OCEAN SCIENCES SEQUENCE FOR GRADES 6–8

Teacher's Guide

Unit 3: What Are the Causes and Effects of Climate Change?

Great Explorations in Math and Science (GEMS®)

Lawrence Hall of Science
University of California, Berkeley

National Oceanic and Atmospheric Administration

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Lawrence Hall of Science
University of California, Berkeley, CA 94720-5200.
Director: Elizabeth K. Stage

GEMS Director: Jacqueline Barber
MARE Director: Craig Strang
Project Directors: Catherine Halversen (Co-Director, MARE), Janice McDonnell (Institute of Marine and Coastal Sciences, Rutgers University), Craig Strang, and Jacqueline Barber
Curriculum Development Team: Catherine Halversen, Kevin Beals, Jonathan Curley, Emily Weiss, Carolyn Willard; Emily Arnold, Lynn Barakos, and Sarah Pedemonte
Assessment Development: Seth Corrigan, Lauren Brodsky; and Lynn Barakos
Science Advisors and Reviewers: Dr. Bob Chant, Dr. Jim Miller, Dr. John Wilkin, Dr. Elizabeth Sikes, Dr. Oscar Schofield, Dr. Josh Kohut, Dr. Carrie Ferraro, Kristin Hunter-Thomson, and Janice McDonnell (Institute of Marine and Coastal Sciences, Rutgers University), Dr. Drew Talley (University of San Diego), Dr. Adina Paytan (University of California, Santa Cruz), Dr. Robert Rhew and Dr. John Chiang (University of California, Berkeley), Dr. Michael Mann (University of Pennsylvania), Paulo Maurin (NOAA Coral Reef Conservation Program), Dr. John Manderson (National Marine Fisheries Service), Eric Simms and Daniel Richter (Scripps Institution of Oceanography), Dr. Fritz Stahr (University of Washington), and Dr. Jen Skene (University of California, Berkeley)
Ocean Science Educator Advisors and Reviewers: Terri Kirby Hathaway (North Carolina Sea Grant), Dr. Diana Payne (University of Connecticut, Sea Grant), and Sarah Ferner (San Francisco National Estuarine Research Reserve, Romberg Tiburon Center for Environmental Studies, San Francisco State University)
Technology Development: Igor Heifetz, Brian Yan, Sage Lichtenwalner, Carrie Ferraro, and Janice McDonnell (Institute of Marine and Coastal Sciences, Rutgers University), Steven Dunphy (Lawrence Hall of Science)
Field Trial Management and Research: Phaela Peck and Lynn Tran
Editor: Barbara Clinton
Production Manager: Steven Dunphy
Illustrations: Lisa Haderlie Baker, Barbara Clinton, Sarah Kessler, and Carolyn Willard
NOAA Program Officer: Sarah Schoedinger

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UNIT 3: WHAT ARE THE CAUSES AND EFFECTS OF CLIMATE CHANGE?

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UNIT OVERVIEW

Students learn about the causes of climate change and the effects on sea level, currents, and organisms, and then they investigate possible solutions. Through information cards, graphs, and readings, students learn about changes to the atmosphere and ocean over the course of Earth's history. They discover how carbon dioxide affects temperature, using a computer simulation and graphs. They explore evidence of the effects of climate change from photographs, short readings, and a physical model. Through a video, a desktop model, a computer simulation, and a reading, students explore how climate change affects currents. They read about effects on organisms and about possible solutions. At various points in the unit, they create cause and effect chains to synthesize their learning. Students learn that the climate change occurring now is caused by CO_2 added to the atmosphere by human industry. Throughout the unit, students learn about the practices of science, with a focus on scientific explanations and the role of evidence.

SESSION SUMMARIES

3.1 Introducing Earth's History
Students write their initial ideas about climate change. Using cards, groups create a timeline of major changes in Earth's atmosphere throughout history, gaining a sense of deep time and rate of change for those events.

3.2 Tracking Earth's CO_2 through Time
Students learn about interpreting graphs and how scientists collect data about atmospheric CO_2 levels throughout Earth's history. They analyze millions of years of Earth's atmospheric CO_2 data and learn that the rate of change since 1960 is much faster than any other known time in Earth's history.

