**Teacher Guide and Student Journal**
SampleActivity and Planning Pages

# Interactions Among Earth & Space Systems: Earth Systems MSENG3-Earth

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

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## MSENG3-Earth

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

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

CEREAL CITY SCIENCE™ by BCAMSC

# Interactions Among Earth & Space Systems: Earth Systems

## Pre-Activity Information Pages



## Activities



## Appendix

## NEXT GENERATION SCIENCE STANDARDS

| DISCIPLINARY CORE IDEAS/PERFORMANCE ASSESSMENTS | Activity |
|---|---|
| **ESS2.A: Earth's Materials and Systems**<br>• 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. | 2,5,6,7 |
| MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. | 2,3,5,6,7 |
| **ESS2.C: The Roles of Water in Earth's Surface Processes**<br>• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, precipitation, as well as downhill flows on land.<br>• Global movement of water and its changes in form are propelled by sunlight and gravity. | 1,2,3 |
| MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. | 1,2,3,4 |
| **ESS3.A: Natural Resources**<br>• 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. | 1,2,3,4,5,6,7 |
| MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy (fossil fuels), and groundwater resources are the result of past and current processes. | 6,7 |

## NEXT GENERATION SCIENCE STANDARDS

| SCIENCE AND ENGINEERING PRACTICES/PERFORMANCE ASSESSMENTS | |
|---|---|
| **Developing and Using Models**<br>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.<br>• Develop and use a model to describe phenomena.<br>• Develop a model to describe unobservable mechanisms. | 1,2,3,5,6,7 |
| MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. | 1,2,3,5,6,7 |
| MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. | 1,2,3,5,6,7 |
| **Constructing Explanations and Designing Solutions**<br>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 ideas, principles, and theories.<br>• Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe natural world operate today as they did in the past and will continue to do so in the future. | 2,3,4,5,6 |
| MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy (fossil fuels), and groundwater resources are the result of past and current processes. | 6,7 |
| **Analyzing and Interpreting Data**<br>Analyzing and interpreting 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.<br>• Analyze and interpret data to determine similarities and differences in findings. | 1,3,4,5 |
| MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy (fossil fuels), and groundwater resources are the result of past and current processes. | 6,7 |

## NEXT GENERATION SCIENCE STANDARDS

| CROSSCUTTING CONCEPTS/PERFORMANCE ASSESSMENTS | Activity |
|---|---|
| **Cause and Effect**<br>• Cause and effect relationships may be used to predict phenomena in natural or designed systems | 1,2,3,4,5,6,7 |
| MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy (fossil fuels), and groundwater resources are the result of past and current processes. | 7 |
| **Energy and Matter**<br>• Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. | 1,2,3,6,7 |
| MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. | 2,3,5,6,7 |
| **Stability and Change**<br>• Explorations 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. | 3,6,7 |
| MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. | 3,6,7 |

## COMMON CORE STATE STANDARDS—READING

| READING SCIENCE AND TECHNICAL SUBJECTS—GRADES 6–8 | Activity |
|---|---|
| **Key Ideas and Details** | |
| RST.6–8.1: Cite specific textual evidence to support analysis of science and technical texts. | 2,3,5,6,7 |
| RST.6–8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. | 2,3,4,5,6,7 |
| RST.6–8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. | 3 |
| **Craft and Structure** | |
| RST.6–8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics. | 2,3,5,6,7 |
| RST.6–8.5: Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic. | |
| RST.6–8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text. | |
| **Integration of Knowledge and Ideas** | |
| RST.6–8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). | 2,3,5,6,7 |
| RST.6–8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. | 7 |
| RST.6–8.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. | 2,3,4,5,6,7 |
| **Range of Reading and Level of Text Complexity** | |
| RST.6–8.10: By the end of grade 8, read and comprehend science/technical texts in the grades 6–8 text complexity band independently and proficiently. | 2,3,5,6,7 |

## COMMON CORE STATE STANDARDS—WRITING

| HISTORY/SOCIAL STUDIES, SCIENCE, AND TECHNICAL SUBJECTS WRITING STANDARDS—GRADES 6–8 | Activity |
|---|---|
| Text Types and Purposes | |
| WHST.6–8.1: Write arguments focused on discipline-specific content. | 7 |
| 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. | 2,3,4,5,7 |
| 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. | 2,3,4,5,6,7 |
| WHST.6–8.1.C: Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence. | 2,3,4,5,6,7 |
| WHST.6–8.1.D: Establish and maintain a formal style. | |
| WHST.6–8.1.E: Provide a concluding statement or section that follows from and supports the argument presented. | 5,6,7 |
| WHST.6–8.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. | 1,2,3,5,6,7 |
| WHST.6–8.2.A: Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension. | 2,3,4,5,6,7 |
| WHST.6–8.2.B: Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. | 2,7 |
| WHST.6–8.2.C: Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts. | 4,5,6,7 |
| WHST.6–8.2.D: Use precise language and domain-specific vocabulary to inform about or explain the topic. | 7 |
| WHST.6–8.2.E: Establish and maintain a formal style and objective tone. | 7 |

## COMMON CORE STATE STANDARDS—WRITING

| | |
|---|---|
| WHST.6–8.2.F: Provide a concluding statement or section that follows from and supports the information or explanation presented. | 6,7 |
| Production and Distribution of Writing | |
| WHST.6–8.4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. | 3,4,5,6,7 |
| WHST.6–8.5: With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. | 4,7 |
| WHST.6–8.6: Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. | 4,7 |
| **HISTORY/SOCIAL STUDIES, SCIENCE, AND TECHNICAL SUBJECTS WRITING STANDARDS—GRADES 6–8** | **Activity** |
| Research to Build and Present Knowledge | |
| WHST.6–8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. | 2,4,6,7 |
| WHST.6–8.8: Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. | 2,3,4,6,7 |
| WHST.6–8.9: Draw evidence from informational texts to support analysis, reflection, and research. | 2,3,4,7 |
| 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. | 1,3,5,6,7 |

## COMMON CORE STATE STANDARDS—MATHEMATICS

| MATHEMATICS—GRADES 6–8 | Activity |
| --- | --- |
| **Mathematical Practices** | |
| 1. Make sense of problems and persevere in solving them. | 1,2,3,4,5,6,7 |
| 2. Reason abstractly and quantitatively. | 1,2,3,4,5,6,7 |
| 3. Construct viable arguments and critique the reasoning of others. | 2,3,4,5,6,7 |
| 4. Model with mathematics. | 1,2,3 |
| 5. Use appropriate tools strategically. | 1,2,3,4,5,6,7 |
| 6. Attend to precision. | 1,2,3,4,5,6,7 |
| 7. Look for and make use of structure. | 1,2,3,4,5,6,7 |
| 8. Look for and express regularity in repeated reasoning. | 2,3,4,5,6,7 |

## UNIT AT A GLANCE

| Activity | Time to Complete | Lesson Level Learning Goal | Phenomena | Summary: Students will . . . |
|---|---|---|---|---|
| 1 Cracks in the Earth | Preparation: 30 minutes<br>Activity: 5 classes<br>Lesson 1A : 55–60 min., 2 classes<br>Lesson 1B: 55–60 min., 2 classes<br>Lesson 1C: 55–60 min | Develop an initial model of how cracks form in the Earth's crust caused by groundwater use. | Cracks in the surface of the Earth. | • Make observations of a video to obtain information.<br>• Raise questions about water and the effect of pumping water from below the surface of the Earth.<br>• Share ideas from previous knowledge and experiences.<br>• Determine their own water footprint.<br>• Map cracks in the Earth across the world and make comparisons to tectonic plates. |
| 2 Where Does Our Water Come From? | Preparation: 20 minutes<br>Activity: 8 classes<br>Lesson 2A: 55–60 min., 2 classes<br>Lesson 2B: 55–60 min. 2 classes<br>Lesson 2C: 55–60 min. 2 classes<br>Lesson 2D: 55–60 min., 2 classes | Obtain information and develop and use models to figure out how water moves beneath the Earth's surface.<br>Determine the cause and effect relationship between human dependency on fresh water and changes in the Earth and availability of this resource. | Cracks in the surface of the Earth. | • Read articles by USGS.<br>• Use Note-taking strategies to obtain and organize information.<br>• Share findings from reading.<br>• Revise initial models based on new information.<br>• Define key terms using text clues.<br>• Develop a working aquifer/ groundwater model using limited materials and information from graphics and text.<br>• Make changes and improvements based on tests and feedback.<br>• Use SageModeler to show causal relationship between changes in the amount of water and the surface of Earth. |
| 3 The Water Cycle | Preparation: 20 minutes<br>Activity: 4-5 classes<br>Lesson 3A: 55–60 min., 2 classes<br>Lesson 3B: 55–60 min., 2–3 classes<br>Lesson 3C: 55–60 min., 2 classes<br>Lesson 3D: 55–60 min., 2 classes | Use models to explain how the movement of water (water cycle) is part of the aquifer system and is propelled by sunlight and gravity.<br>Obtain information to figure out how the groundwater supply is replenished. | Cracks in the surface of the Earth. | • .Broaden their understanding of how water cycles through an experience as a water droplet in role-play.<br>• Determine the processes that move water throughout land, water, air, and living things.<br>• Analyze and interpret data to find out how much water on Earth is usable by living things.<br>• Obtain further information through text.<br>• Define key terms to explain the water cycle.<br>• Use SageModeler to explain the transfer of energy that drives the motion and cycling of water. |

