. It is important for success in student-to-student interactions for the anchor charts to be developed by the students.

Example charts:

Respectfully Disagreeing with an Idea

- I agree with… but…
- I disagree with... because...
- I agree with part of your model but disagree with this part…
- I respectfully disagree because…
- I understand where you are coming from, but I have a different idea.
- I agree with you but also think…
- I see your reasoning, but I disagree with some of the ideas because…

Asking a Clarifying Question

- What do you mean by…?
- Can you be more specific about…?
- What makes you think that?
- What evidence do you have that supports that?
- How do you know?
- Can you tell us more about…?
- What do you mean by…?
- So are you saying…?

Asking a Probing Question

- What do you mean by…?
- What makes you think that?
- If that were true, then wouldn't __________ be true?
- Where did you get this idea?
- How did you come up with…?
- What is your evidence?
- Why is ________ important in your model?
- Can you say more about…?

Adding to an Idea

- I agree with you, but also…
- I would like to add…
- I agree but also think…
- I agree with this part, but could you add…?
- Do you think adding ______ would make it more clear?
- I agree but have an idea that might add more clarity or information.
- Would it make it more clear if you added…?

SCIENCE TALK

Science Talk is a conversation among the students that allows them to have the opportunity to orally express their ideas and listen to the ideas of others. Allow sufficient time for each student to express ideas and opinions. Create a classroom culture where all ideas are respected and considered.

Science Talk is not an add-on to science investigations. It addresses important science content and is a critical part of the lesson and learning. Science Talk can be whole group, small group, and teams of two students. Through discussion with one another, students explore their ideas, make comparisons to the ideas of others, use evidence, and develop the skills to critique and prepare academic arguments. See the appendix, pp. 138–40, on setting up your class for Science Talk.

TEACHING TIP
The five-column What We Think chart is an important tool in making the storyline and progression of learning visible to the class. It serves as a record of students' new knowledge as well as changes to their previous thinking.

If using Google Docs or another electronic posting platform, have students in each group post their initial ideas and questions in the document you have created and shared. Be sure to monitor the student postings to avoid duplicates and/or inappropriate comments.

ASKING QUESTIONS AND DEFINING PROBLEMS
Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables and clarifying arguments and models.

- **Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and or seek additional information.**
- Ask questions to identify and clarify evidence of an argument. (MS-ESS3-5)

After the completion of the anchor questioning charts, conduct a gallery walk. Allow time for each group to make observations of the different models. Encourage students to look for common components that are in each of the models.

Science Talk
After the groups have completed the gallery walk, ask them to bring the models and form a circle for discussion and sharing. Ask each group to explain their model and, as a class, look for common ideas, unique ideas, and questions. To help the students elaborate on their explanation of their models, ask:

- __________, I heard you use the term ____________. Can you tell us more about that?
- What does __________ represent in your model? What makes you think that is an important component to include in your model?
- Tell us more about what you mean by _________________.
- What questions do you have about earthquakes and why and where they happen?
- What do you mean when you say _______________?
- How might where you live affect your chances of experiencing an earthquake?

Display the What We Think chart. Explain that the class has modeled and discussed their initial ideas about earthquakes and how and where they occur and they will be using the What We Think chart to keep a record of their initial ideas and new understandings as the lessons progress. Take this time to have students use their ideas from their notes in the Student Journals and models to make a list in the What We Think column.

Continue with the Questions We Have column and explain that the class still has questions about earthquakes and how they occur that need to be answered. The chart will help the class keep track of their questions and when and how they have answered their questions.

Develop the driving questions for following lessons by building on student ideas. Help students turn their wonderings and ideas into questions that can be answered through investigation and research in the following lessons. (See sample Questions We Have chart on p. 44.)

To help students collectively raise questions about earthquakes and where they occur, ask:

- What questions do we need to answer to figure out where and why earthquakes occur?
- What do you think about what ____________ said?
- Does anyone have a question that relates to ____________'s question?

To help the students collaborate to form questions, ask them to return to their groups and use their Activity Page and models as references to develop as many questions they can think of about earthquakes. Distribute sticky notes to each group. Ask students to use scrap paper or Student Journals and write as many questions as they can think of about earthquakes and how, why, and where they might happen. Then collaborate to find four or five of the most pressing questions to write on the sticky notes (one question per note).