3.3 What Does CO_2 Have to Do with Temperature?
Through use of a computer simulation and interpretation of graphs, students learn about the greenhouse effect. They learn that as atmospheric CO_2 levels rise on Earth, so does Earth's temperature.

3.4 Reflecting on Carbon and Climate Change
Through writing and discussion, students reflect on the connections between atmospheric CO_2 and global temperatures. They explore the difference between weather and climate and the definition of climate change.

3.5 Investigating Climate Change: Evidence Stations
Students investigate evidence about three effects of climate change—rising sea level, and shrinking glaciers and sea ice, using a Model Glacier as well as maps, graphs, and photographs found at learning stations around the room.

3.6 Demonstrating Cause and Effect
Students debrief the stations from Session 3.5. Groups use Cause and Effect cards to create flow charts showing a chain of causes and effects, which help them make causal connections between events related to climate change.

3.7 Investigating Climate Change: Ocean Currents
Students review how climate change not only affects ocean temperatures, but also how salty the ocean is in certain areas. Through video observation, a desktop model and a computer simulation, students learn about present day global ocean circulation as well as how circulation may change with a warming climate.

3.8 Connecting Climate and Ocean Currents
Students read and discuss an article reinforcing the idea that climate affects currents, which also explains how the converse is true: changes in currents can affect climate.

3.9 Investigating Climate Change: Organisms
First, students brainstorm the effects of climate change on organisms, then they choose one of seven articles to read, discuss, and share with the class. They learn that climate change affects organisms all over the planet.

3.10 Solutions to Climate Change, Part 1
After a review of the causes and effects of climate change, groups of students are challenged to brainstorm some ideas for slowing or stopping climate change, and lessening or reversing its effects.

3.11 Solutions to Climate Change, Part 2
Pairs of students choose several solutions from Climate Change Solution sheets to read and discuss. Students share solutions with each other, explaining how each solution addresses the causes or effects of climate change and reflect on whether they themselves might take some of these actions.

3.12 Thinking Critically about Climate Change Solutions
Each pair of students creates a cause and effect flow chart predicting the effects of one possible solution to climate change. The class discusses a few of the flow charts, then each student writes their Revised Ideas, Part 2, summarizing what they have learned about the causes and effects of climate change.

Session 3.1

Introducing Earth's History

To set the stage for investigating climate change, students discuss and write their first ideas about the topic. They will revisit this and similar writing prompts several times during the unit to reflect on their growing understanding. In the next part of the session, groups of students use Events in Earth's History cards to create a timeline that chronicles major changes in Earth's ocean and atmosphere over the course of the planet's history. This gives some perspective to the long periods of time over which these changes have taken place and will help students as they analyze data about more recent climate change in later sessions. Student learning is focused on the following key concepts:

- Early Earth had no ocean or atmosphere, but ever since they formed billions of years ago, they have been constantly changing.
- The first photosynthetic organisms developed in the ocean, and that led to Earth having an atmosphere rich in oxygen.

Students also learn:

- Earth formed about 4.5 billion years ago.
- Earth's atmosphere formed in part from gases released by volcanoes.
- Water vapor from volcanoes, comets, and asteroids condensed into liquid water on Earth's surface, forming the ocean.
- Photosynthetic organisms in the ocean released O_2 into the ocean water, which then entered the atmosphere and made it rich in oxygen.
- Human life on Earth and human industry are extremely recent developments compared to the history of Earth.

Introducing Earth's History	Estimated Time
Introducing the Unit	5 minutes
Writing First Ideas	10 minutes
Introducing the Events in Earth's History Activity	10 minutes
Ordering Events and Gaining a Sense of Time in Earth's History	20 minutes
Total	**45 minutes**

UNIT GOALS

SCIENCE CONTENT
- Climate Change

PRACTICES OF SCIENCE
- Making explanations from evidence
- Interpreting graphs

NATURE OF SCIENCE
- Scientific explanations are based on evidence
- Technology plays a role in gathering new evidence

SCIENCE LANGUAGE
- Using science vocabulary
- Having evidence-based discussions

Ocean Literacy Scope and Sequence and Climate Literacy Principle Correlations
Ocean Literacy S&S 4. The ocean makes Earth habitable.
Climate Literacy Principle 3. Life on Earth depends on, is shaped by, and affects climate.