## UNIT AT A GLANCE

| Students Figure Out How to: | Practice/Crosscutting Concepts | Assessment |
|---|---|---|
| • Develop an initial model that explains what caused the crack in the Arizona desert.<br>• Use a chart to figure out their own water footprint.<br>• Use longitude and latitude to figure out the location of cracks in the Earth.<br>• Compare and contrast the location of the cracks with the location of the tectonic plates.<br>• Determine if tectonic motion is responsible for some cracks. | **Asking Questions and Defining Problems**<br>**Developing and Using Models**<br>**Analyzing and Interpreting Data**<br>**Cause and Effect**<br>**Systems and System Models**<br>**Energy and Matter**<br>**Patterns** | **Formative Assessment**<br>Initial models<br>Questions chart<br>Activity Pages<br>Revised Models<br>Science Talk<br>Journal Entry |
| • Determine the main idea and supporting details from USGS articles.<br>• Recognize the components that interact within the system model.<br>• Test working aquifer/groundwater models for accurate simulation of the natural system.<br>• Recognize common components within the system model.<br>• Use models to find out the effect of extracting water from the aquifer.<br>• Represent unobservable mechanisms within a model.<br>• Develop before-during-after models. | **Developing and Using Models**<br>**Asking Questions and Defining Problems**<br>**Obtaining, Evaluating, and Communicating Information**<br>**Constructing Explanations and Designing Solutions**<br>**Cause and Effect**<br>**Energy and Matter**<br>**Systems and System Models** | **Formative Assessment**<br>Activity Pages<br>Science Talk<br>Revised models<br>Group presentations<br>Journal Entry |
| • Use experience and information from role-play to recognize the observable and unobservable (gravity, sunlight, energy) mechanisms that move water throughout Earth's systems.<br>• Develop a model to explain how kinetic energy form the sun transfers to potential and kinetic energy in water. | **Obtaining, Evaluating, and Communicating Information**<br>**Developing and Using Models**<br>**Constructing Explanations and Designing Solutions**<br>**Cause and Effect**<br>**Systems and System Models**<br>**Energy and Matter** | **Formative Assessment**<br>Science Talk<br>Activity Pages<br>Card set models<br><br>**Summative Assessment**<br>Journal Entry<br>Group charts<br>SageModeler<br>Science Talk |

## UNIT AT A GLANCE

| Activity | Time to Complete | Lesson Level Learning Goal | Phenomena | Summary: Students will . . . |
|---|---|---|---|---|
| 4 What is the Water Source for Your Community? GeoInquiry Project | Preparation: 20 minutes<br>Activity: 5–6 classes<br>Lesson 4A: 55–60 min., 2 classes<br>Lesson 4B: 55–60 min., 8–12 classes | Obtain information about the local community water source.<br>Determine threats to the water source and develop a plan to protect the local water. | **Cracks in the surface of the Earth.** | • Research the water source in their community.<br>• Engage in a Geo-Inquiry investigation.<br>• Choose a question to investigate that is local and of interest.<br>• Investigate on a team.<br>• Develop a Geo-Inquiry story and present to an appropriate audience.<br>• Explain why the question/inquiry is important |
| 5 Beyond Water–What About Rocks? | Preparation: 20 minutes<br>Activity: 4 classes<br>Lesson 5A: 55–60 min., 2 classes<br>Lesson 5B: 55–60 min. 2 classes | Raise questions about rocks and minerals and how they are formed. | **Cracks in the surface of the Earth.**<br>"rocks that can naturally be dissolved by groundwater circulating through them. As the rock dissolves, spaces and caverns develop underground." | • Make observations and compare rocks and minerals.<br>• Make observations of the properties of rocks<br>• Ask questions about the make-up of rocks and how they are formed<br>• Obtain information about rocks from text. |
| 6 Exploring Weathering, Sediments, and How Rocks are Formed | Preparation: 20 minutes<br>Activity: 12–14 classes<br>Lesson 6A: 55–60 min., 2 classes<br>Lesson 6B: 55–60 min., 2 classes<br>Lesson 6C: 55–60 min., 3–4 classes<br>Lesson 6D: 55–60 min., 3 classes<br>Lesson 6E: 55–60 min., 2– 3 classes | Use models to explain how rocks and minerals are formed and how they are distributed unevenly around the planet.<br>Develop a model that explains the energy flow and possible pathways that matter may travel through the rock cycle. | **Cracks in the surface of the Earth.**<br>"rocks that can naturally be dissolved by groundwater circulating through them. As the rock dissolves, spaces and caverns develop underground." | • Make observations and comparisons of sediments and different rocks.<br>• Revise initial models of how sediments form.<br>• Obtain information about sedimentary, metamorphic, and igneous rocks.<br>• Write a summary paragraph of how the three different types of rocks are formed and cite text to support their claim. |

## UNIT AT A GLANCE

| Students Figure Out How to: | Practice/Crosscutting Concepts | Assessment |
|---|---|---|
| • Develop a Geo-Inquiry question about the water source in their community.<br>• Develop a plan to collect data to answer their question.<br>• Organize and analyze data<br>• Use maps to locate key water sources and facilities.<br>• Develop and present their findings in a Geo-Inquiry story. | **Obtaining, Evaluating, and Communicating Information**<br>**Constructing Explanations and Designing Solutions**<br>**Analyzing and Collecting Data**<br>**Planning and Carrying Out Investigations**<br>**Asking Questions and Defining Problems**<br>**Cause and Effect** | **Formative Assessment**<br>Geo-Inquiry Questions<br>Journal Entry<br><br>**Summative Assessment**<br>Geo-Inquiry Questions (final)<br>Activity pages<br>Analyzing Data Worksheet<br>Geo-Inquiry presentations<br>Journal Entry |
| • Use observations of properties of rocks to determine that rocks are formed in different ways.<br>• Develop models to explain their initial ideas of what rocks are made of.<br>• Make revisions to models based on new information.<br>• Use observations to construct explanations that rocks are made from minerals and that some rocks and minerals dissolve in water. | **Developing and Using Models**<br>**Obtaining, Evaluating, and Communicating Information**<br>**Constructing Explanations and Designing Solutions**<br>**Systems and System Models**<br>**Energy and Matter**<br>**Cause and Effect** | **Formative Assessment**<br>Questions We Have chart<br>initial models<br>Science Talk<br>Activity Pages<br>Journal Entry<br><br>**Summative Assessment**<br>Science Talk<br>Journal Entry<br>revised models<br>class chart |
| • Construct explanations abut how rocks form under pressure, pressure and heat, and great heat.<br>• Use crayons and tools to model weathering.<br>• Plan and carryout a procedure to make crayon sediments into models of sedimentary, metamorphic, and igneous rocks.<br>• Develop a model to compare and contrast how sedimentary, metamorphic, and igneous rocks are formed.<br>• Plan and develop a role-play or interactive game that explains the rock cycle. | **Developing and Using Models**<br>**Asking Questions and Defining Problems**<br>**Obtaining, Evaluating, and Communicating Information**<br>**Constructing Explanations and Designing Solutions**<br>**Cause and Effect**<br>**Scale, Proportion, and Quantity**<br>**Systems and System Models** | **Summative Assessment**<br>Science Talk<br>Journal Entries<br>rock models<br>Activity Page<br>Rocking With the Rock Cycle Game |

## UNIT AT A GLANCE

| Activity | Time to Complete | Lesson Level Learning Goal | Phenomena | Summary: Students will . . . |
|---|---|---|---|---|
| 7 Beyond Water–Removing Resources from the Ground | Preparation: 20 minutes<br>Activity: 5–6 classes<br>Lesson 7A: 55–60 min., 2 classes<br>Lesson 7B: 55–60 min., 3–4 classes | Obtain information from text and media to figure out the effect of human dependence on Earth's resources. | **Cracks in the surface of the Earth.** | • Choose an Earth material (natural resource) to investigate.<br>• Plan and follow a Research Product Descriptor<br>• Present research |

## UNIT AT A GLANCE

| Students Figure Out How to: | Practice/Crosscutting Concepts | Assessment |
|---|---|---|
| • Use research information to figure out how the material is made, where it is found, why it is found there, how it is extracted and how it is used.<br>• Develop a model that explains the flow of energy and cycling of matter to produce an Earth material. | **Developing and Using Models**<br>**Asking Questions and Defining Problems**<br>**Constructing Explanations and Designing Solutions**<br>**Obtaining, Evaluating, and Communicating Information**<br>**Cause and Effect**<br>**Energy and Matter**<br>**Systems and System Models** | **Formative Assessment**<br>Activity Page<br><br>**Summative Assessment**<br>Science Talk<br>Research Presentation<br>Presentation Product Descriptor<br>Journal Entry |

# Cracks in the Earth

**Teacher Background Information**
Students begin their exploration through the lens of large cracks that occurred quickly in the desert of Arizona. They begin to think about water usage, where it comes from, and if it is possible to run out of water. The initial lessons in this unit help to serve as a formative assessment of knowledge your students bring from previous science units and experiences.

Through the initial phenomenon of cracks in the Earth, students explore their own water usage and water usage in industry and manufacturing. The human impact on water supply leads to investigations into the flow of energy throughout the Earth's systems (geosphere, hydrosphere, atmosphere, and biosphere) and the cycling of water and other resources.

**Engage the Learner**
The initial phase of the learning cycle is intended to engage students in thinking about water usage, water sources, and real-world activity that humans engage in that has an effect on Earth's resources (water). The lesson activates prior knowledge regarding Earth's resources and human impact on Earth's systems. Prior to investigating the question "Are we running out of water?", students develop initial models, raise questions and establish what they need to know regarding sources of water, Earth's systems, and water usage to better understand how and why it is necessary for humans to protect the environment.

**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 cracks in the Earth occur. | Student initial questions about cracks in the Earth | 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. |

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

## LESSON LEVEL LEARNING GOAL
Develop an initial model of how cracks form in Earth's crust caused by groundwater use.

## MATERIALS NEEDED
**For each student:**
- student pages

**For each group of 4:**
- chart paper/whiteboards
- markers
- Post-It Notes

**For the class:**
- Internet access

**Teacher provides:**
- chart paper/whiteboards
- markers
- Post-It Notes
- Internet access

## 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)

**ESS2.C: THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES**

- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, precipitation, as well as downhill flows on land.
- Global movement of water and its changes in form are propelled by sunlight and gravity.