As a class, categorize the questions. To facilitate the categorizing of questions, ask a group to read one of their questions and place it on the Questions We Have column. Ask if anyone has the same or a similar question. Ask the groups to read their similar questions, decide on a category for the questions, and invite all similar questions to be posted on the column in proximity to one another. Write the category on the chart. Continue until all questions are acknowledged and categorized.

Categories for the student questions about earthquakes may include:

- strength
- location
- damage
- cause
- safety and building standards
- shifting plates

Your students may have questions similar to and different from those on the example chart. Raising and categorizing questions as a class is an important process for students to undertake to give them the sense that they are investigating what is real and relevant to them. The chart is merely a sample. Your students' questions may include many more questions and questions that relate to your location.

Explain that the chart is going to remain visible for the remainder of the unit and that as new questions and categories develop, they will be added to the chart. Explain that as the lessons progress, the class will periodically review their initial questions, add new questions, and decide which questions have been answered and what questions remain to be investigated.

Take this opportunity to develop with the class the overarching driving question that will drive the following lessons. The driving question should be broad enough that the individual questions are incorporated into the broader question. The driving question may include questions similar to the following:

- Where do earthquakes most often occur?
- How do earthquakes occur?

TEACHING TIP

As the unit progresses and questions are answered, move them from the Questions We Have Column to the What We Figured Out Column. Students have the opportunity to see the progress toward answering student-generated questions.

Be prepared to add new questions as the lessons progress.

TEACHING TIP

If your students have completed the MSPNG3 *Energy and the Electromagnetic Spectrum* unit, encourage connections to seismic waves, energy moving from place to place, and potential and kinetic energy throughout this unit.

Check for students' ability to describe the position and motion at the plate boundaries in terms of potential and kinetic energy. Students may also make connections to energy associated with seismic waves and tsunamis.

FORMATIVE ASSESSMENT

The artifacts and components used for assessment in the beginning lessons serve as a formative assessment to guide instruction in following lessons.

For example, do initial models include motion in Earth's crust, a representation of a fault line or shifting plates, a representation of forces and motion, a representation of seismic waves?

ASKING QUESTIONS AND DEFINING PROBLEMS

Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables and clarifying arguments and models.

- **Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and or seek additional information.**
- Ask questions to identify and clarify evidence of an argument. (MS-ESS3-5)

This may also be a good opportunity to develop a class definition of the terms *earthquake*, *magnitude*, and *vibrations*. Write the terms on the board and, after the class is satisfied with their definitions, have them write them in the Key Terms section of the Student Journal.

Assessment: Formative
Use the initial models and questions to assess the students' ability to develop models based on current thinking and their beginning ideas about earthquakes and shifting tectonic plates.

Sample Questions We Have chart:

Lesson 1B: Mapping Earthquakes

Teacher Background Information
To gain a deeper understanding of earthquakes and to begin to answer their questions, students begin to analyze real earthquake data and map the quakes on a world map. They discover that the frequency of earthquakes is greatest along edges of the tectonic plates.

Explore the Concept
During this phase of the learning, students explore real data from earthquakes that have occurred around the world, map the tectonic plates, and develop models of how they move.

Advance Preparation
Retrieve the earthquake data from the following website. Select one day of data for each student of earthquakes over 4.0.

http://ds.iris.edu/sm2/eventlist/

Make copies of the handout *Mapping Earthquakes*, found in Handouts in the Teacher Guide.

Choose a significant earthquake that occurred in the last day or two. Use the following USGS site:

https://earthquake.usgs.gov/earthquakes/browse/significant.php

Examples:

https://earthquake.usgs.gov/earthquakes/eventpage/us60004zhq/map

https://earthquake.usgs.gov/earthquakes/eventpage/us60004zhq/executive

Make copies of earthquake activity information from past seven months and the current month. You will need at least eight months of data to plot (one month for each group of three or four students).

Display the world map for all the class to view. You may choose to locate your world map in an area where students can access it without disturbing the rest of the class or on a mobile easel or board for easy access during, before, and after class. Keep the world map displayed throughout the unit.

Make arrangements to use the computer and projector to view the National Earthquake Information Center website and United States Geological Survey website.