WHAT YOU NEED

Summative Assessments are included in the Copymaster Packet. Administering the assessments as a pretest before beginning the unit provides baseline information about what students know and do not know. Administering the assessments again at the end of the unit will provide information about what students have learned during the unit. An answer key can be found in the Assessment section of the Introduction Book on page 81.

For the class:

- ❏ projection system*
- ❏ computer with Internet connection* or resource disc
- ❏ 4 slides for Session 3.1
- ❏ Scientific Evidence chart (from Session 1.2 or 2.3, or 1 sheet of chart paper and a marker)
- ❏ masking tape
- ❏ (optional) Copymaster Packet

For each group of students:

- ❏ 1 set of Events in Earth's History cards (set/12)
- ❏ 1 envelope

For each student:

- ❏ Investigation Notebook: pages 2, 3–5
- ❏ (optional) Copymaster Packet: Unit 3 Assessment Answer Sheet, Unit 3 Assessment (pretest)

*not provided in kit

GETTING READY

Before the day of the session:

1. **Set up projection system/review multimedia.** Set up and test the projection system to be sure all students will be able to see items projected during the session. Spend a few minutes reviewing this session's materials and supplemental resources found at mare.lawrencehallofscience.org/oss68 or by following the links (eBook) or using the resource disc (print version).
2. **Make and post chart (if you don't still have it from Unit 1 or 2).** Using a marker and a sheet of chart paper, make the following chart:
   - _ Scientific Evidence (See Figure 3–1 on page 261.) If you taught Unit 1 or Unit 2, this is the same chart created for Session 1.2 or Session 2.3. Post the chart so all students can see and refer to it throughout the unit.
3. **Prepare envelopes of Events in Earth's History cards.** If this is the first use, separate the Events in Earth's History card sets along the perforations. Place one 12-card set into each envelope (one envelope for each group).
4. **Prepare Investigation Notebooks.** If you did not purchase a printed Investigation Notebook for each student, use the sample notebook from the materials kit to duplicate a notebook for each student. If you do not have the materials kit, a printable PDF version is on the resource disc (attached to the back cover of the Introduction Book).
5. **Plan student pairs and groups.** In this and later sessions, students will frequently discuss their ideas with someone sitting near them and work together, either in pairs or groups of four.
6. **(optional) Prepare student sheets.** Makes copies of the following pages from the Copymaster Packet if you plan to administer the summative assessment as a pretest:
   - _ Unit 3 Assessment Answer Sheet (one for each student)
   - _ Unit 3 Assessment (one for each student)

LANGUAGE OF SCIENCE

VOCABULARY

absorb
atmosphere
carbon cycle
carbon dioxide/CO_2
climate
climate change
currents
dense/density
evidence
fossil fuels
heat energy
heat-trapping gases
model
organism
sea level

LANGUAGE OF ARGUMENTATION

What do you think?
Why do you think that?
What is your evidence?
Do you agree? Why?
Do you disagree? Why?
How sure are we?
How could we be more sure?

Introducing the Unit

1. **Project session-title slide and introduce the unit.** Tell students that they are beginning a new unit about climate change and the Earth's ocean and atmosphere. Say, **"This is an image of Earth photographed from space. The blue layer is the atmosphere."**

2. **Review the word *climate*.** Remind students that *climate* means the normal weather patterns in a place over the course of many years. The phrase *climate change* refers to changes in the normal weather for the entire planet.

3. **Review Turn and Talk routine and ask about climate change.** Remind students that Turn and Talk is a partner discussion routine used to start a discussion. Each partner in the pair gets a turn to share and a turn to listen carefully to the other partner's ideas. Ask, **"What have you heard about climate change?"** Make sure each student has a partner and give pairs a minute or two to discuss.

4. **Share ideas with whole class.** Regain the class's attention and have a few students share what they've heard about climate change. Do not correct or confirm their statements at this point. Tell students that during the unit they'll find out more about climate change and investigate which of their ideas are more or less accurate.