**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.

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 Crack in the Arizona Desert

**Procedure**

*Engage the learner.*

Introduce the unit by asking the students to observe a video about a discovery in a desert in Arizona. Encourage students to listen and observe with a focus on what they understand about deserts, water, water sources, and how water is used and where it comes from.

Show the video: H2O: The Molecule That Made Us | Cracks in the Earth | PBS

https://www.youtube.com/watch?v=eE4o80xAfcQ&t=31s

Have students refer to the Student Journal.

*Record your ideas and questions about your observations of the cracks in the Arizona desert. Include key terms and ideas that you think are important to understanding the phenomenon.*

| *Observations* | *Questions* |
|---|---|
| | |
| | |

Divide the class into groups of four and allow time for students to discuss the phenomenon of cracks in the Earth. Encourage students to share their observations from the video and discuss their initial ideas of the cause of the cracks.

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 crack? What makes you think that?
- Does anyone have similar or different ideas about the cause of the cracks?
- Tell me what you already know about cracks and what causes them to occur?
- Can someone describe an observation or idea everyone had in common after viewing the video?
- What information did you obtain about the water source for the irrigation of the desert? Can someone add on to ______'s idea?

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 a crack in the Earth.

*Develop a model that explains what caused the crack in the Arizona desert. Remember, models are used to show the visible and invisible components within the model system and the interactions of the components.*

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 cracks in the Earth to happen in Arizona. 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 to develop the model that represents their collective thinking to look, distribute chart paper or whiteboards and markers (or assign a Jamboard) for them to develop a model to share with the class. Encourage groups to write questions that come up during the model development. Distribute Post-It Notes to each group and encourage students to write the questions about cracks in the earth, water sources, groundwater, etc. 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 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.

**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 ground water and water sources. Make note of students' ideas about the cause of cracks. Some students may refer to the movement of the tectonic plates from previous experiences.

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.**
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

**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.**

**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 terms *tectonic plates, ground water, and fissures* in student discussions about cracks in the Earth. Make a note of how students used the terms to use as a reference in the following lesson.

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…?

After the completion of the anchor questioning charts, conduct a gallery walk of the group models. 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 explanations 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 cracks in the Earth and water sources?
- What do you mean when you say _______________?
- How might where you live affect your chances of experiencing a crack in the Earth?
- What do the arrows represent on your model? Did anyone else have a similar idea for using arrows?
- ___________________, I heard you say the water moves. What do we know about motion that applies to the motion of water? What is the force?

Display the What We Think chart. Explain that the class has modeled and discussed their initial ideas about cracks in the earth 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 cracks in the Earth 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. 43.)

To help students collectively raise questions about cracks in the Earth and where they occur, ask:

- What questions do we need to answer to figure out where and why large cracks 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 as they can think of about cracks in the Earth and groundwater. Distribute Post-It Notes to each group. Ask students to use scrap paper or Student Journals and write as many questions as they can think of about cracks in the Earth and how, why, and where they might happen. Then collaborate to find four or five of the most pressing questions to write on the Post-It 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

### 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. 172-73, on setting up your class for Science Talk.

### ENERGY AND MATTER

- **Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.**

**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.

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:

- cause
- location
- damage
- water sources/groundwater
- irrigation
- desert
- shifting tectonic plates
- water use
- where water comes from
- limited resource/running out of water

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.

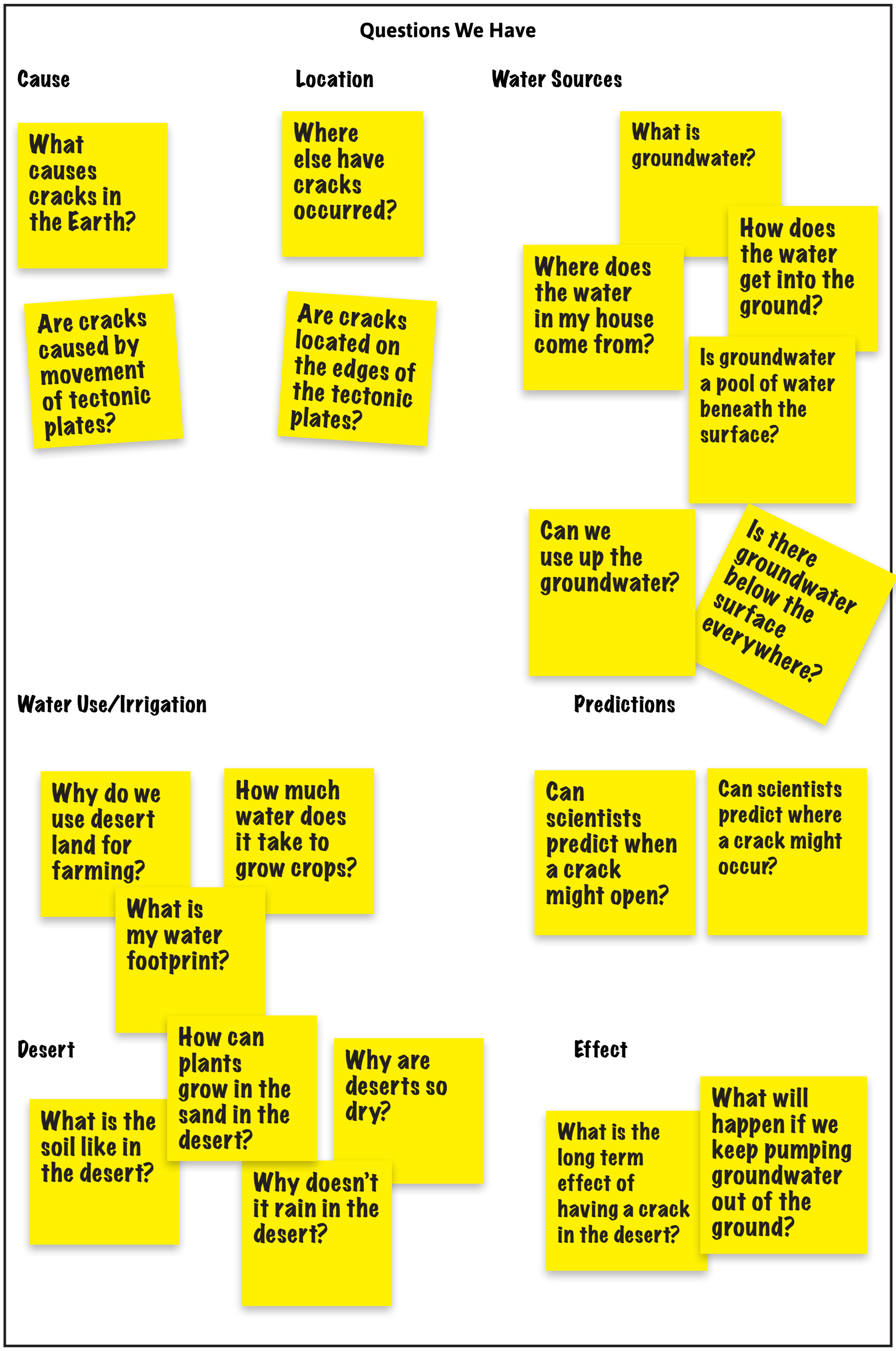
Take this opportunity to develop with the class the overarching driving question that will drive the following lessons. The driving question should be broad enough that the individual questions are incorporated into the broader question. The driving question may include questions similar to the following:

- What causes the cracks in the Earth?
- Are we running out of water?

This may also be a good opportunity to develop a class definition of the term *natural resource*. Write the term on the board and, after the class is satisfied with their definition, 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 the phenomenon.

Sample Questions We Have chart:




## 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.

## 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 a representation of forces and motion, a representation of layers of the Earth's crust, a representation of ground water, and/or a representation of sediments and soils? Do initial models include representations or symbols to show interactions of the components in the system?

## Lesson 1B: What is Your Water Footprint?

**Teacher Background Information**
Exploration into student questions begins with their questions in the water use category. Students may have questions about their own water usage and where their water comes from. This lesson provides opportunities to calculate the household use of water and water usage in the classroom, and to explore the source of water that provides water to the taps within the community.

The following lessons are intended to not only extend student thinking beyond their own and household use of water, but to consider and gather information about how much water is used to grow our food and make our clothes and the products we use on a daily basis. Their investigations into water use include research and reaching out to the community for information.

Students are encouraged to survey water usage and availability within the community including businesses, manufacturing, restaurants, and medical facilities.

In the 5th Grade Unit, *Earth and Space Systems*, students investigated the use of water within their household and developed an investigation into classroom use of water. In this unit, students review and build on their previous experience and investigate water use beyond personal, household, and classroom use.

The crosscutting concept, Energy and Matter is an important idea that can help in a deeper understanding of Earth materials and systems. As students develop models of different systems within the context of Earth's process, they can follow the flow of energy and cycling of matter within and outside of systems. They begin to recognize that matter and energy are conserved and flow within systems and can move in and out of systems. The use of Energy and Matter as a tool for learning enables students to recognize the connections among Earth's systems and beyond.

**Explore the concept**
During this phase of learning, students explore and investigate the answers to their questions. Students actively explore, investigate, and research water usage, water resources, and how water cycles through the Earth's systems.

**Advance Preparation**
Preview the video *$H_2O$: The Molecule That Made Us*:

https://www.youtube.com/watch?v=4HC6bibnw6o&t=8s

Become familiar with the water calculator program:

https://www.watercalculator.org/wfc2/q/household/

### MATERIALS NEEDED

**For each student:**
student page

**For the class:**
Internet

**Teacher provides:**
chart paper
markers
Internet
Post-it Notes

### 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)

### ESS2.C: THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES

- **Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, precipitation, as well as downhill flows on land.**
- Global movement of water and its changes in form are propelled by sunlight and gravity.