Procedure
Explore the concept.
Review the questions from the What We Think chart. Focus on questions that relate to location of earthquakes. Ask students for ideas of how they can find out where most earthquakes occur.

Show students the map of the world and give them the opportunity to find San Francisco on the map. Show the information for a significant earthquake that occurred in the last day or two. Ask students to find that location on the world map. Allow time for students to describe

MATERIALS NEEDED

For each student:
- student page

For each group of 4:
- 20 beaded pins
- handout: *Mapping Earthquakes*

For the class:
- world map (with latitude and longitude)

Teacher provides:
- Internet access
- earthquake data from IRIS website (see Advance Preparation)
- computer
- colored pencils (to match the colors of the beaded pins)

ESS2.A: EARTH'S 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 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)

TEACHING TIP
If students do not suggest collecting actual earthquake data from a reliable source, provide prompts to get the students to ask the question and make suggestions. Example:

- How do we know when an earthquake has occurred that is not in our area?
- Do you think there are scientists keeping track of earthquake data?
- What type of scientist would be interested in keeping track of earthquakes?
- How do you think we can access scientific data of significant earthquakes?

Check for student ideas that relate to online data and scientific record keeping.

TEACHING TIP
Teaching multiple classes in a day will require some collaboration among classes. All classes will need to go through the process of recognizing the pattern in where earthquakes most often occur. Decide how they can use the earthquake data to map the earthquakes over a year.

Each class may record the earthquakes over two to three months, depending on the number of classes you teach, and then look at the data collected as a whole.

and find different locations that they believe experience earthquakes. Invite students to describe why they think earthquakes occur and what makes more areas prone to earthquakes than other areas. Ask students to estimate how many earthquakes they think occur on Earth each year.

Record any new ideas and add them to the students' initial ideas on the What We Think chart. Check for prior knowledge regarding magnitude and how earthquakes are measured, and ideas about how they occur and how often they occur.

Return to the driving question: "Where do earthquakes most often occur on Earth?" Ask students for ideas of how they can find out. Students may suggest researching the data through a website and using real data collected by geologists around the world.

Explain that the locations of earthquakes are recorded and posted on the National Earthquake Information Center website, and that the students will be working in groups to use the NEIC data and plot the location of the earthquakes on the world map. Ask students what they predict they will find after plotting the earthquake activity. Write additional ideas on the class chart.

Before engaging in plotting data, check students' map-reading skills. Focus the class's attention on the world map. Ask students to identify the continents and major bodies of water. Have students pay attention to the western hemisphere and share information about different regions that they have been researching and exploring in their social studies curriculum and places they have heard about on the news. Review the parts of the map that help geologists locate different areas on a map. Have students locate the compass rose and determine north, south, east, and west.

Explain that the lines on the map are coordinates that help to locate specific areas. Show students the longitudinal and latitudinal lines on the world map. Locate Michigan and identify the latitude and longitude for the state and your city.

Explain that *longitude* determines direction east and west and is measured with respect to the prime meridian in Greenwich, England. The *latitude* lines determine north and south angular distances from the equator. Have students locate the equator and prime meridian on the map. Have the students add the terms and their definitions to the Key Terms in the Student Journal.

Model how to locate major cities on the map. Start on the equator or prime meridian and travel up and down, left or right. Give students the opportunity to practice using the classroom map. After the students are comfortable plotting locations on the map, as a class, plot two or three recent earthquakes in the format of the USGS data.

For example:

Magnitude	Date/Time	Degrees Latitude	Degrees Longitude	Region
4.4	2019/08/05 21:05:08	45.84	26.76	Romania
4.8	2019/08/04 11:44:22	-48.81	163.77	South Island of New Zealand
4.2	2019/08/03 08:09:15	38.84	70.09	Afghanistan

Discuss students' ideas about the *magnitude* of earthquakes. If students referred to the term in previous lessons, ask them to explain what they mean by magnitude and if they have ideas of how it is measured. Check for understanding that the lower the number, the weaker or more minor the earthquake. Earthquakes that are rated at a 6 or above are considered strong to major to great in magnitude.

After the students feel comfortable locating specific places and earthquake coordinates on a map, divide the class into groups of three or four students. Distribute one set of data for one day for each student (see Advance Preparation), *Mapping Earthquakes* handouts, colored pencils, and beaded pins to each group. Explain that all groups will follow the same color code; review the color code key on the handout. Encourage groups to divide their data into on day per student, and have each student map one day of earthquake activity.