TEACHER CONSIDERATIONS

PROVIDING MORE EXPERIENCE

Prepare: Review *Atmosphere*. Students learned about the atmosphere in Units 1 and 2 of the Ocean Sciences Sequence. Since this unit focuses on changes in Earth's atmosphere over time, you may want to reinforce students' understanding of the term. Ask, **"What is the atmosphere?"** [The layers of gas that surround Earth.] Point to the blue atmosphere layer on the title slide and tell students that, compared to the whole planet, the layer of air is very thin. If you were to compare Earth to an apple, the atmosphere would be equivalent to the thickness of the skin on the apple. Though the atmosphere is thin compared to the size of Earth, it actually reaches about 75 miles above the ground. You can have students "breathe in" some air, to make sure they know that the atmosphere isn't just "up there," but also surrounds us here on the ground.

INSTRUCTIONAL ROUTINE

Session-Title Slides. Most sessions begin with a projected session-title slide. This provides students with the opportunity to engage with other students in discussing what they think the session will be about and serves as an invitation to learning about the subject.

Turn and Talk. Throughout the unit, students will discuss a question or idea with the person sitting next to them as preparation for a whole-class discussion or creating a written response. This can be a first step in building small-group discussion skills. If you did not teach Unit 1 or Unit 2 you may need to spend more time explaining and having students practice attentive listening in pairs.

SCIENCE NOTES

Teaching about Climate Change. Climate change is a long-term change in the average weather patterns over a period of time that can range from decades to millions of years. It may be a change in the average weather conditions in a region (such as the average temperature in summer), or a change in the average number of weather events (such as more or fewer hurricanes or tornadoes). Climate change may describe change that occurs in a specific region, or it may describe changes that occur across the whole Earth. Scientists generally use the term *climate change* rather than *global warming* because (*1*) on average, Earth is getting warmer, but some parts of the planet may experience cooler-than-average weather; (*2*) *climate change* encompasses all changes, natural and human-induced, whereas *global warming* is a term used to describe the specific climate change caused by human-induced increases in heat-trapping gases, such as CO_2.

LANGUAGE OF SCIENCE

VOCABULARY

absorb
atmosphere
carbon cycle
carbon dioxide/CO_2
climate
climate change
currents
dense/density
evidence
fossil fuels
heat energy
heat-trapping gases
model
organism
sea level

LANGUAGE OF ARGUMENTATION

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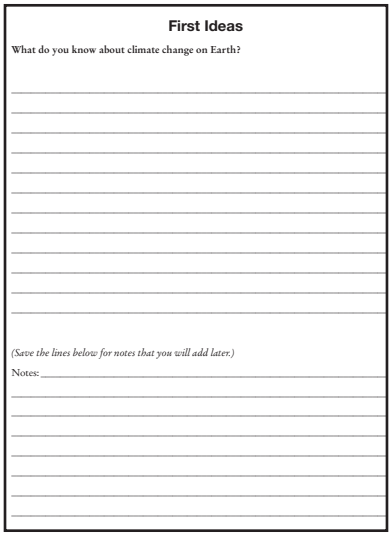

First Ideas

What do you know about climate change on Earth?

(Save the lines below for notes that you will add later.)

Notes:

Investigation Notebook, p. 2

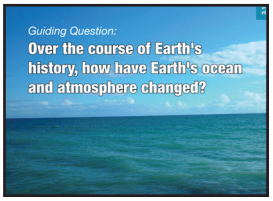
Writing First Ideas

1. **Introduce First Ideas activity.** Distribute Investigation Notebooks, and have students turn to page 2, First Ideas. Explain that students will write all they can about climate change. Students should leave the notes section at the bottom of the page blank for now. Throughout the unit, students will learn much more about this topic, and they will have the opportunity to add to and possibly change their ideas. In the last session of the unit, they will complete a similar writing activity to show what they have learned.

2. **Students work independently and do their best, even if they're not sure.** Say that during most activities in this unit it will be fine for students to help one another. In this activity, however, students will work independently without talking. Tell students that their writing today will not be graded. Encourage them to answer as completely as possible, but not to worry if they are unsure about their writing—they will soon learn more about this topic.

3. **Students write.** Give students about eight minutes to write independently.