### 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. 172-73, on setting up your class for Science Talk.

**Procedure**

*Explore the concept.*

Review the questions from the What We Think chart. Focus on questions that relate to water use. Ask students to brainstorm ideas of how they use water. Have students make an individual list and then invite them to calculate their household water usage using the water calculator:

https://www.watercalculator.org/wfc2/q/household/

After all the students have had the opportunity to complete their lists and use the calculator, divide the class into groups to share their lists and findings from the household water calculator. Facilitate the group sharing by circulating among the students and listening to their ideas. As groups complete their sharing of ideas, ask them to consider where the water comes from. Make notes of their ideas and comments about water use and water sources to use in the Science Talk that follows later in the lesson. To help students expand their thinking, ask:

- What are the common uses among the group?
- Did anyone think about uses of water beyond what we use in our homes?
- Where does all that water come from?
- Can you expand on that idea?
- We know that it takes water to grow plants, what about making things?
- How might we find out?
- What questions do we have that we need to figure out?

**Science Talk**

After all groups have shared ideas, conduct a whole class discussion to share and compare ideas. Invite the class to form a circle so all students are facing one another and no students have their back to another student. To help the students collectively make sense of their ideas and findings, ask:

- Would someone like to share an unexpected finding in our water use?
- ______________, I heard you say, _____________ in your group discussion. Can you share that idea with the rest of the class?
- Can someone add on to ______________'s idea?
- What activity did you find is the most common? How much water does it take to complete that activity?
- Did any group discuss water uses beyond the household or classroom? What about the school as a whole?
- Do you think water is used to make other things?
- Can you elaborate on that idea?
- Who can add on to ______'s idea?

- Can we use water from anywhere for drinking, washing, and making things? Why not?
- Could the farmers in the desert use a different water source?

Following the discussion, review the What We Think chart and the Questions We Have column. Ask students if they have additional questions based on their exploration and discussion about water use and water sources. Make additions to the questions column as suggested by the students.

Explain that the class will view another video to gain information into water use and where water comes from. Have students use the chart in the Student Journal to record the observations and questions that arise from viewing the video.

https://www.youtube.com/watch?v=4HC6bibnw6o&t=8s

*Record your ideas and questions about your observations of the water used to grow tomatoes. Include key terms and ideas that you think are important to understanding the phenomenon.*

| *Observations* | *Questions* |
|---|---|
| | |
| | |

At the conclusion of the video, ask students to return to their groups and share their observations and questions. Distribute Post-It Notes to each group and encourage them to add questions to the notes to post on the What We Think Chart.

Facilitate the group discussion by circulating among the students and listening to their ideas and questions. To help the group discussion get started and to raise additional questions, ask:

- What are some of the common observations that most or all of you thought were important?
- Why do you think that idea is important?
- We found out that it takes a lot of water to grow tomatoes. What do you think that water use does to the water supply?

Allow sufficient time for all groups to complete their sharing and raise further questions based on the information in the video. Additional questions may include:

- Why does it take so much water to make stuff?
- Where does the water come from for manufacturing?
- Is any of the water for manufacturing able to be reused?
- What is the water footprint for making ___________?
- Will the lake ever fill with water again?
- Why didn't rain water (the water cycle) replenish the water in the lake?

**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)

**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.

**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.**

**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.

Take this opportunity to record their new information on the What We Figured Out column of the What We Think chart. Ask students to review the questions and what they have figured out so far and help determine what new information they need to figure out the cause and effect relationship between the cracks in the Earth and water use.

Ask students to revisit their initial models of the cause of the crack in the Earth in Arizona. Allow sufficient time for students to make additions and revisions and share their revised models in a gallery walk. Review the anchoring questions charts and encourage students to ask questions and post comments on the revised models as they review each others' work.

Continue to check for symbols that relate to motion, forces, and energy within their models. If some students have started to make the connections, ask them to explain their thinking.

- _______________, I see that you included arrows in your model. What do they represent?
- Did anyone else have a similar idea?
- What causes the motion of the water? What do we know about motion and energy that might be important to include in our models?

**Assessment: Formative**
Use the Activity Page to assess the students ability to use media to obtain information and raise questions.

Use the revised cracks in the Earth models to assess the students' ability to develop and use a model to describe phenomena and include unobservable mechanisms (force, energy, motion, gravity).

## Lesson 1C: Mapping the Large Cracks in the Earth

**Teacher Background Information**
To gain a deeper understanding of cracks in the Earth and to begin to answer their questions, students begin to analyze real data and map the cracks on a world map.

**Explore the Concept cont.**
During this phase of the learning, students explore real data from cracks that have occurred around the world and compare the cracks with the map of the tectonic plates.

**Advance Preparation**
Preview the videos about cracks in the Earth:

https://www.youtube.com/watch?v=eE4o80xAfcQ&feature=emb_logo

http://www.bbc.com/earth/bespoke/story/the-cracks-ripping-earth-apart/index.html

https://www.youtube.com/watch?v=PITJoxhL0hs

https://www.youtube.com/watch?v=RG-wx-KYnTk

https://www.youtube.com/watch?v=z7YmnWHexTk

https://www.youtube.com/watch?v=El9zXXpZtCU

https://www.youtube.com/watch?v=lXVJy8jgg4I

https://www.youtube.com/watch?v=6841bFyEHwQ

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.

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

Show students the map of the world and give them the opportunity to find Arizona on the map.

Record any new ideas and add them to the students' initial ideas on the What We Think chart. Check for prior knowledge regarding the motion of the tectonic plates.

Return to the driving question: "Where do cracks in the Earth occur and Are We Running Out of Water?" Ask students for ideas of how they can find out. Explain that the locations of cracks can be found in different reports and sightings of cracks.

### MATERIALS NEEDED

**For each student:**
- student pages

**For the class:**
- world map
- tectonic plates map

**Teacher provides:**
- chart paper
- markers

**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.**

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

- Do you think there are scientists keeping track of where cracks in the Earth occur?
- What type of scientist would be interested in keeping track of cracks?
- How do you think we can access scientific data of significant cracks?

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 determining if there is a pattern in where cracks most often occur.

**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)**

Before engaging in plotting locations, 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 the crack in the Arizona desert.

After the students feel comfortable locating specific places on a map, divide the class into groups of three or four students. Assign a crack in the Earth video to each group.

Give the groups sufficient time to watch the video, find the location of the crack, and enter 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?
- What do you think about the number of cracks that have occurred?
- 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?

**Science Talk**
*Explain the concept and define the terms.*
As a class, share the experience of plotting the location of different cracks in the Earth. Ask:

- What information can we gather from the patterns we uncovered?

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

- Why are some areas of the world more prone to cracks than others?
- What made the Arizona desert likely to have a crack occur?

Give the class sufficient time to hypothesize if any patterns emerged on the map and what causes the patterns. Listen for ideas that relate to water use or plate tectonics. Some student preconceptions about cracks in the Earth and movement of plate tectonics 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 cracks occurred. Have students discuss their ideas about the cause-and-effect relationship between the location of the cracks 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 cracks 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 cracks in the Arizona desert. 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 cracks in the Earth to happen in the Arizona desert. Include any new information you gathered from mapping the cracks in the Earth. 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.

### TEACHING TIP

Plotting the cracks in the Earth on the classroom map may become a time-consuming task.

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 between the different classrooms; the students from each class can watch the data unfold and patterns begin to form.

### PATTERNS

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

### 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.~~
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

**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.**

**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.

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.

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.

**Journal Entry**

1. *Through the mapping of cracks in the Earth locations, I figured out…*
2. *I still have questions about…*
3. *I was surprised about…*

**Assessment: Formative**

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

Use the world map, class discussion, and Journal Entry to assess the students' ability to identify patterns in data and analyze information from media 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.