Give the groups sufficient time to make sense of the data and map their coordinates on the handout prior to entering the data on the classroom map. Facilitate the group activity by circulating among the students, listening to their ideas and checking for appropriate mapping skills and use of coordinates. To check student progress, ask:

- Can someone explain what you have discovered so far?
- What information did you have to place that dot in that place? How do the coordinates help you find the location? Can you imagine what it would be like to find the location by city name alone?
- What do you think about the number of earthquakes that have occurred on the one-month time span? How many did you think you would be plotting?
- What can you tell from the data about the most frequent magnitude of earthquakes?
- Are any of your locations concentrated in one area? Why do you think they are all clustered together at times and spread out across the world at other times?

TEACHING TIP

Plotting the earthquakes on the classroom map may become a time-consuming task. Many earthquakes happen every day. Have the class determine what magnitudes they are going to start mapping. They may choose to map 4.0 and above to make the mapping process a little less tedious.

Allow groups to plot their information before school, after school, and at other "down" times during the day. If you teach multiple science classes throughout the day, divide the data for a year between the different classrooms; the students from each class can watch the data unfold and patterns begin to form.

ANALYZING AND INTERPRETING DATA

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.

- **Analyze and interpret data to provide evidence for phenomena. (MS-ESS2-3)**

PATTERNS

- Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2)

ASKING QUESTIONS AND DEFINING PROBLEMS

Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables and clarifying arguments and models.

- **Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and or seek additional information.**
- Ask questions to identify and clarify evidence of an argument.

CAUSE AND EFFECT

- Cause-and-effect relationships may be used to predict phenomena in natural and designed systems.
- ~~Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.~~

After the groups are satisfied with their data and mapping, have them select one or two students to use the pins to mark the earthquakes on the classroom map. Inform the groups that the pins are colored and that the class will use the same color code as with the colored pencils.

Science Talk
Explain the concept and define the terms.
As a class, share the experience of plotting the earthquake data and the number of earthquakes that occur during one year. Ask a student to start the conversation by sharing if the actual numbers of earthquakes in a year were close to their original thinking. Ask:

- Did anyone have a similar reaction to the number of earthquakes that happen in a year?
- What are your ideas of why all that shaking is going on?
- Can someone add on to ___________’s idea?
- Who can restate or put in your own words what __________ just said?
- How does mapping the earthquakes over a year help us to understand why the earth shakes?
- What patterns emerged on our world map?
- What information can we gather from the pattern we uncovered?

Discuss the patterns that emerged on the world map. Ask a student volunteer to describe the areas of the world that are most affected by earthquakes and those that are calm. Refer to the Questions We Have column of the What We Think chart. Check if plotting the earthquake data helped in answering any “location” questions about where most earthquakes occur. Review questions that ask about why these areas are more prone to earthquakes:

- Why are some areas of the world more prone to earthquakes than others?
- What made San Francisco likely to have an earthquake?

Give the class sufficient time to hypothesize why certain patterns emerged on the map and what causes the patterns. Listen for ideas that relate to plate tectonics, Earth’s crust, and movement of the molten core below the crust. Some student misconceptions about earthquakes may surface in the discussion.

Display the map of the world that includes Earth’s tectonic plates. Write the term *plate tectonics* on the board. Ask students to compare the boundaries of the plates and the areas where most of the earthquakes occurred. Have students discuss their ideas about the cause-and-effect relationship between the location of the earthquakes and the boundaries of the plates.

Facilitate the discussion to encourage students to build on the ideas of others. Ask:

- Can someone add on to __________'s idea?
- Who can rephrase what __________ just said?
- Do the rest of you agree? Why or why not?

Ask the students what further information they need to find out why these areas on the map are more prone to earthquakes than others. Listen for ideas that include researching and finding out more about what Earth is made of and what lies below the surface of Earth.

Add new questions and ideas to the What We Think chart when necessary. Ask the class to return to their groups from Lesson 1A and revisit their original models of the cause of the earthquakes in San Francisco. Allow time for students to make additions and revisions to their models. Inform students that they will have the opportunity to revisit and revise as lessons progress and as more questions are addressed.