Introducing Events in Earth's History Activity



1. **Project slide; introduce activity and guiding question.** Project the guiding question slide, and have a volunteer read it aloud. Tell students that before they investigate climate change in today's world, it's important to get a sense of how Earth has changed in the past. With a group, they will try to put twelve events from Earth's history in order from earliest (longest ago) to most recent.

2. **Review *evidence*.** Remind students that *evidence* is a clue that helps answer a question or explain something. Students will use evidence in this activity to figure out the order of events. And throughout this unit, they will be looking at evidence of climate change.

TEACHER CONSIDERATIONS

INSTRUCTIONAL RATIONALE

Investigation Notebook. The Investigation Notebook contains most of the student sheets for the unit. Having all the pages in one place allows students to look back at their work for reminders about what they have learned and how their ideas have changed. This is a place for students to do things that scientists do—read science articles and record questions, ideas, and observations. If you did not teach Unit 1 or Unit 2, explain to students that the notebooks will be used throughout the unit to record their ideas and what they are learning.

About First Ideas Writing. During the unit, as students learn more, they revisit their writing and add notes. They also answer similar but more sophisticated prompts—Revised Ideas, Part 1 (Session 3.4) and Revised Ideas, Part 2 (Session 3.9). Comparing students' responses on First Ideas and both Revised Ideas allows you to evaluate their progress toward understanding many of the unit's core concepts. Revisiting ideas is a useful tool for students—it helps them to be aware of their growing understanding of climate change and to reflect on ways their ideas have changed since the unit began.

ENGLISH LANGUAGE LEARNERS

Promoting Use of Native Languages. Encouraging ELLs to use their native languages helps students access content and feel more comfortable in the classroom. Invite ELLs to use their native languages in the First Ideas writing. Students who are more experienced with English might write their responses in English, with only a few key words in their native languages, while those with less English might write entirely in their native languages. Don't worry if this means you won't understand their writing. This writing is for the students themselves—to help them access their prior knowledge and to provide a baseline record of their initial thinking for later comparison.

ASSESSMENT

Embedded Assessment: First Ideas about Climate Change. Read through students' responses to gain insight into their prior knowledge about the changes that have occurred in Earth's climate. Note in particular if students mention an increase in carbon dioxide levels in the atmosphere due to human industrial activity. Don't be surprised if they are not yet aware that Earth's climate has been changing for millions of years, or of the causes of changes related to climate, or the patterns or effects of these changes over time. These ideas will be more fully explored over the course of the unit. You may use the First Ideas/Revised Ideas Scoring Guide (on page 86 of the Assessment section in the Introduction book) to evaluate students' responses. This will give you a baseline against which to measure students' progress when they answer the two Revised Ideas prompts.

LANGUAGE OF SCIENCE

VOCABULARY

absorb
atmosphere
carbon cycle
carbon dioxide/CO_2
climate
climate change
currents
dense/density
evidence
fossil fuels
heat energy
heat-trapping gases
model
organism
sea level

LANGUAGE OF ARGUMENTATION

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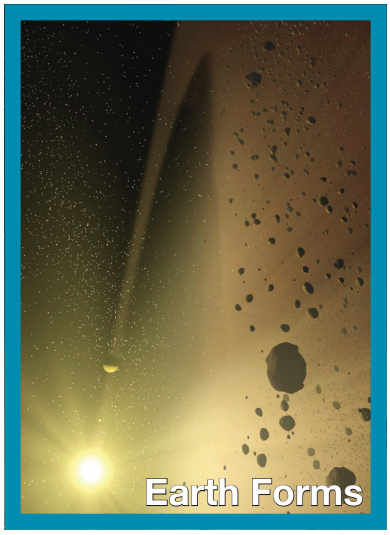


Front side of Events in Earth's History card (1 of 12)

Back side of Events in Earth's History card (1 of 12)

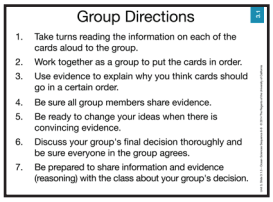
3. **Review Scientific Evidence chart.** Point to the chart you posted and go over the definition and different kinds of evidence:

   - **Evidence can come from our own investigations.** For example, if students conducted an investigation in class, they could use the results from the investigation to help answer a question or explain something.
   - **Evidence can come from other people's investigations.** Information you get from diagrams, such as the Carbon Cycle Diagram, or watching a science video or reading about other people's investigations can be used as evidence.
   - **Evidence can come from reasoning, thinking, and discussing.** Sometimes evidence comes from thinking and talking about evidence or experiences you have had in the past, as students have just done during the Turn and Talk.
   - **Scientific explanations are based on evidence.** Tell students that a good scientific explanation puts together evidence in a way that answers a question and provides reasons for the answer. The evidence is carefully collected data and information from a variety of reliable sources.