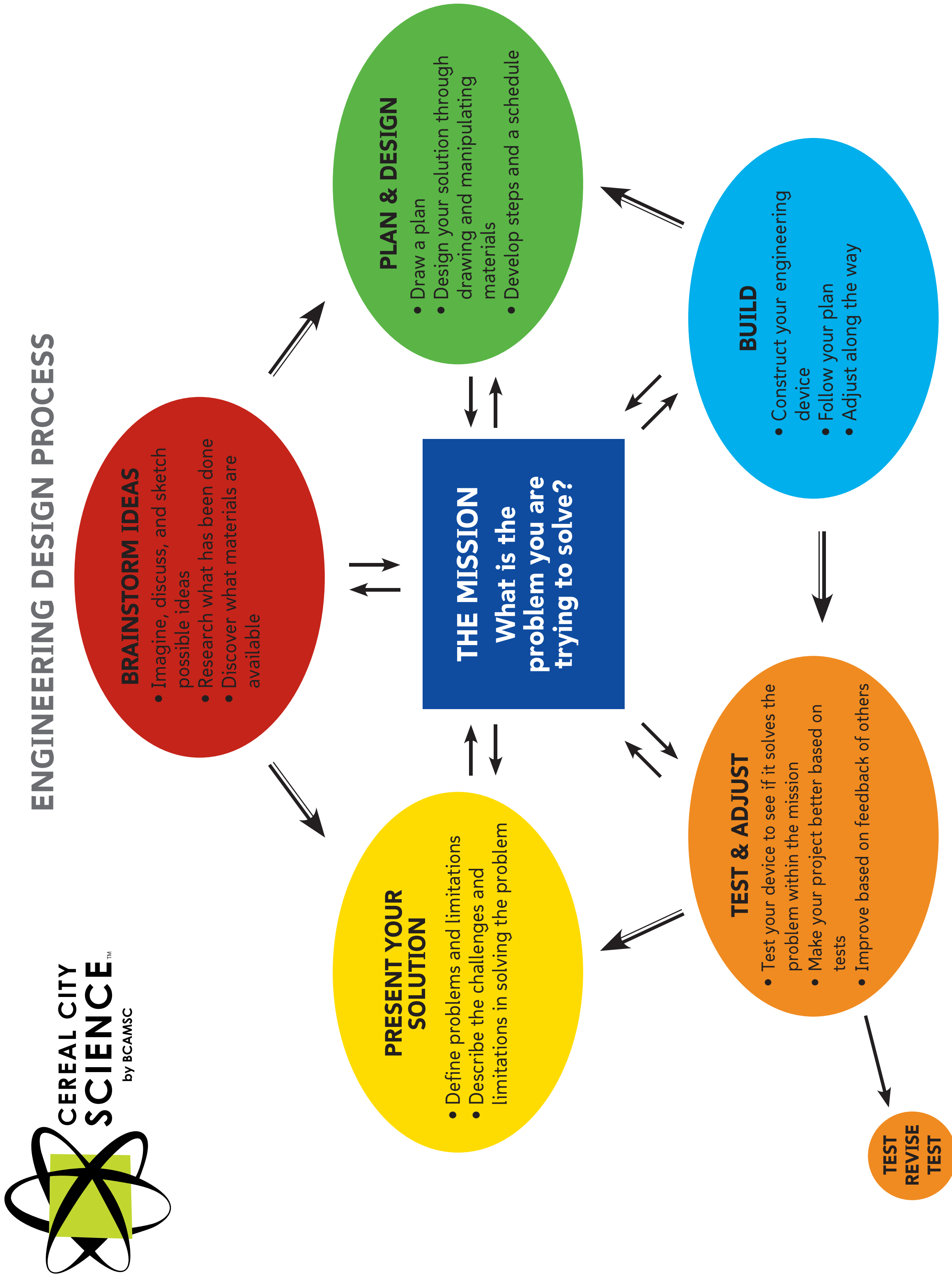
**Plan and Design**
- Draw and write a plan.
- Design your solution through drawing and manipulating materials.
- Develop a plan or steps and a schedule.

**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.

## ENGINEERING DESIGN PROCESS




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

CEREAL CITY SCIENCE by BCAMSC

**Student Journal**
MS.ES.NGSS

# Interactions Among Earth & Space Systems: Earth Systems MSENG3-Earth

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

Name:

**Name:** ______________________________

**Date:** ______________________________

Record your ideas and questions about your observations of the cracks in the Arizona desert. Include key terms and ideas that you think are important to understanding the phenomenon.

| Observations | Questions |
|---|---|
| | |
| | |
| | |
| | |
| | |

# 1A ACTIVITY
## A Crack in the Arizona Desert

**Name:**______________________________

**Date:**______________________________

Develop a model that explains what caused the crack in the Arizona desert. Remember, models are used to show the visible and invisible components within the model system and the interactions of the components.

Name:______________________________

Date:______________________________



Work with your group and use the space below to draw and label a model that explains what caused the cracks in the Earth to happen in Arizona. 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.

# 1B ACTIVITY
## What Is Your Water Footprint?

**Name:** ______________________________

**Date:** ______________________________

Record your ideas and questions about your observations of the water used to grow tomatoes. Include key terms and ideas that you think are important to understanding the phenomenon.

| Observations | Questions |
|---|---|
| | |
| | |
| | |
| | |

**Name:**______________________________

**Date:**______________________________



Work with your group and use the space below to draw and label a revised model that explains what caused the cracks in the Earth to happen in the Arizona desert. Include any new information you gathered from mapping the cracks in the Earth. Remember that models include the unobservable mechanisms that help explain the phenomenon.

# 1C JOURNAL
## Mapping the Large Cracks in the Earth

**Name:**

**Date:**

1. Through the mapping of cracks in the Earth locations, I figured out . . .

2. I still have questions about . . .

3. I was surprised about . . .

Name:______________________________

# K E Y T E R M S

Date:______________________________

**Teacher Guide and Student Journal**
SampleActivity and Planning Pages

# Interactions Among Earth & Space Systems: Space Systems

# MSENG3-Space

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

# Interactions Among Earth & Space Systems: Space Systems

## MSENG3-Space

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

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

CEREAL CITY SCIENCE™
by BCAMSC

# Interactions Among Earth & Space Systems: Space Systems

## Pre-Activity Information Pages



## Activities



## Appendix

## *NEXT GENERATION SCIENCE STANDARDS*

| DISCIPLINARY CORE IDEAS/PERFORMANCE ASSESSMENTS | |
|---|---|
| **ESS1.A: The Universe and Its Stars**<br>• Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted and explained with models.<br>• Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. | 1,2,3,4,5 |
| MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. | 1,2,3 |
| MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. | 1,2,3,4,5 |
| **ESS1.B: Earth and the Solar System**<br>• The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.<br>• This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across a year.<br>• The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. | 1,2,3,4,5 |
| MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. | 1,2,3,4,5 |
| MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system. | 4,5 |
| MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. | 1,2,3 |

## NEXT GENERATION SCIENCE STANDARDS

| SCIENCE AND ENGINEERING PRACTICES/PERFORMANCE ASSESSMENTS | |
|---|---|
| **Developing and Using Models**<br>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.<br>• Develop and use a model to describe phenomena.<br>• Develop a model to describe unobservable mechanisms. | 1,2,3,4,5 |
| MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. | 1,2,3 |
| MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. | 1,2,3,4,5 |
| **Analyzing and Interpreting Data**<br>Analyzing and interpreting 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.<br>• Analyze and interpret data to determine similarities and differences in findings. | 4,5 |
| MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system. | 4,5 |
| **CROSSCUTTING CONCEPTS/PERFORMANCE ASSESSMENTS** | **Activity** |
| **Patterns**<br>• Patterns can be used to identify cause-and-effect relationships. | 1,2,3 |
| MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. | 1,2,3 |
| **Scale Proportion, and Quantity**<br>• Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. | 2,3,4,5 |
| MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system. | 4,5 |
| **Systems and System Models**<br>• Models can be used to represent systems and their interactions. | 1,2,3,4,5 |
| MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. | 1,2,3,4,5 |

## COMMON CORE STATE STANDARDS—READING

| READING SCIENCE AND TECHNICAL SUBJECTS—GRADES 6–8 | Activity |
|---|---|
| **Key Ideas and Details** | |
| RST.6–8.1: Cite specific textual evidence to support analysis of science and technical texts. | 1,3,4,5 |
| RST.6–8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. | 1,3,4,5 |
| RST.6–8.3: Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks. | |
| **Craft and Structure** | |
| RST.6–8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics. | 1,3,4,5 |
| RST.6–8.5: Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic. | |
| RST.6–8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text. | |
| **Integration of Knowledge and Ideas** | |
| RST.6–8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). | 1,3,4,5 |
| RST.6–8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. | 3,4 |
| RST.6–8.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. | 1,3,5 |
| **Range of Reading and Level of Text Complexity** | |
| RST.6–8.10: By the end of grade 8, read and comprehend science/technical texts in the grades 6–8 text complexity band independently and proficiently. | 1,3,4,5 |

## COMMON CORE STATE STANDARDS—WRITING

| HISTORY/SOCIAL STUDIES, SCIENCE, AND TECHNICAL SUBJECTS WRITING STANDARDS—GRADES 6–8 | Activity |
|---|---|
| Text Types and Purposes | |
| WHST.6–8.1: Write arguments focused 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. | 1,2,3,4,5 |
| 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. | 1,2,3,5 |
| WHST.6–8.1.C: Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence. | 2,3,5 |
| WHST.6–8.1.D: Establish and maintain a formal style. | |
| WHST.6–8.1.E: Provide a concluding statement or section that follows from and supports the argument presented. | 2,3 |
| WHST.6–8.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. | 1,2,3,4,5 |
| WHST.6–8.2.A: Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension. | 3 |
| WHST.6–8.2.B: Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. | 2,3 |
| WHST.6–8.2.C: Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts. | 2,3 |
| WHST.6–8.2.D: Use precise language and domain-specific vocabulary to inform about or explain the topic. | 2,3 |
| WHST.6–8.2.E: Establish and maintain a formal style and objective tone. | 2 |
| WHST.6–8.2.F: Provide a concluding statement or section that follows from and supports the information or explanation presented. | 2,3 |
| Production and Distribution of Writing | |
| WHST.6–8.4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. | 1,2,3,5 |
| WHST.6–8.5: With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. | |
| WHST.6–8.6: Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently. | |

## COMMON CORE STATE STANDARDS—WRITING

| HISTORY/SOCIAL STUDIES, SCIENCE, AND TECHNICAL SUBJECTS WRITING STANDARDS—GRADES 6–8 | Activity |
|---|---|
| Research to Build and Present Knowledge | |
| WHST.6–8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. | 1,2,5 |
| WHST.6–8.8: Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. | 1,5 |
| WHST.6–8.9: Draw evidence from informational texts to support analysis, reflection, and research. | 1,5 |
| 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. | 1,2,3,4,5 |