Work with your group and use the space below to draw and label a revised model that explains what caused the earthquakes to happen in San Francisco. Include any new information you gathered from mapping the earthquakes over the past year. Remember that models include the unobservable mechanisms that help explain the phenomenon.

Have the groups display their models around the room and have students do a gallery walk to observe the revisions of the different models. Allow time for questions and discussion of the revisions. Encourage students to use the anchor charts developed in Lesson 1A to add to, question, and dig deeper into an idea on the models.

Return to the What We Think chart and review the students' original thinking. Make adjustments to the chart and ask students if they have any information that they can enter in the final three columns of the chart. Return to the questions column and see if any student questions were answered in the first lessons. Fill in the What We Did, What We Learned, and How This Helps Us to Figure Out the Phenomenon columns. Check for understanding that the majority of earthquakes occur along the boundaries of the tectonic plates. Review questions that remain to be answered and what questions they have already answered.

Have the students complete the Journal Entry.

Pre-Writing Strategy
In their groups of four, have the students discuss their ideas of what they learned and still want to know. Give them sufficient time to orally express what they have learned and are still curious about and to listen to the ideas of others.

CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.

- **Construct an explanation using models or representations.**
- **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.

HISTORY/SOCIAL STUDIES, SCIENCE, AND TECHNICAL SUBJECTS WRITING STANDARDS—GRADES 6–8

Text Types and Purposes
WHST.6–8.A: Write arguments based on discipline-specific content.

WHST.6–8.1.A: Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.

WHST.6–8.1.B: Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

Journal Entry

1. *Through the mapping of earthquake data, I figured out…*
2. *The data provided evidence about…*
3. *I still have questions about…*
4. *I was surprised about…*

Assessment: Formative

Use the class Science Talk and Journal Entry to assess the students' initial understanding of how earthquakes occur.

Use the world map, class discussion, and Journal Entry to assess the students' ability to identify patterns in data and analyze information from data tables and graphs to answer scientific questions.

ENGINEERING DESIGN PROCESS

The Engineering Design Process provides students with a series of steps to guide them as they solve problems and design and test products, models, and solutions. The process is cyclical, yet not necessarily in an order. Students are encouraged to evaluate as they progress through the process, revisit the mission often, and revise thinking and their plan multiple times as the process unfolds.

Engineers do not always follow the Engineering Design Process steps in order, one after another. It is very common to design something, test it, find a problem, and then go back to an earlier step to make a modification or change the design. Engineers must always keep in mind the mission or problem they are trying to solve and the limitations (cost, time, material, etc.) that are part of the solution to the problem. Two key elements in working as an engineer are teamwork and design-test-and-redesign.

Mission
- Defines the problem and what the engineers are trying to design or build.
- Describes the limitations within which the engineers must solve the problem.

Brainstorm Ideas
- Imagine, discuss, and sketch possible solutions.
- Conduct research into what has already been done.
- Discover what materials are available, time frame, and other limitations.

Plan and Design
- Draw and write a plan.
- Design your solution through drawing and manipulating materials.
- Develop a plan or steps and a schedule.

Build
- Construct your engineering device or project.
- Follow your plan.
- Adjust and test along the way.

Test and Adjust
- Test your device to see if it solves the problem within the mission and limitations.
- Make your project better based on tests: Test → Revise → Test.
- Improve based on feedback of others.

Present Your Solution
- Demonstrate how your solution solves the problem.
- Define problems and limitations.
- Describe the challenges and limitations in solving the problem.
- Describe additional revisions that could improve the device or project.