4. **Introduce Events in Earth's History cards.** Hold up an envelope with a 12-card set of Events in Earth's History cards. Explain that each card inside has a picture on the front and information on the back about an event that happened during Earth's long history. The challenge will be for each group to use the information and anything they already know to put the events in order from earliest (longest ago) to most recent.

5. **Give instructions for placing first card.** Tell students that the card "Earth Forms" will be the earliest event. Suggest that they place other cards next to that card, one at a time, and then move them around as they discuss and add each event card.

6. **Project slide, Group Directions.** Emphasize that this is a group activity. By sharing ideas within their groups, students will have more ideas and more evidence to consider. They should discuss their reasoning when trying to figure out the most logical order for the Earth events. Go over the directions on the slide. Organize students into groups of four and pass an envelope of cards to each group. Give students about 15 minutes to work.


Group Directions

1. Take turns reading the information on each of the cards aloud to the group.
2. Work together as a group to put the cards in order.
3. Use evidence to explain why you think cards should go in a certain order.
4. Be sure all group members share evidence.
5. Be ready to change your ideas when there is convincing evidence.
6. Discuss your group's final decision thoroughly and be sure everyone in the group agrees.
7. Be prepared to share information and evidence (reasoning) with the class about your group's decision.

TEACHER CONSIDERATIONS

Scientific Evidence

Evidence is a clue that helps answer a question or explain something.

Evidence can come from…

- our own investigations.
- other people's investigations.
- reasoning, thinking, and discussing.

Scientific explanations are based on evidence.

Figure 3–1.

PROVIDING MORE EXPERIENCE

Prepare: Evidence. If you did not teach Unit 1 and/or Unit 2, you may need to spend a little more time introducing the concept of evidence. Give an example of a question that could be solved using evidence or scientific clues. For example, **"Do ocean birds come to this particular beach?"** Give examples of possible evidence. [Actually seeing ocean birds at the beach, seeing birds swimming in the surf near shore.] Then ask, **"But if you didn't actually see birds there, what other evidence might you look for to see if ocean birds come there?"** [Finding prints on the beach that look like ocean bird footprints, feathers, bird droppings, nests, reading scientists' reports about the beach or about ocean birds in the area.] You might also point out things that are NOT evidence, such as opinions or fictional sources.

SCIENCE NOTES

About Earth's History and Climate Change. Throughout Earth's history, the climate has changed many times. Over the past two million years, Earth has oscillated between intense cold periods (glacials) and warmer periods (interglacials) due to natural processes. Since the start of the Industrial Revolution, however, Earth has undergone more rapid changes than at any time we know of in the past.

LANGUAGE OF SCIENCE

VOCABULARY

absorb
atmosphere
carbon cycle
carbon dioxide/CO_2
climate
climate change
currents
dense/density
evidence
fossil fuels
heat energy
heat-trapping gases
model
organism
sea level

LANGUAGE OF ARGUMENTATION

What do you think?
Why do you think that?
What is your evidence?
Do you agree? Why?
Do you disagree? Why?
How sure are we?
How could we be more sure?

Ordering Events and Gaining a Sense of Time in Earth's History

1. **Students order cards; check in with groups while they work.** As students discuss and organize their cards, circulate and listen, and if needed, encourage them to use evidence to support their ideas, get ideas from all group members, and work together to place the cards. You may need to remind students to refer to the backs of the cards. Ask, **"What made you decide to put _____ earlier than_____?" "What evidence did you use to make your decision?"**