## COMMON CORE STATE STANDARDS—MATHEMATICS

| Mathematics—Grades 6–8 | Activity |
|---|---|
| **Mathematical Practices** | |
| 1. Make sense of problems and persevere in solving them. | 1-5 |
| 2. Reason abstractly and quantitatively. | 1-5 |
| 3. Construct viable arguments and critique the reasoning of others. | 1-5 |
| 4. Model with mathematics. | 1-5 |
| 5. Use appropriate tools strategically. | 1-5 |
| 6. Attend to precision. | 1-5 |
| 7. Look for and make use of structure. | 1-5 |
| 8. Look for and express regularity in repeated reasoning. | 1-5 |
| **Ratios and Proportional Relationships** | |
| 6. Understand ratio concepts and use ratio reasoning to solve problems. | 4 |
| 7. Analyze proportional relationships and use them to solve real-world and mathematical problems. | 4 |
| 8. Know that there are numbers that are not rational, and approximate them by rational numbers. | 4 |
| **The Number System** | |
| 4. Apply and extend previous understandings of multiplication and division to divide fractions by fractions. | 4 |
| 5. Multiply and divide multi-digit numbers and find common factors and multiples. | 4 |
| 6. Apply and extend previous understandings of numbers to the system of rational numbers. | 4 |
| 7. Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers. | 4 |
| 8. Know that there are numbers that are not rational, and approximate them by rational numbers. | 4 |

## UNIT AT A GLANCE

| Activity | Time to Complete | Lesson Level Learning Goal | Phenomena | Summary: Students will . . . |
| --- | --- | --- | --- | --- |
| 1 Surfing a Tidal Bore! | Preparation: 30 minutes<br>Activity: 5 classes<br>Lesson 1A : 55–60 min., 2 classes<br>Lesson 1B: 55–60 min., 2 classes | Develop an initial model of the cause of tidal bores. | **Video of a surfer riding a tidal bore.** | • Make observations of a video to raise questions and obtain information.<br>• Share initial ideas of what causes a tidal bore.<br>• Share ideas of their understanding of waves. |
| 2 What Causes Tides? | Preparation: 20 minutes<br>Activity: 4 classes<br>Lesson 2A: 55–60 min., 2 classes<br>Lesson 2B: 55–60 min. | Obtain and apply information about the cause of tides to the initial models of how tidal bores are formed. | **Video of a surfer riding a tidal bore.** | • Review the effect of gravity among objects.<br>• Rank the sun, moon, and Earth by size. |
| 3 Moon Phases, Eclipses, and Seasons | Preparation: 20 minutes<br>Activity: 7–8 classes<br>Lesson 3A: 55–60 min., 2 classes<br>Lesson 3B: 55–60 min., 2 classes<br>Lesson 3C: 55–60 min., 3–4 classes | Develop models to explain the phases of the moon, lunar and solar eclipses, and the reason for the seasons.<br>Construct explanations of how moon phases, eclipses, and seasons affect the tides and tidal bores. | **Video of a surfer riding a tidal bore.**<br><br>**Moon Phases: Shape of the Moon** | • Explore the *Moon Phases* card set and put them in order.<br>• Raise questions about the moon and its shapes.<br>• Role-play the rotations of Earth and position of the moon and sun to explain moon phases and eclipses.<br>• Work collaboratively to develop models and presentations.<br>• Present ideas to an audience. |

## UNIT AT A GLANCE

| Students Figure Out How to: | Practices/Crosscutting Concepts | Assessment |
|---|---|---|
| • Develop an initial model that explains the cause of a tidal bore.<br>• Locate tidal bores on a world map.<br>• Recognize patterns in where tidal bores occur. | **Asking Questions and Defining Problems**<br>**Developing and Using Models**<br>**Cause and Effect**<br>**Systems and System Models**<br>**Energy and Matter**<br>**Patterns** | **Formative Assessment**<br>Initial models<br>Questions chart<br>Activity pages<br>Model revisions |
| • Develop models of the sun, moon, and Earth and the effect of the pull of gravity on each object<br>• Develop a model to explain the pull of the moon's gravity on Earth's ocean waters. | **Developing and Using Models**<br>**Obtaining, Evaluating, and Communicating Information**<br>**Constructing Explanations and Designing Solutions**<br>**Cause and Effect**<br>**Systems and System Models** | **Formative Assessment**<br>Activity Pages<br>Science Talk<br>Revised models |
| • Recognize patterns in the phases of the moon.<br>• Develop a model to explain what causes the phases of the moon.<br>• Obtain, Evaluate, and communicate information about the solar eclipse and lunar eclipse.<br>• Develop a model and create a presentation to explain the cause of the seasons. | **Obtaining, Evaluating, and Communicating Information**<br>**Developing and Using Models**<br>**Constructing Explanations and Designing Solutions**<br>**Cause and Effect**<br>**Systems and System Models**<br>**Energy and Matter**<br>**Patterns** | **Formative Assessment**<br>*Moon Phase Card Set* models<br>Science Talk<br>**Summative Assessment**<br>Revised consensus moon phase models<br>Journal Entry<br>Revised seasons models<br>Activity page<br>Science Talk |

## UNIT AT A GLANCE

| Activity | Time to Complete | Lesson Level Learning Goal | Phenomena | Summary: Students will . . . |
|---|---|---|---|---|
| 4 Size and Distance | Preparation: 20 minutes<br>Activity: 7–10 classes<br>Lesson 4A: 55–60 min., 2 classes<br>Lesson 4B: 55–60 min., 3–6 classes<br>Lesson 4C: 55–60 min. 2 classes | Develop a model to explain how the gravitational pull of the sun holds planets, their moons, and asteroids in orbit.<br>Obtain, evaluate, and present information to inform how the solar system is held together by the gravitational pull of the sun. | **Shooting star observation**<br>**Challenge: What's Wrong With This Picture?** | • View a video of a meteor shower<br>• Use prior knowledge to evaluate a picture of space.<br>• Raise questions about meteors and different objects in space.<br>• Conduct research of an object in the solar system.<br>• Develop presentations to communicate research findings.<br>• Use a demonstration model to compare the sizes of some of the objects in the solar system. |
| 5 Stargazing | Preparation: 20 minutes<br>Activity: 4 classes<br>Lesson 5A: 55–60 min., 2 classes<br>Lesson 5B: 55–60 min. 2 classes | Develop a model to explain the movement of objects across the night sky.<br>Obtain, evaluate, and present information to inform how the solar system is held together by the gravitational pull of the sun. | **Shooting star observation** | • Record observations and questions from viewing a video.<br>• Use a computer program to observe the apparent movement of objects across the night sky.<br>• Take notes from reading and media. |

## UNIT AT A GLANCE

| Students Figure Out How to: | Practices/Crosscutting Concepts | Assessment |
| --- | --- | --- |
| • Develop models to rank relative size of objects in space.<br>• Recognize the challenges in representing vast sizes and distances of objects in space.<br>• Use mathematics and computational thinking to develop a scaled model of objects in the sky.<br>• Analyze information through research.<br>• Use ratios to analyze proportional relationships of size and distance of objects in space. | **Developing and Using Models**<br>**Obtaining, Evaluating, and Communicating Information**<br>**Constructing Explanations and Designing Solutions**<br>**Asking Questions and Defining Problems**<br>**Systems and System Models**<br>**Scale, Proportion, and Quantity** | **Formative Assessment**<br>Activity Page (and revised responses)<br>Science Talk<br><br>**Summative Assessment**<br>Student Research and Presentations<br>Class Demonstration<br>Journal Entry<br>Science Talk |
| • Develop an individual model to explain the cause of meteors.<br>• Work collaboratively to develop a group model to explain the causes of meteors.<br>• Explain the components and how they interact within a system model.<br>• Obtain, evaluate, and communicate information from text and media about asteroids, comets,and meteors.<br>• Develop a consensus model of what causes meteor showers. | **Developing and Using Models**<br>**Obtaining, Evaluating, and Communicating Information**<br>**Constructing Explanations and Designing Solutions**<br>**Asking Questions and Defining Problems**<br>**Systems and System Models**<br>**Cause and Effect**<br>**Scale, Proportion, and Quantity** | **Formative Assessment**<br>Initial models<br>Science Talk<br><br>**Summative Assessment**<br>Science Talk<br>Journal Entry<br>Consensus models<br>Activity Pages |

# ACTIVITY 1

## Surfing a Tidal Bore!

**Teacher Background Information**
Students begin their exploration into space systems and cycles through the lens of a phenomenon of what happens on Earth. Students raise questions and share initial ideas of what is happening after viewing a video of a surfer riding the wave of a tidal bore.

A tidal bore is a relatively rare occurrence that happens where a river empties into an ocean or sea. A tidal bore is a strong tide that pushes up the river, against the current. A tidal bore is a type of tidal wave. Not all coasts feature tidal bores. In fact, there are few places where tidal bores occur. The river must be fairly shallow. It must have a narrow outlet to the sea. The estuary, or place where the river meets the sea, must be wide and flat. The coast's tidal range—the area between high tide and low tide—must be quite large, usually at least 6 meters (about 20 feet). When all of these conditions are met, a tidal bore is formed. Tidal bores occur on several rivers emptying into the Bay of Fundy, between the Canadian provinces of New Brunswick and Nova Scotia. The surge of the incoming Fundy tide is so strong it temporarily reverses the flow of these rivers and appears as a crest of water traveling upriver.

The use of the tidal bore provides the opportunity to integrate student understanding of waves and energy transfer from the physical science unit, *Energy and the Electromagnetic Spectrum*. They also have the opportunity to revisit their understanding of oceans and their effect on the land from the unit, *Weather, Climate, and Human Impact*.

**Engage the Learner**
The initial phase of the learning cycle is intended to engage students in thinking about and raising questions about tidal bores and the tides. The phenomenon of a tidal bore leads to exploring tides, gravity, the moon, and beyond.

### Lesson 1A: Tidal Bores

**Advance Preparation**
Preview the Surfing the Tidal Bore videos:

Tidal Bore Surfers April 2021:
https://www.youtube.com/watch?v=dzpOBacF-1U

Tidal Bore Surfers May 2021:
https://www.youtube.com/watch?v=0jlp17zKXEI

Prepare 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.