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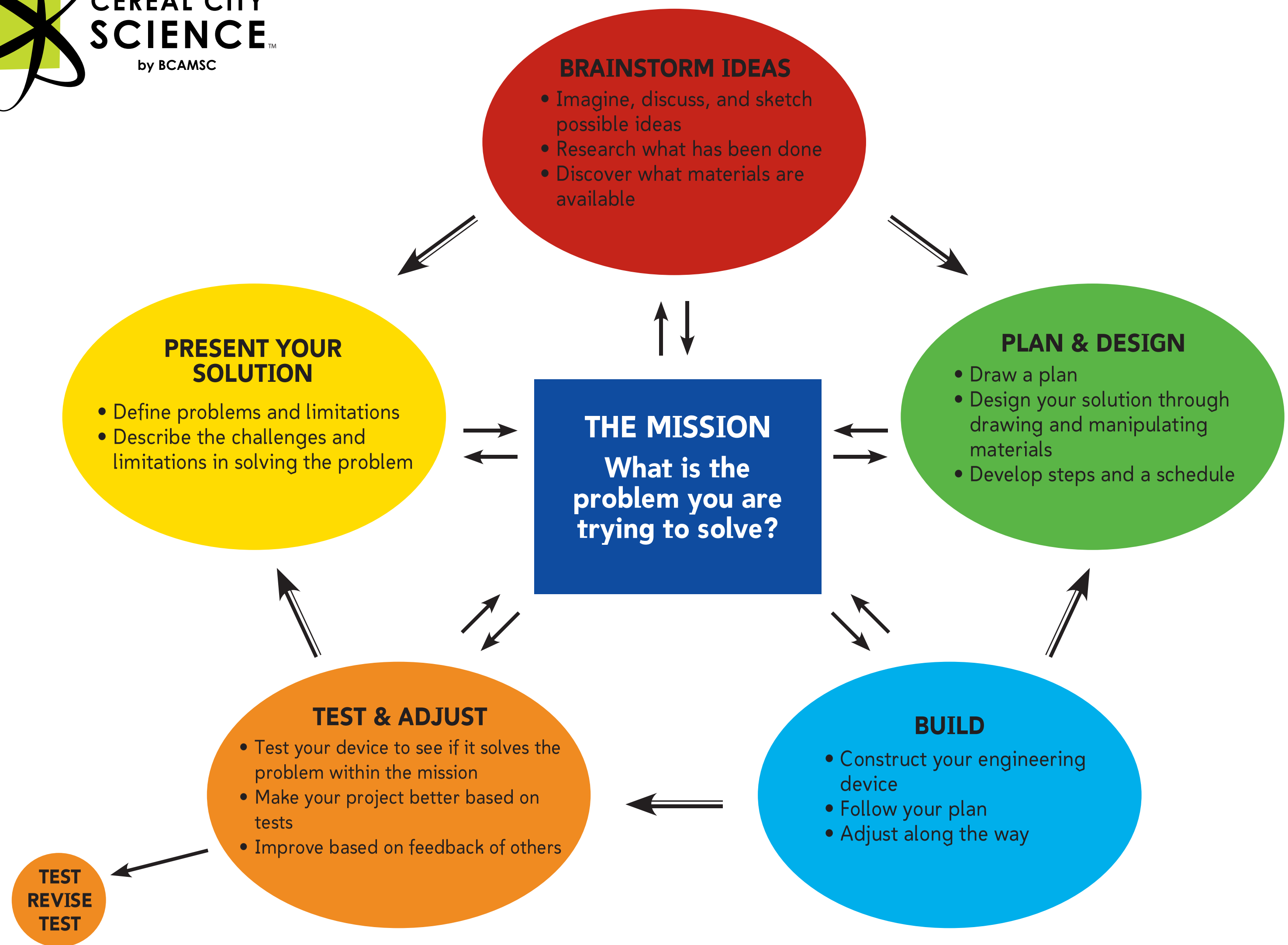
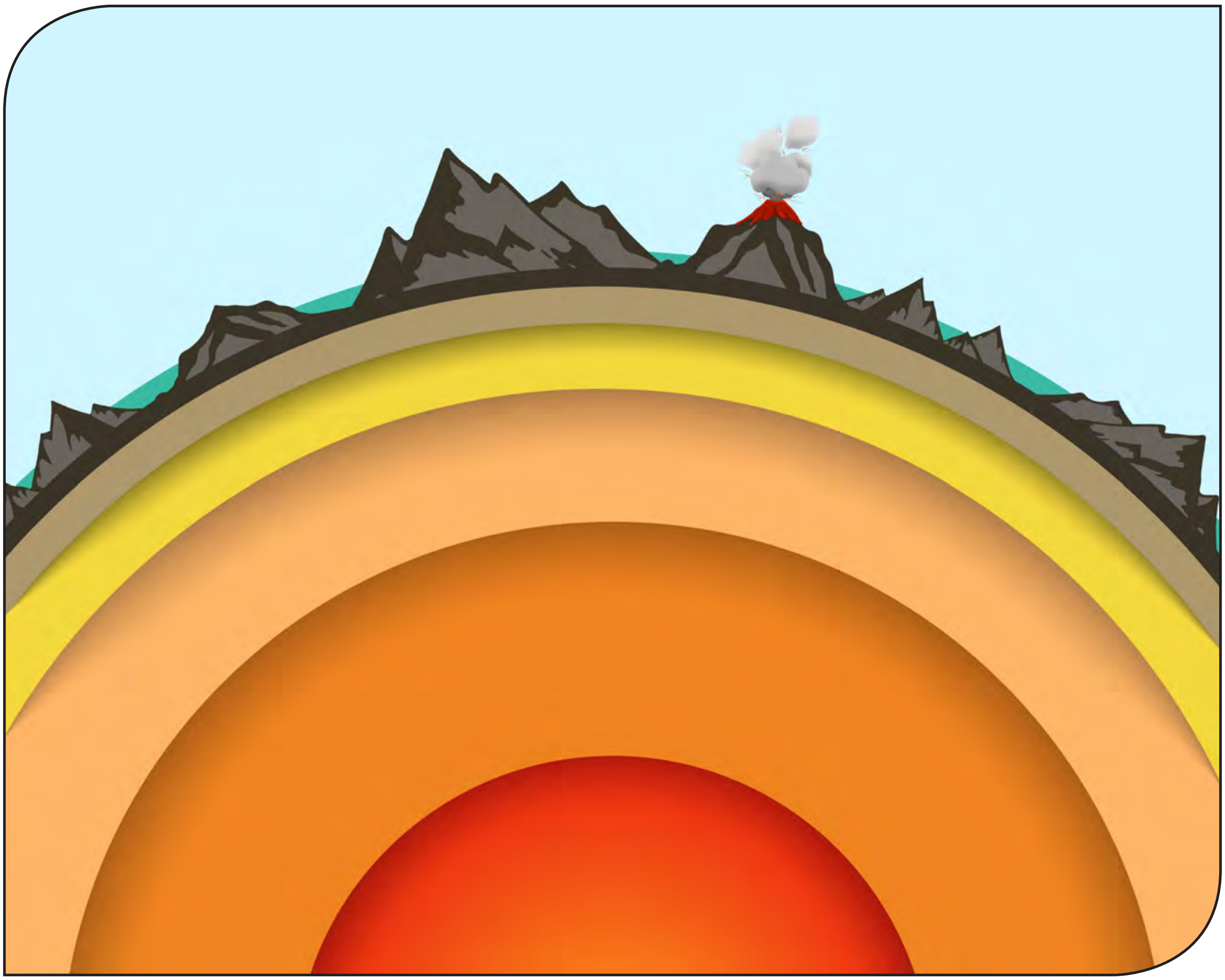
ENGINEERING DESIGN PROCESS