2. **Discuss millions and billions of years.** After five to ten minutes, get the class's attention. Say, **"Because Earth is so old, understanding very large numbers is an important part of learning about Earth's history."** Tell students that while one thousand years ago seems like a very long time ago, some events in Earth's history happened more than 1000 times longer ago than that. Write "1,000,000 = one million" on the board and say that one million is one thousand times one thousand. Some events in Earth's history happened more than one thousand times longer ago than one million years! Write "1,000,0000,000 = one billion" on the board. Add the following abbreviations to the board:

   - YA = Years Ago
   - MYA = Million Years Ago
   - BYA = Billion Years Ago

3. **Reveal that times for events are listed on the backs of the cards.** Have students look at the back of the "Earth Forms" card and find where "4.5 BYA" is written in small print. Explain that scientists have concluded that Earth is about four and a half billion years old based on a lot of evidence. Point out that each card has the age of the event listed in this same location on the back of the card; the time information represents the number of years ago it took place, using scientists' conclusions that were based on evidence.

4. **Students reorder events.** Tell students that they will need to remember that a billion years is more than even hundreds of millions of years and that a million years is more than even hundreds of thousands of years. Have students reorder their cards using the time information on the backs of the cards. Circulate and assist as needed.

5. **Discuss results.** When groups finish reordering, regain the class's attention, and discuss the events on the cards. Begin by asking general questions such as, **"What surprised you? Why?"** Next ask a few specific questions such as, **"What are two events that happened with the least amount of time between them?"** [Any of the most recent events.] or **"What are some events that changed the Earth's atmosphere?"** [Earth cools; photosynthetic organisms; oxygen in atmosphere; land plants; most recent ice age; Industrial Revolution.] or **"What are some events that changed Earth's ocean?"** [Ocean formation; first life; photosynthetic organisms.]

TEACHER CONSIDERATIONS

INSTRUCTIONAL SUGGESTIONS

What If Students Discover the Time Information on the Backs of the Cards during Step 1? It is unlikely that many students will notice the time information on the backs of the cards during the first sort. Even if students do notice these numbers, they are unlikely to figure out what they mean on their own. If some students get focused on these numbers, say something like "Since you're not sure right now what those numbers mean, they are not very good evidence to help put these events in order." Encourage students to focus on the other information on the cards. Even if a few students do "crack the code" during the first sort, it won't greatly affect the overall success of the activity. Encourage them to discuss other evidence they could use to put the cards in order if they did not have access to the time information.

INSTRUCTIONAL RATIONALE

Purpose of Discussing Deep Time. This brief activity is not intended to prepare students to fully understand what is referred to in geology as "deep time" or "geologic time," but rather to give students an initial appreciation for the very long time spans involved in Earth's history. Organizing the event cards will encourage students to realize that events in Earth's history happened over a much larger time scale than students are used to thinking about. Many students may struggle with conceptualizing the actual lengths of time represented in this activity. If you want to offer additional opportunities for students to think about the relative magnitude of millions versus billions, consider leading the Providing More Experience activity below.

PROVIDING MORE EXPERIENCE

Reinforce: Deep Time Activity. To give students slightly more of a feel for the differences between millions and billions, you might tell them that when they were one year old, they'd been alive for 525,600 minutes, at five they'd reached 2,628,000 minutes, at 10 they were 5,256,000 minutes old. They wouldn't reach one billion minutes until they were older than 1,900 years, which could never happen.

Reinforce: Make Earth Timeline. Post one set of Events in Earth's History cards on a timeline on a classroom wall, with years spanning from 4.5 billion years ago to the present. This will help illustrate the huge expanse of time of Earth's history and emphasize that humans are a relatively recent addition.

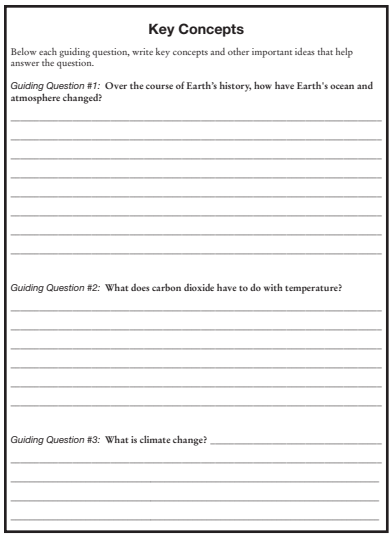
LANGUAGE OF SCIENCE

VOCABULARY

absorb
atmosphere
carbon cycle
carbon dioxide/CO_2
climate
climate change
currents
dense/density
evidence
fossil fuels
heat energy
heat-trapping gases
model
organism
sea level

LANGUAGE OF ARGUMENTATION

What do you think?
Why do you think that?
What is your evidence?
Do you agree? Why?
Do you disagree? Why?
How sure are we?
How could we be more sure?