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

**LESSON LEVEL LEARNING GOALS**
Develop an initial model of how tidal bores are formed.

**MATERIALS NEEDED**
**For each student:**
student pages
**For each group of 4:**
chart paper/whiteboards
markers
Post-It Notes
**For the class:**
Internet access
**Teacher provides:**
chart paper/whiteboards
markers
Post-It Notes
Internet access

**ESS1.B: EARTH AND THE SOLAR SYSTEM**

- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.
- **This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across a year.**
- ~~The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.~~

**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**
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).

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 tidal bores and tides occur | Student initial questions about tides and tidal bores | 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 |

**Procedure**
*Engage the learner.*
Introduce the unit by asking the students to observe a video that records a surfer riding the wave of a tidal bore.

Encourage students to listen and observe with a focus on what they understand about oceans, tides, and waves.

Show the videos:

Tidal Bore Surfers April 2021:
https://www.youtube.com/watch?v=dzpOBacF-1U

Tidal Bore Surfers May 2021:
https://www.youtube.com/watch?v=0jlp17zKXEI

Have students refer to the Student Journal.

*Record your ideas and questions about your observations of the waves and surfers. Include ideas that you think are important to understanding the phenomenon of where, how, and causes.*

| *Observations* | *Questions* |
|---|---|
| | |
| | |

Divide the class into groups of four and allow time for students to discuss the phenomenon of the tidal bore surfer. Encourage students to share their observations from the video and discuss their initial ideas of the cause of the waves in the river.

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 wave in the river? What makes you think that?
- Does anyone have similar or different ideas about the cause of the wave?

- Tell me what you already know about waves on the water and what causes them to occur?
- Can someone describe an observation or idea everyone had in common after viewing the video?
- What information did you obtain about the area around the river? What are some of the features of the river and surrounding land? Does that give you any clues? Can someone add on to ______'s idea?

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 waves large enough for a surfer in the river.

*Develop a model that explains what caused the waves in the Petitcodiac River. Remember, models are used to show the visible and invisible components within the model system and the interactions of the components.*

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 waves in the Petitcodiac River to form. 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 to develop the model that represents their collective thinking to look, distribute chart paper or whiteboards and markers or assign a Jamboard for them to develop a model to share with the class. Encourage groups to write questions that come up during the model development. Distribute Post-It Notes to each group and encourage students to write the questions about waves in the river, location of the river, features of the river, etc. 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 models, ask them to display their models around the room.



### TEACHING TIP

Listen for ideas that relate to waves and energy transfer. Make note of students' ideas about the cause of the waves.

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

### 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.**

### CAUSE AND EFFECT

- **Cause-and-effect relationships may be used to predict phenomena in natural and 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 and matter flows within systems.

**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. 112-13, on setting up your class for Science Talk.

**ENERGY AND MATTER**

- **Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.**

As a class, review the four anchor posters that were developed in Lesson 1A of the unit, *Interactions Among Earth and Space Systems: Earth Systems*. The posters are used to guide the class throughout the unit when sharing ideas. Display the four charts with the questioning and critiquing categories.

After the review of the anchor questioning charts, conduct a gallery walk of the group initial models. Allow time for each group to make observations of the different models. Encourage students to look for common components that are in all or most 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 explanations of their models, ask:

- _____________, I heard you use the term tides. 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 the waves on the river?
- What do you mean when you say ________________ ?
- How might the location of the river play a role in the cause of the waves?
- Can someone describe the system we are attempting to develop models for?
- ____________, I heard you use the term energy. Can you explain the role of energy within the system?
- How do the models demonstrate the force that is causing the motion of the water?

Display the What We Think chart. Explain that the class has modeled and discussed their initial ideas about the tidal bore and how and why it occurs. Explain that 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. Remind the class that all ideas are valued and welcomed to get the discussion and thinking started.

Continue with the Questions We Have column and explain that the class will keep track of their questions they have as the unit progresses and the questions they answer as they investigate. The Questions We Have column of the chart will help the class keep track of their questions, and when and how they have answered their questions.

Help students turn their wonderings and ideas into questions that can be answered through investigations and research in the following lessons. Ask groups to retrieve questions from their models that developed as they were trying to figure out the components and that represent their thinking. (See sample Questions We Have chart on p. 37.)

To help students collectively raise questions about the tidal bores and where and how they occur, ask:

- What questions do we need to answer to figure out the cause of tidal bores in some rivers?
- What do think about what ___________said?
- Does anyone have a question that related 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 as they can think of about tidal bores. Distribute Post-It Notes to each group. Ask students to use scrap paper and write as many questions that they can think of about tidal bores and how, why, and where they might happen. Then collaborate to find four or five of the most pressing questions to write on the Post-It 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 tidal bores may include:

- cause
- location
- size of waves
- river features
- oceans
- when the tidal bores occur
- distance waves travel
- surfing questions
- tides

Your students may have questions similar to and different from those of 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 sample chart is merely an example of questions students might generate. Your students' questions may include many more questions, including questions that relate to your location.

**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.

If students do not have questions about tides, discuss the name of the phenomenon, tidal bores, and ask students to take the words apart to generate questions about the what causes tides and their effect on the flow of water in some rivers.

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:

- What causes the tidal bores on some rivers?

**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 the phenomenon.

### 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.

### 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 a representation of forces and motion, a representation of tides, a representation of gravity, forces, motion, and energy? Do initial models include representations or symbols to show interactions of the components in the system?


## 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.

## Lesson 1B: Where Do Tidal Bores Occur?

**Teacher Background Information**
A tidal wave is a shallow water wave caused by the gravitational interactions between the sun, moon, and Earth. A tidal bore happens where a river empties into an ocean or sea. There are approximately 66 known tidal bores in the world.

Tidal bores occur in several river estuaries throughout the world. Before engineering modifications such as dredging, diversions, entrainment, and the construction of barriers and dams, many more existed. A few of the well known bores, together with the location in which they occur are:

Qiantang River, Haining Province, China

Petitcodiac, New Brunswick, Canada

Salmon River, Nova Scotia, Canada

Shubenacadie River, Nova Scotia, Canada

Solway Firth, between England and Scotland

Severn Estuary, England

River Trent, England

Orne River, France

Gironde River, France

Hooghly River, West Bengal, India

Amazon River, Brazil

Turnagain Arm, Cook Inlet, Alaska

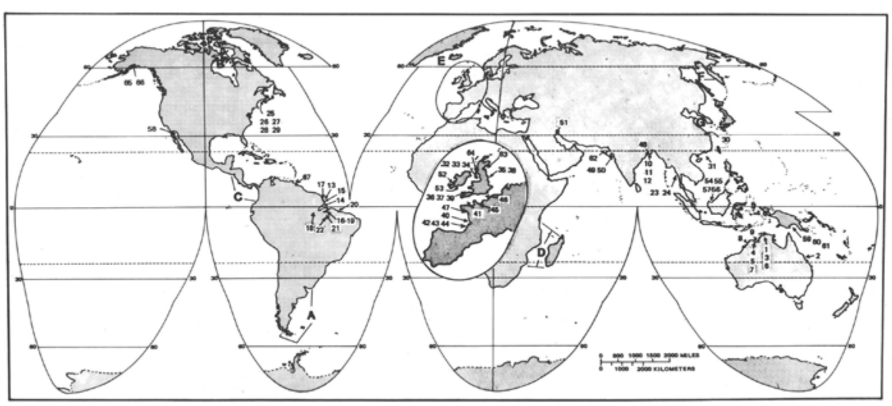


Figure 4. Worldwide distribution of tidal bores. Numbers are keyed to locations in table 2. A–G show regions where additional or undocumented bores are likely to occur.

**Explore the Concept.**
In this phase of the learning, students begin to investigate answers to their questions. Students actively explore, investigate, and research tidal bores, tides, and the gravitational interactions between the sun, moon, and Earth that cause the bores to occur. The exploration of the reason for the tidal bores and tides leads to the exploration of the tilt

**MATERIALS NEEDED**
**For each student:**
student pages
handout: *Tidal Bore Locations*
**For each group of 4:**
chart paper/whiteboards
markers
Post-It Notes
**For the class:**
Internet access
World map
colored push pins
**Teacher provides:**
chart paper/whiteboards
markers
Post-It Notes
Internet access

**ESS1.B: EARTH AND THE SOLAR SYSTEM**

- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.
- **This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across a year.**
- ~~The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.~~

**ESS1.A: THE UNIVERSE AND ITS STARS**

- **Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted and explained with models.**
- ~~Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.~~

**TEACHING TIP/TECHNOLOGY**

If your class is equipped with sufficient technology devices for individuals, have the students use the ArcGIS program to locate the assigned tidal bore.

See the Technology section for instructions of how to access the ArcGIS program and how to use it to locate the tidal bores. As the groups combine their data, they should have a map that shows clusters of where the tidal bores occur.

**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.

**PATTERNS**

- Patterns can be used to identify cause-and-effect relationships.

of Earth, reason for the seasons, and finally to explore the solar system and the orbit of the bodies around the sun by its gravitational pull on them.

**Advance Preparation**

Become familiar with the USGS tidal bore report and the informational text in the National Geographic encyclopedia.

https://pubs.usgs.gov/circ/1988/1022/report.pdf

https://www.nationalgeographic.org/encyclopedia/tidal-bore/

Prepare a space to hang the world map for students to locate some of the tidal bores.

If you choose to have students engage in technology to map the tidal bores, become familiar with the use of ArcGIS mapping tools. (See directions in the Technology Section of the Teacher Guide.)

**Procedure**

*Explore the concept.*

Review the questions from the What We Think chart. Focus on questions that relate to location of tidal bores throughout the world. Ask students how they can find out where most tidal bores occur and discuss how that might help in gaining information for why they occur.

Show students the map of the world and give them the opportunity to find major rivers on the map and the Petitcodiac River, Moncton, New Brunswick, Canada. Allow time for students to struggle in locating the Petitcodiac River and other rivers they know about.