by Battle Creek Area Mathematics and Science Center
Cereal City Science
Adopted from the Carnegie Mellon Robotics Academy

Student Journal
MS.ES.NGSS

History of Earth
MSENG1



A Middle School Unit supporting Next Generation Science Standards and Michigan Science Standards

Name:

Name: ____________________

Date: ____________________

A C T I V I T Y **1A**
A Shaky Day in San Francisco

Record your ideas and questions about your observations of the San Francisco earthquake. Include key terms and ideas that you think are important to understanding the phenomenon.

Observations	Questions

1A ACTIVITY
A Shaky Day in San Francisco

Name: ______________________

Date: ______________________

Work with your group and use the space below to draw and label a model that explains what caused the earthquakes to happen in San Francisco. Include the unobservable mechanisms that help explain the phenomenon. Share your individual ideas with your group to develop a group model that includes ideas of all members.

Name: ______________________________

Date: ______________________________

Work with your group and use the space below to draw and label a revised model that explains what caused the earthquakes to happen in San Francisco. Include any new information you gathered from mapping the earthquakes over the past year. Remember that models include the unobservable mechanisms that help explain the phenomenon.

1B ACTIVITY Mapping Earthquakes

Name: ______________________________

Date: ______________________________

1. Through the mapping of earthquake data, I figured out...

2. The data provided evidence about...

3. I still have questions about...

4. I was surprised about ...