Key Concepts

Below each guiding question, write key concepts and other important ideas that help answer the question.

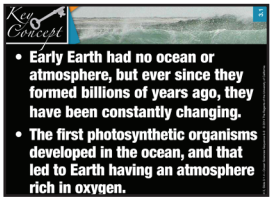
Guiding Question #1: **Over the course of Earth's history, how have Earth's ocean and atmosphere changed?**

Guiding Question #2: **What does carbon dioxide have to do with temperature?**

Guiding Question #3: **What is climate change?**

Investigation Notebook, p. 3

6. **Establish "deep time" for Earth's history events.** Point out that except for the two event cards having to do with people, each of the events in Earth's history not only happened very long ago but also took a long time to happen—millions, hundreds of millions, and billions of years in many cases. Tell students that it is difficult for us to comprehend how long a million or a billion years is, but the main goal of this activity is for them to understand that individual events in Earth's history happened long ago and over extremely long periods of time.



7. **Project slide; have students record key concepts.** Project the key concept slide and have students read it. Call on a volunteer or two to give examples of these changes. Have students turn to page 3, Key Concepts, in their Investigation Notebooks, and copy the key concepts onto the lines below Guiding Question #1. If time allows, invite students to add other notes from what they learned in this session that would help answer this guiding question.

8. **Preview next session.** Tell students that in the next session they will look at evidence about changing CO_2 levels in Earth's atmosphere over time. They will also explore possible explanations for these changes.

TEACHER CONSIDERATIONS

INSTRUCTIONAL RATIONALE

Reasons for Recording Key Concepts. When students record the key concepts presented in each lesson in a dedicated section of their notebooks, they have a powerful tool for reflecting on and synthesizing the most important ideas from the unit. Having students organize key concepts by the guiding questions they answer, adding their own related notes, and reviewing these pages helps them reflect on their learning and prepare for writing and discussions during the unit.

PROVIDING MORE EXPERIENCE

Reinforce: Create a Concept Wall. In addition to having students record key concepts in their Investigation Notebooks, it can be quite beneficial to post key concepts and guiding questions on a wall of the classroom to create a concept wall. This will allow students to reference important ideas simply by glancing at the wall, and will reinforce target vocabulary by keeping key words in students' view. Post related concepts and questions near each other. You can also add copies of student work and artifacts from the unit. Consider inviting students to add relevant illustrations.

Extend: Online Videos. *Comets Bombard the Early Earth* (4 minutes, 45 seconds) and *Life Before Oxygen* (1 minute, 39 seconds) are two recommended video resources that complement the discussion of significant events in Earth's early history. (Go to mare.lawrencehallofscience.org/oss68.)

Extend: Reflection Prompts for the Session. At the end of each session, we provide prompts that can be used in various ways. However you choose to use them, the goal is to provide additional opportunities for students to process and apply information and ideas they've learned in the session. Try using them for partner discussions after the session or during a final student sharing opportunity in which each student gets a turn to share. Or, use the prompts for science journal writing during class or as homework. If student responses are written, you can collect them and quickly gauge students' understanding of important ideas from the session. **Note:** These prompts are not part of the Investigation Notebook, and the time you choose to spend on them has not been included in the overall session time frame.

- How has Earth changed through time?
- Why might a scientist say that humans are a relatively recent addition to Earth, even though humans have been here for about 200,000 years?

LANGUAGE OF SCIENCE

VOCABULARY

absorb
atmosphere
carbon cycle
carbon dioxide/CO_2
climate
climate change
currents
dense/density
evidence
fossil fuels
heat energy
heat-trapping gases
model
organism
sea level

LANGUAGE OF ARGUMENTATION

What do you think?
Why do you think that?
What is your evidence?
Do you agree? Why?
Do you disagree? Why?
How sure are we?
How could we be more sure?