If your class is unfamiliar with using latitudinal and longitudinal data, take this opportunity to locate the lines on the map and choose one location to demonstrate how they are helpful in using a map.

Divide the class into groups of 3-4 students and distribute the *Tidal Bore Locations* handout to each student. Based on the number of students/groups in the class, assign 6-7 tidal bore locations for each group to research and locate on the map. After the groups have located the rivers with the tidal bores on the map, have them gather information from the National Geographic informational text.

https://www.nationalgeographic.org/encyclopedia/tidal-bore/

Have students use the note-taking strategies in the Student Journal to record the information gained from the text. Encourage groups to section off the text and read a section, stop and discuss, and record their ideas in the Student Journal.

*In your reading team, preview the article you are reading.*
***Tool for Pre-reading Notes***

*Title of chapter or article:*

*List the titles and subtitles of the reading.*

*List any bolded terms in the article.*

*Write down the main ideas or questions you will focus on during the reading.*

*Write any information you learned from pictures and graphs or charts in the article.*

*What questions(s) do you think this reading is attempting to answer?*

***Note-Taking Tool for Reading in Science***

*Read the first selected section to get a good idea of the material, then go back and reread to take notes:*

- *Write the main idea or concept of the selection in your own words.*
- *Write the meaning of key terms in your own words.*
- *Review and compare your notes with a partner.*

*Continue to read the next selected section.*

- *Write the main idea or concept of the selection in your own words. Write the meaning of key terms in your own words.*
- *Review and compare your notes with a partner.*

*Compare and combine the pre-reading notes with the notes from the reading.*

- *How did the reading answer the question?*
- *How did the reading cover the main idea?*
- *Write the meaning of unfamiliar terms in your own words.*

*List questions or concepts that are unclear in the reading.*

Facilitate the group mapping and research activity by circulating among the groups and listening to their ideas and discussions.

- What have you discovered from mapping the rivers with tidal bores so far?
- Are you recognizing any patterns in the map data? Can you say more about that?
- Who can add onto that idea?
- What information in the text helps us to answer some of our questions?
- What does the article say about the necessary components in a river for a tidal bore to form? What makes the river different from rivers without tidal bores?
- Does anyone have other components to add onto that idea?
- Are there any terms in the text that are unfamiliar or confusing? How might you figure out what the author is trying to say?
- What do you already know about ______________? How can you use that information to help you figure out the meaning in the article?
- How does the information from the text provide ideas for revisions to your initial model of the tidal bore and surfer? What components did you include? What components were missing?

In their groups, have the students develop and complete the Summary Table in the Student Journal.

**READING SCIENCE AND TECHNICAL SUBJECTS—GRADES 6–8**

**Key Ideas and Details**

**RST.6–8.1:** Cite specific textual evidence to support analysis of science and technical texts.

**RST.6–8.2:** Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

**Craft and Structure**

**RST.6–8.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.

**Integration of Knowledge and Ideas**

**RST.6–8.7:** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

**RST.6–8.9:** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

**Range of Reading and Level of Text Complexity**

**RST.6–8.10:** By the end of grade 8, read and comprehend science/technical texts in the grades 6–8 text complexity band independently and proficiently.

**OBTAINING, EVALUATING, AND COMMUNICATING INFORMATION**

Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods.

- **Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).**
- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

**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)

*In your group, compare notes and discuss main ideas and important details from your reading about tidal bores.*

| *Main Idea* | |
|---|---|
| *Supporting Details* | *Supporting Details* |
| | |
| | |
| | |

Distribute chart paper and markers (or assign a Jamboard) and have the groups make a chart from their reading and Student Journal entries.

**Science Talk**

*Explain the concept and define the terms.*

After the students have had the opportunity to find the locations of their assigned rivers on the map and obtain information from the National Geographic text, ask them to bring their Student Journals and charts and form a circle to share their findings.

As a class, share the experience of plotting the location of different rivers with tidal bores. Ask:

- Did we uncover any patterns from mapping the rivers with tidal bores? If so, can someone explain what information that pattern tells us?

Discuss any patterns or clusters that emerged on the map. Ask a student volunteer to describe the areas of the world that are most prone to have tidal bores. Refer to the Questions We Have column of the What We Think chart. Check if plotting the location of tidal bores helped in answering any "location" questions about where most tidal bores occur. Review questions that ask about why these areas are more prone to tidal bores:

- Why are some areas of the world more prone to tidal bores than others?
- What information can we gain by recognizing the clusters of bores on the map?

Give the class sufficient time to hypothesize if any patterns emerged on the map and what causes the patterns or clusters. Listen for ideas that suggest that the areas where they occur may have similar terrain, currents, winds, etc.

Refer to the Questions We Have column of the What We Think chart and ask if mapping the tidal bores provided information to help answer any of their questions.

Ask students to turn to their notes and Summary Tables from the Tidal Bore text and ask a student to share information that might answer some of their questions. Ask students to review the Main Ideas from the reading from each group. Ask:

- Will someone from this group tell us more about your thinking about the main idea from the reading?
- Can someone add on to that idea?
- What other groups had the same or similar idea?
- What details help to support that claim?
- Ask a student volunteer to make a comparison to the author's description of how tidal bores are formed and the initial models they made in the classroom.
- Ask what each part of the model represents the processes in nature they read about.
- Can someone add on to what ___________ said?
- How is the information we obtained from our mapping and initial models and the information in the text similar? Different?
- Who can repeat what ____________ just said or put it into their own words?
- How do our initial models reflect what we have figured out? What is missing from the system? What interactions are happening?
- What new information, if any, would you like to add to your models?
- ____________, I see your group added motion to the wave. Can you explain what drives that motion?
- What information did we obtain and patterns did we recognize about the cause of tidal bores?
- What information did we obtain about the location of tidal bores?

*Elaborate on the concept.*
Return to the What We Think chart and add new information to the What We Did, What We Figured Out, and How Does That Help Us to Figure Out the Phenomenon? columns. Review the questions that they have answered so far and questions that still remain.

Give students the opportunity to revisit their initial models of the cause of tidal bores and make revisions to their models based on information from mapping the bores and information obtained from the reading. Allow time for sharing of the revisions and the opportunity to discuss the common components among the models.

As a class, identify appropriate and necessary components of the tidal bore system, including visible and invisible components. Check early models for representations of motion, forces, energy, and representations, symbols (such as arrows) or descriptions indicating how components within the system interact. The interaction among components should represent a causal account within the system.

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

**Text Types and Purposes**

**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.

**Production and Distribution of Writing**

**WHST.6–8.4:** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

**Research to Build and Present Knowledge**

**WHST.6–8.7:** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

**WHST.6–8.8:** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

**WHST.6–8.9:** Draw evidence from informational texts to support analysis, reflection, and research.

**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.

**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.**

**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.

**ENERGY AND MATTER**

- **Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.**

**PATTERNS**

- Patterns can be used to identify cause-and-effect relationships.

At this point, all models may not have a complete representation. Assure students that they will revisit models as the lessons progress.

**Assessment: Formative**
Use the Activity Pages in the Student Journal to assess the students' ability to take notes and critically read scientific texts to determine main ideas and obtain scientific and/or technical information.
Use the mapping results and Science Talk to assess the students' ability to communicate scientific information through collaborative conversations and retelling.

Use revision to their initial models of tidal bores to assess the students' ability to develop and use a model to describe phenomenon, including invisible mechanisms.

## 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.

## ENGINEERING DESIGN PROCESS

CEREAL CITY SCIENCE™ by BCAMSC

# 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

# Interactions Among Earth & Space Systems: Space Systems

# MSENG3-Space

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

Name:

**Name:**______________________________

**Date:**______________________________

Record your ideas and questions about your observations of the waves and surfer. Include ideas that you think are important to understanding the phenomenon of where, how, and causes.

| Observations | Questions |
|---|---|
| | |
| | |
| | |
| | |
| | |

# 1A ACTIVITY Tidal Bores

**Name:** ______________________________

**Date:** ______________________________

Develop a model that explains what caused the waves in the Petitcodiac river. Remember, models are used to show the visible and invisible components within the model system and the interactions of the components.

**Name:** ______________________________

**Date:** ______________________________



Work with your group and use the space below to draw and label a model that explains what caused the waves in the Petitcodiac River to form. 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.

# 1B ACTIVITY
## Where Do Tidal Bores Occur?

**Name:** ______________________

**Date:** ______________________

In your reading team, preview the article you are reading.

Tool For Pre-reading Notes

| | |
|---|---|
| Title of chapter or article: | |
| List the titles and subtitles of the reading. | |
| List any bolded terms in the article. | |
| Write down the main ideas or questions you will focus on during the reading. | |
| Write any information you learned from pictures and graphs or charts in the article. | |
| What question(s) do you think this reading is attempting to answer? | |

**Name:** ______________________________

**Date:** ______________________________

Note-taking Tool for Reading in Science

| | |
|---|---|
| Title of chapter or article: | |
| Read the first selected section to get a good idea of the material, then go back and reread to take notes:<br>• Write the main idea or concept of the selection in your own words.<br>• Write the meaning of key terms in your own words.<br>• Review and compare your notes with a partner. | |
| Continue to read the next selected section.<br>• Write the main idea or concept of the selection in your own words.<br>• Write the meaning of key terms in your own words.<br>• Review and compare your notes with a partner. | |

1B ACTIVITY
# Where Do Tidal Bores Occur?

**Name:** ______________________________

**Date:** ______________________________

| | |
|---|---|
| List questions or concepts that are unclear in the reading. | |

Name:______________________________

Date:______________________________



In your group, compare notes and discuss main ideas and important details from your reading about tidal bores.

| Main Idea | |
|---|---|
| | |
| **Supporting Details** | **Supporting Details** |
| | |
| | |
| | |

# K E Y T E R M S

Name:

Date: