LAB-AIDS Correlations for

NEXT GENERATION SCIENCE STANDARDS

HIGH SCHOOL EARTH SCIENCE

Mark Koker, Ph D, Director of Curriculum & Professional Development, Lab-Aids

Lisa Kelp, Curriculum Specialist, Lab-Aids

This document is intended to show how *EDC Earth Science,* published by Lab-Aids, aligns with the *Next Generation Science Standards*[1].

ABOUT OUR PROGRAMS

LAB-AIDS Core Science Programs are developed to support current knowledge on the teaching and learning of science. All materials support an inquiry-driven pedagogy, with support for literacy skill development and with assessment programs that clearly show what students know and can do from using the programs. All programs have extensive support for technology and feature comprehensive teacher support. For more information please visit www.labaids.com and navigate to the program of interest.

ABOUT THE NEXT GENERATION SCIENCE STANDARDS

The National Academy of Sciences, Achieve, the American Association for the Advancement of Science, and the National Science Teachers Association have collaborated over several years to develop the Next Generation Science Standards (NGSS). The first step of the process was led by The National Academies of Science, a non-governmental organization commissioned in 1863 to advise the nation on scientific and engineering issues. On July 19, 2011, the National Research Council (NRC), the functional staffing arm of the National Academy of Sciences, released *the Framework for K-12 Science Education*[2].

The *Framework* was a critical first step because it is grounded in the most current research on science and science learning and it identifies the science all K–12 students should know. The second step in the process was the development of standards grounded in the *NRC Framework*. A group of 26 lead states and writers, in a process managed by Achieve, has been working since the release of the Framework to develop K-12 *Next Generation Science Standards* (NGSS). The final release of the *Standards* was in April 2013.

The NGSS provide an important opportunity to improve not only science education but also student achievement. The Next Generation Science Standards are student performance expectations – not

[1] http://www.nextgenscience.org/next-generation-science-standards
[2] http://www.nextgenscience.org/framework-k-12-science-education

curriculum. Even though within each performance expectation Science and Engineering Practices (SEP) are partnered with a particular Disciplinary Core Idea (DCI) and Crosscutting Concept (CC) in the NGSS, these intersections do not predetermine how the three are linked in curriculum, units, or lessons. Performance expectations simply clarify the expectations of what students will know and be able to do be the end of the grade or grade band. As is generally known, the *Standards* represent content from several domains: (1) science and engineering practices; (2) cross-cutting concepts; (3) the disciplines of life, earth, and physical science. The Standards themselves are written as performance indicators. Various other appendices describe other important elements of the Standards, such as DCI progressions, STS, nature of science, and more.

ABOUT EDC EARTH SCIENCE

EDC Earth Science is a full year, activity-driven high school earth science course developed by the Oceans of Data Institute[3] at the Education Development Center (EDC), with support from the National Science Foundation, and is fully aligned to the *Next Generation Science Framework*. *EDC Earth Science* is designed around the belief that students are capable of rigorous and in-depth explorations in science when given adequate support, structure, and motivation for learning.

EDC Earth Science features the following design components:

- In-depth treatment of content based on recommendations in national standards and representative state frameworks;
- Developmentally appropriate lessons featuring Earth Science concepts that build on previous learning and prepare students for more advanced courses;
- The use of historical, newsworthy, and fictionalized stories to draw students into the Earth Science content, to motivate them to acquire the knowledge for solving problems, and to serve as a framework around which students build conceptual understanding;
- Differentiated instructional strategies and activities that help students construct meaning from their experiences and that serve as bridges between concrete and abstract thinking; and,
- Support for developing literacy skills and the use of formative assessment techniques.

Each chapter of *EDC Earth Science* is a cluster of activities that addresses a specific set of concepts and skills. The amount of class time for each chapter will vary. A chapter may range from one to four weeks of classroom sessions. Not shown in the following table are two project-oriented shorter chapters that open and close the course, which taken together require 2-4 weeks for completion. This provides up to 32 weeks of actual instructional time, plus an additional 4 weeks for assessment and related activities. For more information, visit https://store.lab-aids.com/high-school-curriculum/edc-earth-science.

Unit Title	**Core Science Content**	**Suggested teaching time**
1 Hydrosphere: Water in Earth's	Water cycle; surface water, groundwater, assessing and protecting water supplies, Global patterns of	3-4 weeks

[3] http://oceansofdata.org/

Unit Title	Core Science Content	Suggested teaching time
Systems	ocean circulation; how wind and density differences drive ocean currents; global conveyor belt; El Niño	
2 Atmosphere and Climate	Climate and weather; influence of latitude, atmospheric circulation, proximity to ocean, elevation, land features, and prevailing winds on regional climate, Energy balance, albedo effect, greenhouse effect, carbon cycle, positive and negative feedback loops; Paleoclimatology, climate proxies, climate change in Earth's past, Milankovitch cycles, tectonic processes that influence climate, human impact on climate	5-8 weeks
3 Earth's Place in the Universe	Life and death of stars, solar nebular condensation hypothesis, Kepler's Laws, Earth's interior structure and composition, internal sources of heat energy, seismic waves, introduction to plate tectonic theory, driving forces of plate movement	3-4 weeks
4 Plate Tectonics	Transform-fault boundaries, earthquakes, physical and computer models Subduction zones, volcanoes, formation of igneous rocks, field-measurement technologies for volcano monitoring Seafloor spreading, paleo-magnetism, plate tectonics summary, landforms associated with plate boundaries	5-7 weeks
5 The Rock Cycle	Erosion and deposition, deltaic processes, formation of sedimentary rock, The nature of rocks and minerals, rock cycle	3-6 weeks
6 Earth's Resources	The geologic processes by which mineral ores are formed; mineral extraction and processing Fossil fuel formation, petroleum resources and exploration technologies	3-6 weeks

ABOUT THE LAB-AIDS CITATIONS

The following pages provide an overview of the program design and content, including the NGSF content treatment that was the basis for the development of the program (at the time of the program development, 2010-12, the *Standards* had not yet been released), the Consider-Investigate-Process learning cycle structure used in the program, relevant learning theory and research, support for literacy and assessment, and a brief bibliography. This is followed by detailed tables that set out learning outcomes, related NGSF content (DCI, SEP, CCC) and where taught, on a chapter-by-chapter basis.

EDC EARTH SCIENCE: THE FULL PICTURE

The material in this introduction clarifies the what, why, and how of this curriculum: the science content addressed, the teaching and learning principles and practices employed, and practical considerations for implementing the course.

Science Concepts and Practices

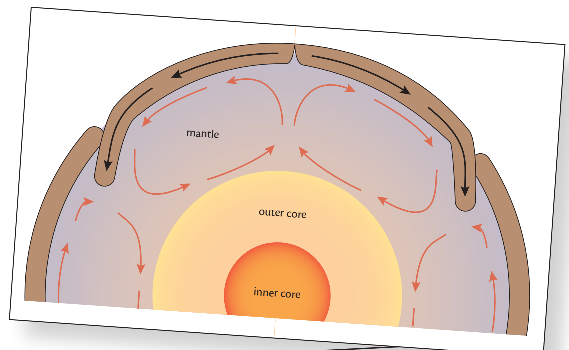
What areas of study are developmentally appropriate for high school students undertaking earth science? What topics best convey the main ideas of this discipline? What treatments lend themselves to understandings about the nature of science and to the development of scientific habits of mind? These are the questions that guided the choice of content for *EDC Earth Science.*

This course follows an Earth systems approach. The key concepts students focus on are:

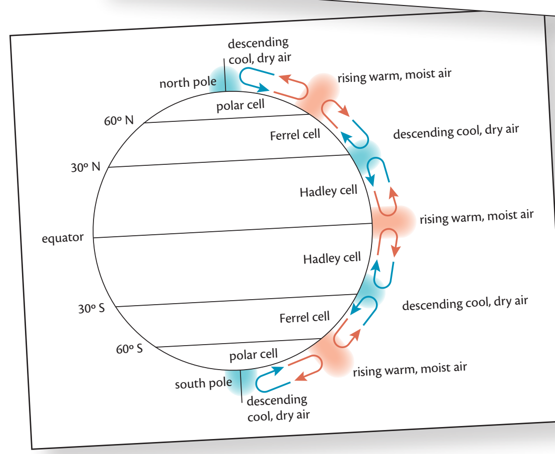
- Earth is a planet within a solar system within a vast universe, and the study of observable patterns reveals the history of Earth and the cosmos.
- Earth's systems are dynamic and constantly changing, driven by the constant flow of energy and matter.
- Changes occur over a wide range of time intervals and spatial scales.
- Complex interactions exist within and among Earth's systems, including its hydrosphere, atmosphere, biosphere, and geosphere.
- Scientists study interactions among Earth systems by using sophisticated technology to collect and analyze data.
- Humans can predict and prepare for natural disasters.
- Humans can act as agents of change in Earth systems.

The course engages students in the crosscutting concepts articulated in the *Framework,* which are: patterns; cause and effect; scale proportion and quantity; systems and system models; energy and matter in systems; structure and function; and stability and change of systems. When students examine interactions between lithospheric plates and the mantle in Chapters 9 and 10, or oceans and atmosphere in Chapter 4, they are learning core content from ESS2.C and ESS2.D, respectively. And when they learn about natural versus human-induced climate change (Chapter 6) and trade-offs in using earth's resources, such as oil or mineral ores (Chapter 16), they are accessing earth science content from ESS.3: Earth and Human Activity in the NGSF.

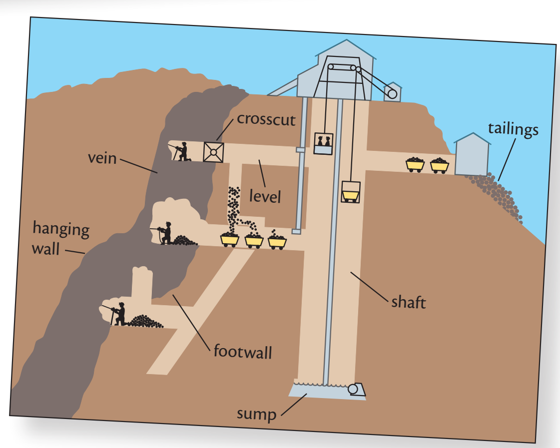
As the table in EDC Earth Science—An Overview shows, each semester begins with an engaging course introduction and ends with a summative performance assessment that



ESS2.B



ESS2.D



ESS3.A

requires students to synthesize their learning throughout the semester. The units within the two semesters are as follows:

EDC Earth Science Semester 1

Unit 1: Hydrosphere: Water in Earth's Systems

Unit 2: Atmosphere and Climate

Mid-Year Challenge

EDC Earth Science Semester 2

Unit 3: Earth's Place in the Universe

Unit 4: Plate Tectonics

Unit 5: The Rock Cycle

Unit 6: Earth Resources

Final Challenge

You will find more information regarding the content of this course at the beginning of each chapter in the teacher edition, along with information about the crosscutting concepts and scientific practices embedded in the chapter activities and readings.

NGSF ALIGNMENT

The following table shows the correlation between the concepts addressed in *EDC Earth Science* and *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012).

Correlation of *EDC Earth Science* with the *Next Generation Science Framework* Core Ideas High School (9–12)

	UNIT	CHAPTER
ESS1 EARTH'S PLACE IN THE UNIVERSE		
ESS1.A: THE UNIVERSE AND ITS STARS		
The star called the Sun is changing and will burn out over a life span of approximately 10 billion years **(HS-ESS-1)**.	3: Earth's Place in the Universe	8
The sun is just one of a myriad of stars in the Milky Way galaxy, and the Milky Way is just one of hundreds of billions of galaxies in the universe.	3: Earth's Place in the Universe	8
The study of stars' light spectra and brightnesses is used to identify compositional elements of stars, their movements, and their distances from Earth **(HS-ESS1-2, HS-ESS1-3)**.	3: Earth's Place in the Universe	8
The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe **(HS-ESS1-2)**.	3: Earth's Place in the Universe	8
Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode **(HS-ESS1-2, HS-ESS1-3)**.	3: Earth's Place in the Universe	8
ESS1.B: THE EARTH AND THE SOLAR SYSTEM		
Kepler's Laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun **(HS-ESS1-4)**.	3: Earth's Place in the Universe	8
Orbits may change due to the gravitational effects from, or collisions with, other bodies **(HS-ESS1-4)**.	3: Earth's Place in the Universe	8
Gradual changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes **(HS-ESS1-4)**.	2: Atmosphere and Climate	6
ESS1.C: THE HISTORY OF PLANET EARTH		
Radioactive-decay lifetimes and isotopic content in rocks provide a way of dating rock formations and thereby fixing the scale of geological time.	3: Earth's Place in the Universe 5: The Rock Cycle	8 14
The continents' rocks (some as old as 4 billion years or more) are much older than rocks on the ocean floor (less than 200 million years), where tectonic processes continually generate new rocks and remove old ones **(HS-ESS1-5)**.	3: Earth's Place in the Universe 4: Plate Tectonics 5: The Rock Cycle	9 10–12 14
Although active geological processes, such as plate tectonics (link to ESS2.B) and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history **(HS-ESS1-6)**.	3: Earth's Place in the Universe 4: Plate Tectonics 5: The Rock Cycle	8. 9 10–12 13, 14

Correlation of *EDC Earth Science* with the *Next Generation Science Framework* Core Ideas High School (9–12)

	UNIT	CHAPTER
ESS2: EARTH'S SYSTEMS		
ESS2.A: EARTH MATERIALS AND SYSTEMS		
Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. A deep knowledge of how feedbacks work within and among Earth's systems is still lacking, thus limiting scientists' ability to predict some changes and their impacts **(HS-ESS2-1, HS-ESS2-2)**.	1: Hydrosphere: Water in Earth's Systems 2: Atmosphere and Climate 4: Plate Tectonics	2, 3 4–6 10, 11
Evidence from deep probes and seismic waves, reconstructions of historical changes in the earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid but plastic mantle, and a solid surface crust **(HS-ESS2-3)**.	3: Earth's Place in the Universe	9
The top part of the mantle, along with the crust, forms structures known as tectonic plates. Motions of the mantle and its plates are driven by convection (i.e., the flow of matter due to the energy transfer from the interior outward and the gravitational movement of denser materials toward the interior) **(HS-ESS2-4)**.	3: Earth's Place in the Universe 4: Plate Tectonics	9 10–12
The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities **(HS-ESS2-4)**.	2: Atmosphere and Climate	4–6
These changes can occur on a variety of time scales from sudden (e.g., volcanic dust clouds) to intermediate (ice ages) to very-long-term tectonic cycles.	2: Atmosphere and Climate	4–6
ESS2.B: PLATE TECTONICS AND LARGE-SCALE SYSTEM INTERACTIONS		
The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle. This energy moves through and out of the planet's interior, primarily by mantle convection **(HS-ESS2-3)**.	3: Earth's Place in the Universe 4: Plate Tectonics	9 10
Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust **(HS-ESS2-1)**.	3: Earth's Place in the Universe 4: Plate Tectonics	9 10–12
ESS2.C: THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES		
The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics **(HS-ESS2-5)**.	1: Hydrosphere: Water in Earth's Systems 4: Plate Tectonics	2, 3 11
These properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting points of rocks **(HS-ESS2-5)**.	1: Hydrosphere: Water in Earth's Systems 2: Atmosphere and Climate 4: Plate Tectonics 5: The Rock Cycle 6: Earth Resources	2, 3 4–6 11 13, 14 15
ESS2.D: WEATHER AND CLIMATE		
Global climate is a dynamic balance on many different time scales among energy from the sun falling on Earth; the energy's reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems; and the energy's re-radiation into space **(HS-ESS2-2, HS-ESS2-4)**.	2: Atmosphere and Climate	4–6
Climate change can occur if any part of Earth's systems is altered. Geological evidence indicates that past climate changes were either sudden changes caused by alterations in the atmosphere; longer term changes (e.g., ice ages) due to variations in solar output, Earth's orbit, or the tilt of its axis; or even more gradual atmospheric changes due to plants and other organisms that captured carbon dioxide and released oxygen **(HS-ESS2-6, HS-ESS2-7)**.	2: Atmosphere and Climate	4–6
The time scales of these changes varied from a few to millions of years. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate **(HS-ESS2-6, HS-ESS2-4)**.	2: Atmosphere and Climate	4–6
Global climate models incorporate scientists' best knowledge of physical and chemical processes and of the interactions of relevant systems. They are tested by their ability to fit past climate variations.	2: Atmosphere and Climate	6
Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise **(HS-ESS3-6)**.	2: Atmosphere and Climate	6
The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and the biosphere. Hence the outcomes depend on human behaviors as well as on natural factors that involve complex feedbacks among Earth's systems **(HS-ESS3-6)**.	2: Atmosphere and Climate	6

Correlation of *EDC Earth Science* with the *Next Generation Science Framework* Core Ideas High School (9–12)

	UNIT	CHAPTER
ESS2: EARTH'S SYSTEMS *(continued)*		
ESS2.E: BIOGEOLOGY		
The many dynamic and delicate feedbacks between the biosphere and other earth systems cause a continual coevolution of Earth's surface and the life that exists on it **(HS-ESS2-7)**.	2: Atmosphere and Climate 3: Earth's Place in the Universe	4, 6 8
ESS3: EARTH AND HUMAN ACTIVITY		
ESS3.A: NATURAL RESOURCES		
Resource availability has guided the development of human society. All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks, as well as benefits **(HS-ESS3-1)**.	1: Hydrosphere: Water in Earth's Systems 6: Earth Resources	2 15, 16
All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors **(HS-ESS-2)**.	1: Hydrosphere: Water in Earth's Systems 6: Earth Resources	2 15, 16
ESS3.B: NATURAL HAZARDS		
Natural hazards and other geological events have shaped the course of human history by destroying buildings and cities, eroding land, changing the course of rivers, and reducing the amount of arable land **(HS-ESS3-1)**.	4: Plate Tectonics 5: The Rock Cycle	10, 11 12, 13
These events have significantly altered the sizes of human populations and have driven human migrations **(HS-ESS3-1)**.	1: Hydrosphere: Water in Earth's Systems 4: Plate Tectonics 5: The Rock Cycle	2 10, 11 13
Natural hazards can be local, regional, or global in origin, and their risks increase as populations grow. Human activities can contribute to the frequency and intensity of some natural hazards.	1: Hydrosphere: Water in Earth's Systems 4: Plate Tectonics 5: The Rock Cycle	2 10–12 13
ESS3.C: HUMAN IMPACTS ON EARTH SYSTEMS		
The sustainability of human societies and of the biodiversity that supports them require responsible management of natural resources not only to reduce existing adverse impacts but also to get things right in the first place **(HS-ESS3-3)**.	1: Hydrosphere: Water in Earth's Systems 6: Earth Resources	2 15, 16
Scientists and engineers can make major contributions—for example, by developing technologies that produce less pollution and waste and that preclude ecosystem degradation **(HS-ESS3-4)**.	1: Hydrosphere: Water in Earth's Systems 6: Earth Resources	2 15, 16
When the source of a problem is understood and international agreement can be reached, it has been possible to regulate activities to reverse or avoid some global impacts (e.g., acid rain, the ozone hole).	2: Atmosphere and Climate 6: Earth Resources	6 16
ESS3.D: GLOBAL CLIMATE CHANGE		
Because global climate changes usually happen too slowly for individuals to recognize them directly, scientific and engineering research—much of it based on studying and modeling past climate patterns—is essential.	2: Atmosphere and Climate	5, 6
The current situation is novel, not only because the magnitudes of humans' impacts are significant on a global scale but also because humans' abilities to model, predict, and manage future impacts are greater than ever before **(HS-ESS3-5)**.	2: Atmosphere and Climate	5, 6
Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities, as well as to changes in human activities. Thus science and engineering will be essential both to understanding the possible impacts of global climate change and to informing decisions about how to slow its rate and consequences—for humanity as well as for the rest of the planet **(HS-ESS3-6)**.	2: Atmosphere and Climate	5, 6

The study of Earth's systems provides rich opportunities to examine such NGSF crosscutting concepts as patterns, stability and change, cause and effect, systems and system models, structure and function, and scale, proportion, and quantity.

Students completing the *EDC Earth Science* course will also gain a robust understanding of how scientists work. The following scientific practices described in the *Framework* are integrated into the activities in this course:

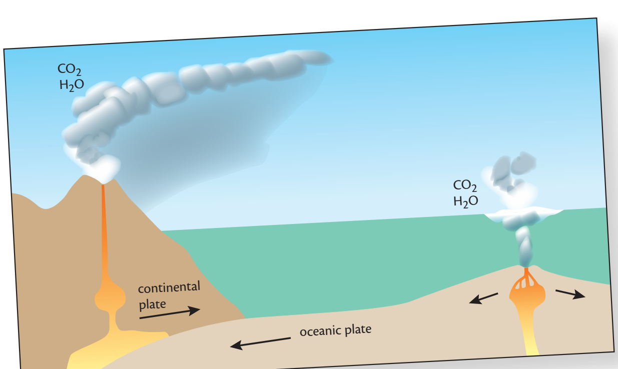
- Asking questions and defining problems.
- Developing and using models.
- Planning and carrying out investigations.
- Analyzing and interpreting data.
- Using mathematics, information and computer technology, and computational thinking.
- Constructing explanations and designing solutions.
- Engaging in argument from evidence.

A final note on content: While the curriculum is designed to promote students' understanding of certain basic concepts, practices, principles, and laws of earth science, there is a second aspect that is equally important. *EDC Earth Science* emphasizes a strong and, we hope, enduring message to students—that the principles of earth science are in action all around them and play an integral role in their everyday lives.

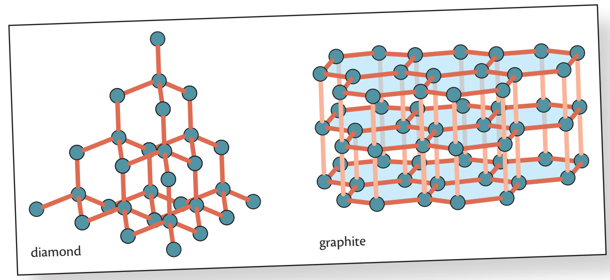
Curriculum Implementation

The teacher edition is the cornerstone for implementing the curriculum and is keyed to the student edition. Each chapter in the teacher edition includes:

- An overview.
- Chapter learning goals correlated with the science content, crosscutting concepts, and practices in the *Framework.*
- Possible misconceptions and possible barriers to learning.



In the Plate Tectonics unit, students study NGSF crosscutting concepts like Cause and Effect *and* Systems and System Models.



In the Earth Resources unit, models illustrate crystalline structures that determine the properties of minerals, exemplifying the crosscutting concept Structure and Function.

- Student assessment outcomes.
- Assessment strategies.
- Scope and sequence section and preview of each activity, with suggested class sessions and the approximate amount of time to conduct the chapter.

Within each chapter for all activities under CONSIDER, INVESTIGATE, and PROCESS, you will also find detailed suggestions for facilitating the activities as well as answers to the questions posed to students.

The teacher edition also presents logistical information:

- Advance Preparation: Special arrangements you will want to work on a bit ahead of time, such as preparing class presentations, securing open space for an outdoor activity, and practicing demonstrations and experiments.
- Materials and Preparation: Arrangements for each activity within the chapter, for example, gathering supplies needed for individuals or groups and obtaining equipment such as projectors and computers. We recommend that students work in groups of up to four students each, to promote cooperation and reduce materials demand and its associated cost. LAB-AIDS kits supply enough materials for up to 8 groups.

ONLINE TEACHING RESOURCES

A suite of online supports is provided to fit the needs of a range of classrooms. Teaching Resources on the *EDC Earth Science* page of the LAB-AIDS website include:

- links to websites containing real-time data, animations, and supplemental information to deepen and extend students' experiences.
- slide presentation for each chapter, which gives the teacher the ability to project and discuss the many maps and other data visualizations that are integral to this course.
- supplemental readings to go with some chapters, allowing students to explore topics in more depth.

- student sheets that provide more complex activities.
- literacy supplements, such as anticipation guides and science fact triangles, customized to each reading in the course.
- a complement of test bank items managed through the ExamView® platform.

The Learning Cycle Framework

EDC Earth Science provides a unique learning cycle framework—CONSIDER–INVESTIGATE–PROCESS (and in some cases, EXTEND)—that delivers consistency to students as they investigate a problem the way a scientist would. For scientists, a natural event stimulates their curiosity and the need for investigation. Through observation, experimentation, and review of the literature, scientists ultimately propose or develop new understandings to resolve the compelling question. They communicate their findings to fellow scientists and reconsider their conclusions in light of others' perspectives. These findings often lead to new investigations.

The CONSIDER–INVESTIGATE–PROCESS framework fully supports the 5E learning cycle model (Bybee et al., 1989), which is widely used in high school lesson planning and instruction in the United States. A more detailed description of how the scientific process and support for the 5E model are reflected in the *EDC Earth Science* framework is presented below.

Consider Investigate Process

The CONSIDER section brings students' own ideas to the forefront and provides insight into their existing perceptions and knowledge. Each chapter begins with a Brainstorming session, where students discuss their own ideas about the science topic to be covered. Students then read a narrative story that describes an event or situation, and sometimes they perform brief activities that engage their curiosity and set the scene for a challenge or problem to be solved. Learning activities in this section most clearly map to the "Engage" element of the 5E model.

Consider **Investigate** Process

The INVESTIGATE section begins by posing a challenge question arising from the narrative in CONSIDER. To address this challenge, students work individually or in teams; gather and synthesize information from readings, demonstrations, and activities; carry out research and collect and analyze data from the Internet or libraries; and communicate their thinking and exchange ideas with others. This section contains the "Explore," "Explain," and "Elaborate" elements of the 5E model.

Consider Investigate **Process**

During PROCESS, students share solutions, communicate their logic and reasoning, listen to the ideas of others, and then reconsider their solutions in light of the conclusions and reasoning of others. It is during this step that students demonstrate their mastery of the key science concepts covered. This section contains the "Evaluate" element from the 5E model.

The following table summarizes the alignment between components in the CONSIDER–INVESTIGATE–PROCESS model used in *EDC Earth Science* and the 5E learning cycle model.

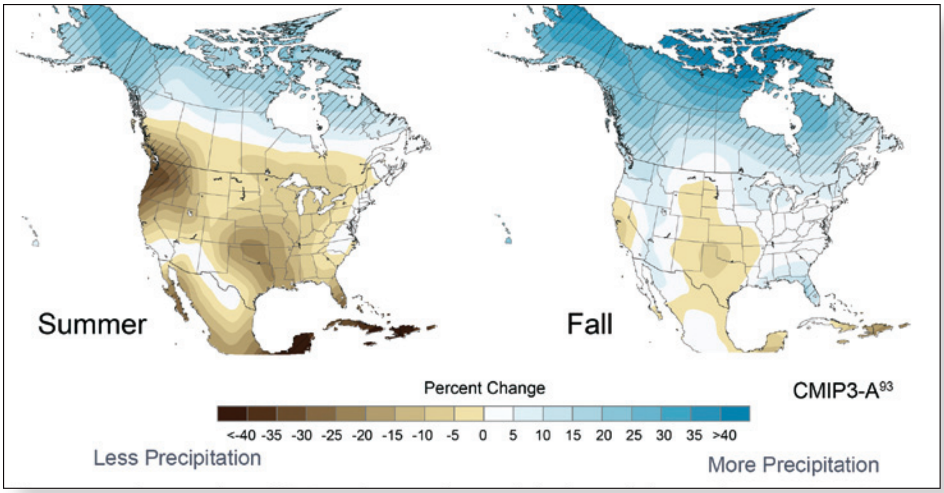
CONSIDER–INVESTIGATE–PROCESS MODEL	5E LEARNING CYCLE ELEMENTS
CONSIDER	Engage
INVESTIGATE	Explore, Explain, Elaborate
PROCESS	Evaluate

In some cases, students pursue additional investigations in an EXTEND that either applies the science concepts they have learned to new situations or extends the learning through the introduction of related concepts.

Teaching and Learning

EDC Earth Science is grounded in current understandings about cognitive development, the learning process, and the pedagogical methods that support construction of science knowledge. All aspects of the instructional materials—from the overall organization of the teaching–learning cycle (CONSIDER–INVESTIGATE–PROCESS) to the design and sequencing of the activities to the detail of the suggested teaching strategies—have been tailored to support students' learning.

The chapters employ varied teaching strategies and learning opportunities, move from the concrete to the more abstract, target common misconceptions, emphasize guided inquiry, and balance a strong, guided-inquiry orientation with readings and opportunities for practice. Sustained attention is applied to processing for meaning as students are often asked to pause and "Think About It." During the PROCESS phase of the learning cycle, students review their data, ideas, and experiences obtained during the experimental phase. In teacher-guided discussions, students present their own ideas, listen to



In EDC Earth Science, *students study such NGSF crosscutting concepts as patterns and cause and effect.*

the ideas of other students, revise their thinking, and come to new understandings of the concepts being developed. Learning goals, assessment outcomes, and assessments are closely aligned and clearly delineated. Students are afforded multiple ways to express their understandings and level of mastery. This array of features allows students with a range of learning styles to achieve their optimal level of understanding.

For each chapter and its activities, the teacher edition gives detailed suggestions for teaching and assessment strategies, discusses the rationales for those strategies, and discusses possible student preconceptions. In the pages that follow, this information is augmented with discussions of key teaching and learning elements of *EDC Earth Science.*

TARGETING MISCONCEPTIONS

Most students come to class with some intuitive notions about the physical world that are contrary to the scientific understandings evolved (often laboriously) over the past millennia. In large part, arising from and continually reinforced by everyday experience, these preconceptions (also called misconceptions) are firmly ensconced and resistant to change. Other sources of misconceptions can include confusion between nonscientific and scientific meanings of words, prior teaching that was incorrect, the interpretation of models, taking metaphors and analogies literally, over- or under-generalization of a concept, and confusion among related concepts.

Identifying students' misconceptions is essential in science teaching. The teacher edition identifies common misconceptions related to the content of each chapter. The Brainstorming in the CONSIDER phase of the learning cycle is designed to identify misconceptions. And the curriculum in its entirety encourages an open atmosphere where students can talk about their ideas, allowing you (and your students) to monitor misconceptions as well as changes in thinking.

Confronting and eventually modifying misconceptions is no easy task. As research in science learning has shown, teachers' lectures and demonstrations and text reading alone do little to correct misunderstanding. The *EDC Earth Science* course materials are, therefore, designed to address misconceptions through a variety of researched strategies. They give students ample direct and active experience with the phenomena in question and challenge them with experiences that directly contradict their misconceptions. Often, students need to predict outcomes based on their own conceptions and then compare their results to their predictions, thus revealing inconsistencies. This curriculum stresses practice in working with concepts in multiple contexts.

The curriculum also identifies certain barriers to learning, such as difficulties in interpreting three-dimensional diagrams, understanding that causal forces involved in changes in the earth are multifaceted and nonlinear, and conceptualizing small, incremental changes over vast periods of time. Suggestions are made as to how to recognize these barriers and assist students through them.

INQUIRY AND THE PRACTICES OF SCIENCE AND ENGINEERING

A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas places a major emphasis on the integration of core content knowledge from the earth sciences with the practices needed to engage in scientific inquiry and engineering design. Indeed, the *Framework* uses the term "practices," instead of a term such as "skills," to stress that engaging in scientific inquiry requires coordination both of knowledge and skill simultaneously. The *Framework* goes on to say that "engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. . . . Participation in these practices also helps students form an understanding of the crosscutting concepts and disciplinary ideas of science and engineering; moreover, it makes students' knowledge more meaningful and embeds it more deeply into their worldview" (NRC, 2012, p. 42).

The *Framework* specifies eight types of science and engineering practices (after NRC, 2012):

1. Asking questions (for science) and defining problems (for engineering).
2. Developing and using models.
3. Planning and carrying out investigations.
4. Analyzing and interpreting data.
5. Using mathematics and computational thinking.
6. Constructing explanations (for science) and designing solutions (for engineering).
7. Engaging in argument from evidence.
8. Obtaining, evaluating, and communicating information.

These practices are embedded in the learning activities in *EDC Earth Science,* which provide ample opportunity for students to engage in scientific practices as they develop conceptual understanding. The NGSS emphasizes that these practices "do not operate in isolation and that it is "important for them to see the connections among the eight practices" (NGSS, App F, p. 3). In *EDC Earth Science,* the CONSIDER–INVESTIGATE–PROCESS learning framework engages students in a coherent set of activities that connect the practices seamlessly. Students learn to ask appropriate questions to determine what they already know and what other information is needed. Students design ways to answer questions by gathering data and knowledge from a variety of sources, apply these data to solve problems, and make decisions based on good information and an understanding of the principles involved.

Students need to experience and practice each component of the inquiry process, and as recognized by the NGSS, "it's too much to expect each performance to reflect all components of a given practice" (NGSS, App F, p. 3). For example, in some cases, students are provided with a question but are challenged to design and perform an experiment, collect and process their data, and reach a conclusion. In other cases, students are provided with data and are challenged to identify patterns and develop new questions.

The teacher's edition support for each chapter shows—in table form—where there are opportunities for students to use and develop the practices of science and engineering.

COOPERATIVE LEARNING

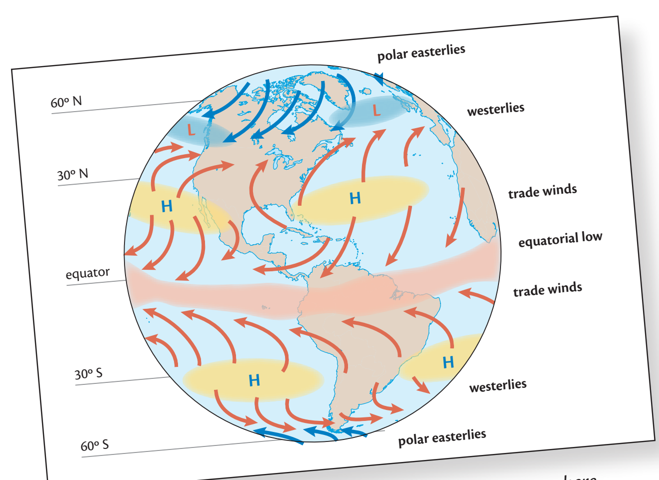
Throughout the curriculum, activities and investigations are designed with cooperative-learning groups in mind. Working in such groups may, however, involve new skills for many students. At first, you may assign students specific roles within a task, with the understanding that each member is accountable for the group's work. As students learn to listen, discuss, and share with each other, they should acquire the confidence to try new roles on their own.

A goal of the curriculum is to enable students to take responsibility for their own learning. In the groups, students discuss observations and ideas, which enhances learning and helps students gain confidence. Furthermore, the process of reaching a consensus models the way actual science is done. Cooperative groups allow students to practice strategies such as concept mapping, jigsaw learning, inquiry investigations, and analyses.

In *EDC Earth Science,* accountability for the work of a group takes many forms. For example, students may submit individual reports or take a specific role in an activity that teachers can assess. For group reports, each student should sign the completed report, signifying that he or she has understood the contents and agrees with the outcome.

USE OF MODELS

Models provide a particularly important strategy in earth science, since many phenomena occur on a size and timescale that is not directly perceivable. Models can be physical structures (students build a three-dimensional representation that allows visualization of a phenomenon), diagrams (students draw and modify diagrams to represent interacting elements of Earth processes), computer simulations (students view



Students study models of prevailing wind patterns in the Atmosphere and Climate unit.

computer simulations of physical phenomena that are used to better understand how complex phenomena interact), analogies (students give an unfamiliar idea or concept meaning by likening it to something familiar), or comparisons (students compare and contrast two phenomena that are related but different). It is important that students understand that most models are flawed; they do not truly represent the system that they model but are providing a stepping stone toward understanding. In many cases, it is important to have students describe the flaws as well as the usefulness of models that they are working with, asking themselves questions such as "how is this like the real thing?" and "how is this different from the real thing?"

TEACHING LITERACY SKILLS WITH *EDC EARTH SCIENCE*

Literacy skills are at the heart of thinking and learning. For students to organize and internalize concepts and information, and thereby construct understanding, they must be able to comprehend and critically analyze the information that they read, view, and hear. They must be able to communicate their ideas in ways that demonstrate sound reasoning based on evidence. As well as reading and writing, literacy skills include speaking, listening, and analyzing information and conveying it in a variety of forms and media.

The *Common Core State Standards* for English Language Arts and Literacy in History/Social Studies and Technical Subjects sets high standards for student literacy. The introduction to the standards says:

> "Students who meet the Standards readily undertake the close, attentive reading that is at the heart of understanding and enjoying complex works of literature. They habitually perform the critical reading necessary to pick carefully through the staggering amount of information available today in print and digitally. They actively seek the wide, deep, and thoughtful engagement with high-quality literary and informational texts that builds knowledge, enlarges experience, and broadens worldviews. They reflexively demonstrate the cogent reasoning and use of evidence that is essential to both private deliberation and responsible citizenship in a democratic republic" (Council of Chief State School Officers & NGA, 2010, p. 3).

The *Framework* makes it clear that teaching literacy skills should be an integral part of teaching science. The *Framework* identifies "obtaining, evaluating and communicating information" and "engaging in argument from evidence and constructing explanations" as key scientific practices (National Research Council, 2012, p. 42). The *Framework* says that students should be actively engaged in making and documenting observations; reading a range of scientific text materials; and incorporating a mix of words, diagrams, charts, symbols, and mathematics.

The teaching of literacy skills does not compete with, but rather supports, the teaching of science concepts and practices. Thier and Daviss, quoted in Worth, Winokur, Crissman, & Heller-Winokur (2009), say that "science and language are inextricably linked in the pursuit, determination, and communication of meaning through discussion, reading, writing, and other forms of representation."

EDC Earth Science provides a rich set of opportunities for students to develop and apply their literacy skills. Students

- *gather information* by engaging with readings in a variety of forms; analyzing data and information displayed in maps, graphs, charts, and photographs; researching topics on the Internet; and carefully observing phenomena.
- *build conceptual understanding* by organizing observations in tables and other data displays, documenting their thinking in writing, and discussing ideas with their peers.
- *communicate learning* through written projects (five-paragraph essays, business plans, and brochures) and orally (formal slide presentations, scientific poster sessions, and structured debates). Students are encouraged to incorporate a variety of new media as they gather, analyze, and communicate scientific information to meet the challenges within each chapter.

• USE OF STORY IN *EDC EARTH SCIENCE*

Stories have long been a means of conveying information, describing events, and passing on cultural history and skills. Story can also be used to engage and motivate learners. A good story will inspire readers to want to learn more about the subject or challenge them to acquire the knowledge required to solve a problem or conundrum presented in the narrative. Science stories in *EDC Earth Science* serve several purposes. Initially, the story engages students' interests by presenting an event or phenomenon that they find interesting or intriguing. The story presents the content in a context that serves as a framework around which students build conceptual understandings. Throughout a chapter, students may return to the story to determine how a concept might apply. The story also presents a challenge or question that students must address by applying the conceptual understandings that they have acquired during the chapter. Stories in *EDC Earth Science* relate historical events, recent newsworthy events, and in some cases fictionalized scenarios.

• LITERACY SUPPLEMENTS

The literacy supplements in *EDC Earth Science* help respond to the goals of the ELA 9–12 Reading and Writing Standards for Science and Technical Subjects in the *Common Core State Standards* (Council of Chief State School Officers & NGA, 2010), and their use is based on three beliefs (Wellington & Osborne, 2001):

- Learning the language of science is a major part of science education; every science lesson is a language lesson.
- Language is a major barrier to learning science.
- There are practical strategies that can help overcome these barriers.

To that end, *EDC Earth Science* provides concrete, embedded strategies to support students in reading, writing, oral discussion, and presentations. These have been adapted from programs used by teachers and researchers across the country. The following pages provide a brief description of the strategies and a table to show their distribution throughout the course.

Literacy supplements often take the form of single sheets that can be duplicated for classroom use. These can be found in the Teacher Resources.

• READING

The Lexile readability scores for the 17 chapters in *EDC Earth Science* range from 1,060 to 1,210. This corresponds to grade 10 or the level suitable for most high school sophomores (and grades 11–12), but the course can be taught to younger students if the Literacy Supplements described in this section are used. The *Framework* recognizes that reading in science is challenging for three primary reasons: (1) scientific terms are often unfamiliar to students; (2) the mode of reading is different from what students have experienced in language arts classes, because the meaning of words and phrases must be precise; and, (3) in addition to words, science texts incorporate diagrams, charts, graphs, maps, symbols, photographs, and mathematics as key elements for communicating ideas (NRC, 2012). *EDC Earth Science* provides many opportunities for students to improve their abilities to comprehend and apply the information in scientific texts.

Each chapter has one or more readings that serve many functions: they may be stories that serve to engage students by relating what they are about to learn to real-world situations (such as in What's the Story?); they may provide background information needed to complete an activity; or they may summarize the conceptual understandings that students should have acquired during the learning experience.

When new scientific terms are introduced in the readings they are highlighted and defined. Although a glossary is provided in the back of the book, students are encouraged to build their own glossaries of terms in their own words as they move through the course to help them reflect on the meaning of the terms. Students should be encouraged to incorporate the scientific terminology into their writing assignments and class discussions. In this way, they build not just the scientific ideas, but also the terms associated with them, into their conceptual understanding.

The readings also contain many maps, graphs, photographs, and diagrams that convey critical content. Students may have limited experience reading and interpreting some of the data visualizations that are common in earth science—particularly maps and other illustrations that require spatial visualization (Ishikawa & Kastens, 2005; Krumhansl, et al., 2012). Although research indicates that spatial thinking is a skill that can be learned, it is not systematically taught in the K–12 curriculum (NRC, 2006). When discussing readings in class, you may project slides of the figures related to the readings. These are provided in the Teacher Resources. You will want to make sure students are noticing the elements of these illustrations and extracting the intended meanings.

Each reading contains information that students must use to address the chapter challenge. The purpose of the reading is communicated to the students before they read, and the About the Reading questions focus them on the information they should retain and require them to think about how this information relates to the challenge.

You might apply a number of strategies with students to complete the reading tasks. Some of the readings may be read out loud during class time; some may be completed as homework; and some may be achieved through organizing students into jigsaw reading-and-sharing groups. In every case, it is critical to discuss the reading and About the Reading questions as a class. This gives you an opportunity for a formative assessment of students' understandings of the information in the reading and a time to reinforce key ideas. The following types of Literacy Supplements are provided in the teacher edition, with the application of a support customized for each reading in the course:

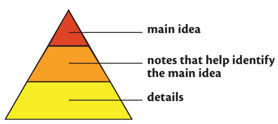
• LITERACY SUPPLEMENTS IN *EDC EARTH SCIENCE*

Anticipation Guide

Anticipation Guides (Herber, 1978; Wood, 2001) help stimulate discussion and students' critical thinking to enable them to better understand expository and narrative material. The guides consist of a series of statements that help elicit students' knowledge about key concepts before reading a selection, and a postreading review of those statements for students and the teacher to see how their knowledge has changed.

Science Fact Triangle

This strategy calls for students to record important concepts and facts from a reading, and to organize the information to highlight the main idea of the reading. The Science Fact Triangle (SFT) is adapted from Buehl's Fact Pyramid literacy technique (Thier & Daviss, 2002, pp. 102–103). It is a simple triangular graphic that helps students who are unable to "see the forest for the trees."



You may have students approach this in either of two ways. One is to have students start at the top where they identify the main idea (expressed as a sentence), and then move down the levels by filling in notes needed for the short term to identify the main idea, and leaving the base of the pyramid for details. Or, have students start at the bottom, noting details, notes, and main idea in reverse.

Three-Level Reading Guide

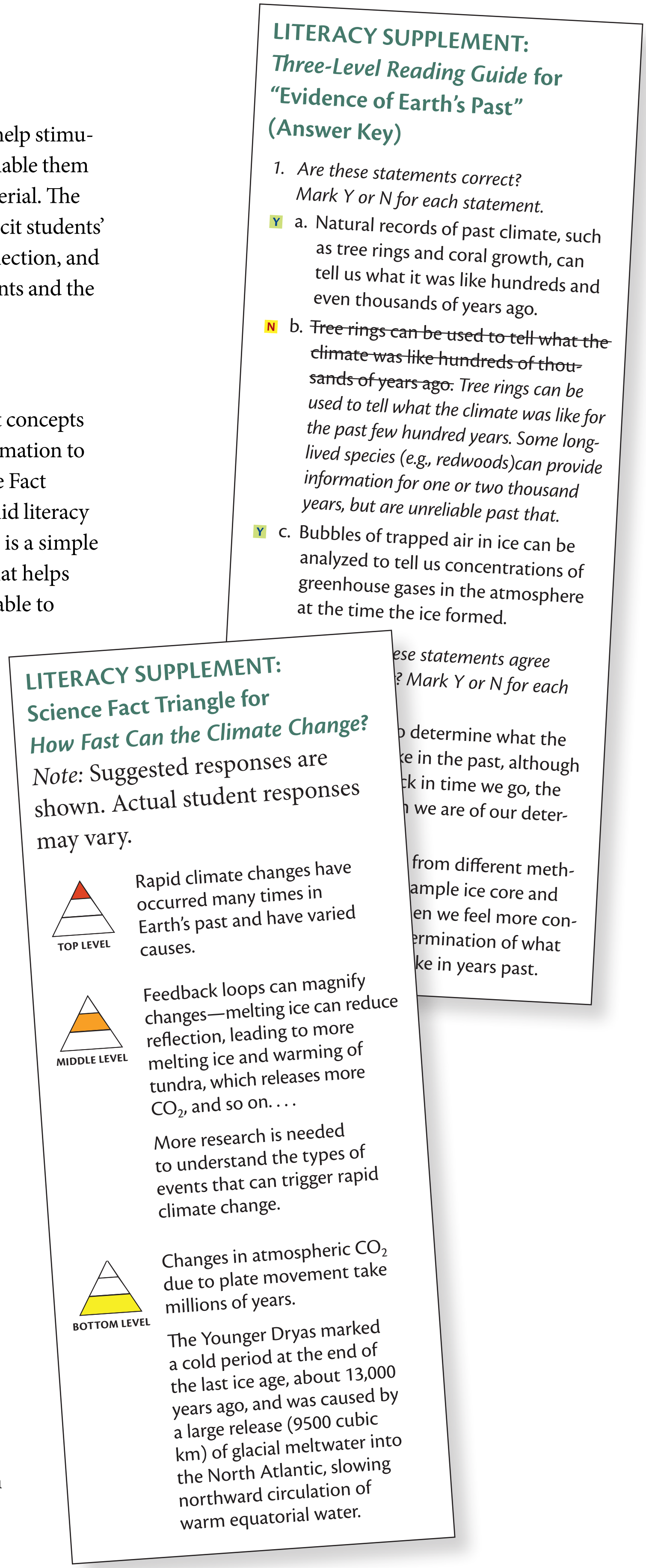
A Three-Level Reading Guide (Vacca & Vacca, 1995) is a sheet of statements students use to analyze a selection from a reading. It allows students to record their reading comprehension at three levels:

Literal—Understanding the literal meaning of the words and ideas in a reading selection.

Interpretive—Grasping the "message" of the selection or understanding what the author meant by the passage.

Applied—Relating the selection's message to other experiences or contexts.

Unlike many other postreading strategies that require extensive writing, this strategy focuses on students processing the ideas they have read.



LITERACY SUPPLEMENT:
Three-Level Reading Guide for "Evidence of Earth's Past" (Answer Key)

1. *Are these statements correct? Mark Y or N for each statement.*

Y a. Natural records of past climate, such as tree rings and coral growth, can tell us what it was like hundreds and even thousands of years ago.

N b. ~~Tree rings can be used to tell what the climate was like hundreds of thousands of years ago.~~ *Tree rings can be used to tell what the climate was like for the past few hundred years. Some long-lived species (e.g., redwoods)can provide information for one or two thousand years, but are unreliable past that.*

Y c. Bubbles of trapped air in ice can be analyzed to tell us concentrations of greenhouse gases in the atmosphere at the time the ice formed.

...ese statements agree ...? Mark Y or N for each

...o determine what the ...e in the past, although ...k in time we go, the ...n we are of our deter-

... from different meth- ...ample ice core and ...en we feel more con- ...ermination of what ...ke in years past.

LITERACY SUPPLEMENT:
Science Fact Triangle for How Fast Can the Climate Change?

Note: Suggested responses are shown. Actual student responses may vary.

TOP LEVEL

Rapid climate changes have occurred many times in Earth's past and have varied causes.

MIDDLE LEVEL

Feedback loops can magnify changes—melting ice can reduce reflection, leading to more melting ice and warming of tundra, which releases more CO_2, and so on. . . .

More research is needed to understand the types of events that can trigger rapid climate change.

BOTTOM LEVEL

Changes in atmospheric CO_2 due to plate movement take millions of years.

The Younger Dryas marked a cold period at the end of the last ice age, about 13,000 years ago, and was caused by a large release (9500 cubic km) of glacial meltwater into the North Atlantic, slowing northward circulation of warm equatorial water.

• ADDITIONAL READING STRATEGIES

Write As You Read

This strategy enables students to become more active readers as they identify and jot down key concepts, words, and passages as they come across them in the text. It helps them further develop the internal monologue that characterizes proficient readers (Thier & Daviss, 2002). Have students use science notebooks or journals or sticky notes that can be later collated in their notebooks and can serve as study guides for later. Possible prompts for making a note include:

- What is the main idea or topic?
- Make a mark next to parts you don't understand.
- Highlight parts you find especially interesting (not the whole text!).
- Circle parts you agree with.
- Identify words you don't know.
- Underline or mark parts your teacher wants you to know.
- Write a short summary (2 or 3 sentences) of the reading.

For time management's sake, it is important for you to identify no more than two of these bullets for students to use for a reading. These can be varied from reading to reading for the sake of variety or for particular problems suggested by the reading.

Talking Drawing

A talking drawing (Wood, 2001) involves students either making or interacting with a drawing suggested by the reading on a pre- and post-reading basis. It helps students connect what they know about a topic with what they are about to learn. The talking drawing is a proven way to help enhance students' understanding and recall.

• BUILDING COMMUNICATION SKILLS

EDC Earth Science helps students develop their communication skills by providing opportunities to demonstrate their knowledge by written, oral, and visual means. Students gain confidence by giving oral presentations, ranging from informal sharing of ideas and models to full-blown prepared presentations with visuals. Often in the course, students are given a choice of ways to demonstrate their learning, although all students are required at some point to employ diverse communication strategies, such as videos, brochures, written essays, position papers, newspaper articles, poster sessions, museum exhibits, construction of 3-D models, debates, and letters. Students can take notes and record observations and ideas in their notebooks and data tables. As students attempt to communicate in order to teach others, they develop such skills as logical organization of ideas, clarity in expressing ideas, and identification of major points to be made in a limited amount of time.

The following strategies support and encourage students' writing and note-taking skills:

Cornell Notes

The Cornell note-taking system was devised in the 1950s by Walter Pauk, an education professor at Cornell University. The Cornell method provides a systematic format for condensing and organizing notes. First, students divide a sheet of paper into two columns: the note-taking column (usually on the right) should be twice the size of the questions/key-word column (on the left). They should leave about two inches at the bottom of the page.

Students write notes from a lecture or teaching in the note-taking column. Such notes usually consist of the main ideas of the text or lecture; long ideas are paraphrased. Students should avoid long sentences, and use symbols or abbreviations instead. To assist with future reviews, students write relevant questions or key words in the key-word column.

Within 24 hours of taking the notes, students revise their notes, write new questions, and then write brief, five to seven line summaries in the space at the bottom of the page. This helps to increase their understanding of the topic. When studying for either a test or quiz, students will have a concise but detailed and relevant record of previous classes.

Science Notebooks

Students should keep science notebooks throughout the *EDC Earth Science* course. Just as a scientist would, students use their notebooks as an informal place to record data, process their ideas and thinking, and build observation skills. The emphasis should be placed on keeping the notebook as an informal place for building knowledge, and while students may use a variety of formats, sometimes they need to record data in a hurry. Notebooks should not take on the appearance of a formal work product—just as a scientist will work up data and observations to produce a paper for publication, students may produce a more formal work product using information logged in their science notebooks when needed.

You may require your students' notebooks to follow one or more of the following guidelines:

- Write daily entries with a clear heading and date.
- Leave space at the beginning for a table of contents and at the end for appendices.

- Use a uniform style for major entries. Elements could include the use of pen or pencil; rules for margin notes, data, or drawings; or standards for attaching and displaying teacher handouts.

You may elect to inspect notebooks regularly and ask that they be left in class instead of taken home each day. There are many online sources for using science notebooks, as well as a good discussion in the book *The New Science Literacy,* by Thier & Daviss (2002).

Writing Frames

A writing frame is a task-specific outline for students. They fill in the frames to come up with technically sound, if somewhat formulaic, paragraphs to give them writing confidence. Over time, you may remove some prompts, based on the difficulty of the assignment.

Concept Maps

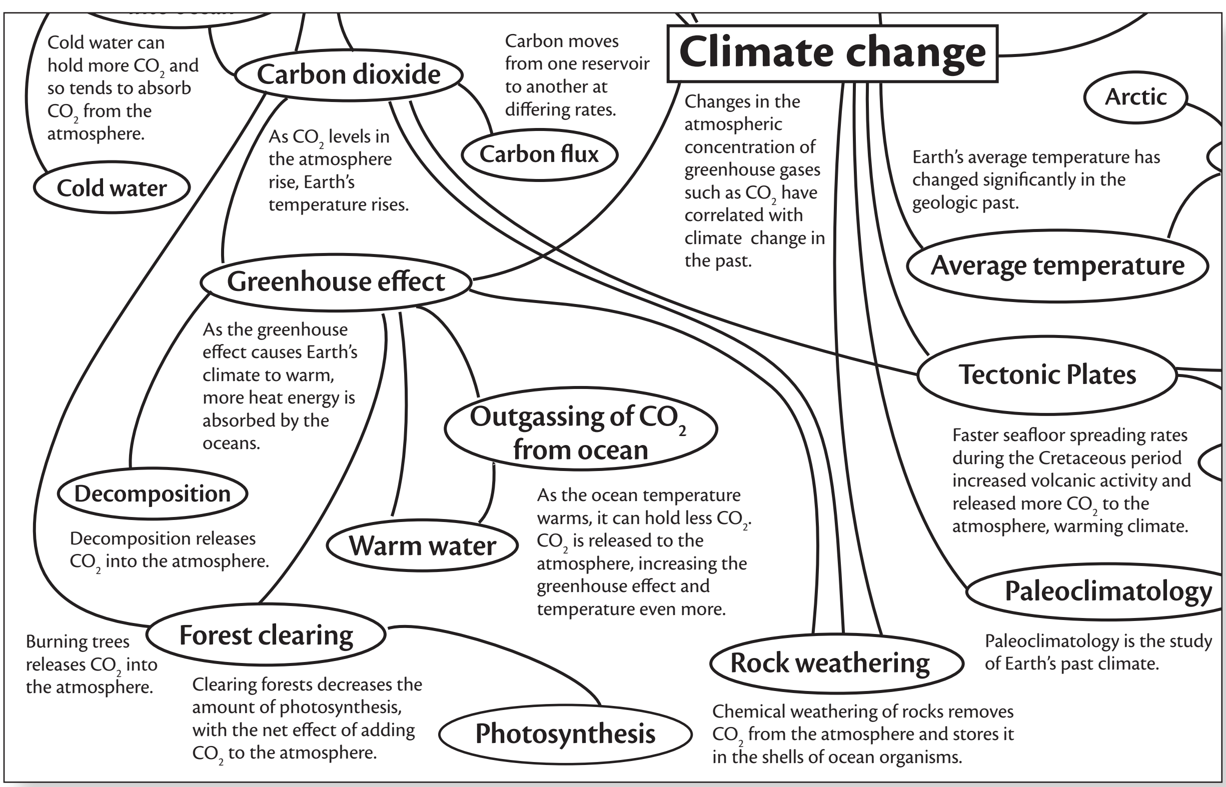
Concept maps are diagrams that illustrate the connections between certain concepts. They provide a way for students to organize information, identify relationships among concepts, and identify gaps in their own understandings. Students' concept maps enable you to identify any misconceptions, assess their understanding, and introduce and review concepts visually.

A concept map usually focuses on a main idea, supported by related ideas and describing connections between ideas. Concepts are placed in circles and linked by lines to other concepts. Words on the connecting lines indicate the relationship between ideas. Concepts should generally be linked to two or more ideas and have branches and cross-linkages.

Emphasize to students that no single concept map is correct. But while there may be no "right" map, maps can be incomplete or have incorrect connections. Ideas of connections can change as students' better understand these concepts. Students may want to initially construct concept maps with sticky notes that enable them to change connections as their understanding increases.

• DISCUSSION AND ORAL PRESENTATION

Class discussions are an integral strategy for teaching and learning in *EDC Earth Science.* Whole-class discussions not only give you a chance to probe students' understanding, they also give students the opportunity to relate their experiences to the topic of discussion. This makes the subject authentic, practical, and relevant. Students can use discussion to explain their ideas and provide evidence for their conclusions. The process of critiquing explanations in a public forum enables students to reach a greater depth of understanding and to confront certain preconceptions.



Partial concept map for climate change (see Resource supplement 6.1)

There are many questions posed in each chapter that help you focus class discussions. The Brainstorming questions at the beginning of each chapter will reveal existing knowledge and preconceptions. Questions provided with the activities and readings will help to reinforce key information, and often invite students to apply what they've learned to different contexts.

Discussions inform instruction by enabling you to assess knowledge and determine levels of understanding, logic, and reasoning.

Since students may not be accustomed to discussions in science classrooms, such sessions at the beginning of the year may seem labored. Encouraging all students to participate and to practice "wait time" will increase class participation and the quality of the responses. Allowing students to have small-group discussions before entering into whole-class discussions will give more reticent students a chance to gain confidence in speaking before a group and to learn the value of their contributions.

Your task as facilitator is to

- pose thought-provoking questions.
- break larger questions into smaller, more manageable ones.
- help students clarify their thinking by rephrasing or asking different questions.
- keep discussion focused on the concepts being explored.
- help students practice discussion etiquette in listening and responding to others.

Oral presentations are likely to be intimidating to students at first, although as they gain practice speaking before each other they will become more comfortable. Initially, you could provide opportunities for informal presentations of group work, with simple rules, such as "all group members should have a part in the presentation." Formal presentations should have clear guidelines and rubrics, and you should expect students to participate as active, respectful listeners when classmates are presenting.

The following strategies help encourage productive class discussions and oral presentations:

Take a Stand

This oral literacy strategy calls for students to physically orient themselves in the classroom depending on their position on an issue. Once there, students discuss reasons for their positions. With the teacher, they can compare and contrast the main points and differences between groups. This can be along a single continuum, for example, to show whether they "strongly agree," "agree," "disagree," or "strongly disagree" in response to a prompt or question. For example, in response to possible actions to save the most energy in a daily commute, those favoring carpooling, public transportation, telecommuting, etc., would occupy different parts of the room. An interesting variation is to have students in one area argue persuasively in order to get other students to change their minds; still another variation is for students to post their opinions on a sticky note and post on the whiteboard for all to see.

Think-Pair-Share

Have students first think or write responses to a prompt that you give them, and then have them discuss their responses with another student, generally a lab partner. You can then have them share their ideas orally with the entire class.

Chalk Talk

This is a "silent" class discussion strategy designed to encourage the participation of quieter students and help focus students' thinking and ideas around key concepts. Students sit on desks so that all can see and easily access the board. After you write a question or concept on the board (for example, "energy"), students then (without any talking) write ideas about that concept on the board, connecting their thoughts with a line to the original concept or to those written by other students.

Oral Presentation Guidelines

These can include informal, exploratory speaking and listening, or more-formal presentational speaking. Thier & Daviss (2002) have developed performance expectations for each type of speech that helps develop a rubric for evaluation purposes.

PERFORMANCE EXPECTATIONS FOR EXPLORATORY SPEAKING

- Initiates new topics and responds to others
- Asks relevant questions
- Responds to questions with appropriate explanation and details
- Uses language cues to indicate different levels of certainty
- Confirms understanding by paraphrasing what others have said

PERFORMANCE EXPECTATIONS FOR PRESENTATIONAL SPEAKING

- Speaks clearly and confidently in pleasant tone, pitch, and appropriate vocabulary that others can easily hear and understand

- Shapes information for a purpose and to appeal to the audience
- Uses notes and other memory aids to structure the presentation
- Uses visual aids to increase audience understanding, when appropriate
- Develops main points related to a single idea
- Engages the audience by using verbal cues and eye contact
- Projects a sense of individuality and personality

THE *EDC EARTH SCIENCE* APPROACH TO ASSESSMENT

Assessments are linchpins of teaching and learning. Used well, they provide powerful tools to inform your instruction so that your students develop rich, well-structured knowledge and scientific reasoning skills. Assessments come in a variety of forms, and should be **directly tied to clear learning goals.** These assessments are useful for a range of purposes, including:

1. **Evaluating the background knowledge** your students bring to each chapter.
2. **Monitoring students' progress** along the way so you can adjust instruction.
3. **Measuring students' achievement** of learning objectives at the end of each chapter.

Equally important is students' use of assessments. Assessments help keep learning goals in high relief, and provide critical feedback to students. In doing so, assessments empower students to take charge of their own learning.

The *National Science Education Standards* (NRC, 1996) says that assessment tasks should "reflect what students are expected to learn; elicit the full extent of students' understanding; [be] set in a variety of contexts; have practical, aesthetic, and heuristic value; and have meaning outside the classroom" (p. 87). Quizzes and tests with multiple-choice and short-answer questions can be efficient measures of content knowledge, but other forms of assessment are necessary to promote learning of the complex relationships between concepts and the scientific practices identified in the *Framework,* such as planning and carrying out investigations, engaging in argument from evidence, and obtaining, evaluating, and communicating information (NRC, 2012). Using a variety of authentic assessments in the context of meaningful learning experiences can engage and motivate students. Such variety also allows those with diverse learning styles and abilities to show what they know and to excel in their schoolwork.

Learning goals are a particularly critical anchor point in extended learning experiences, such as those embodied in the chapters of *EDC Earth Science.* They bring a coherent purpose to the learning activities, and provide a framework against which progress can be measured. To be useful measures of learning and effective motivators of students' achievement, formative and summative assessments should always clearly relate to these learning goals.

Formative assessments are used during the learning process to identify when and where students are having difficulties, so that you can adjust the pace of instruction to allow more time for learning and/or to employ different teaching strategies to improve their understanding. Formative assessments based on clear learning goals also give students a chance to reflect on what they do and don't understand, and to identify personal strategies for improving their performance. They can include:

1. Probing students' understanding during class discussions.
2. Reviewing and providing feedback to students' written responses to homework questions.
3. Formal quizzes.
4. Less formal "minute papers" in which students, at the end of class, write their thoughts about the question, "Do you still have questions about the material we covered today?" (UMass Office of Planning and Assessment, 2001)

Formative assessments should occur frequently—the ambitious goal should be to give students feedback that is "just-in-time, just-for-me information delivered when and where it can do the most good" (Brookhart, 2008, p. 1).

Summative assessments occur at the end of a chapter, unit, or course, and measure the learning that has occurred. In addition to providing a cumulative measurement for grading purposes, summative assessments can give students a valuable opportunity to review and synthesize what they have learned.

Summative assessments, like formative ones, may take various forms:

1. Tests with selected-response and short-answer questions are efficient for assessing content knowledge, and can, in some cases, uncover persistent misconceptions.
2. Open-response questions can yield more information about students' reasoning skills.

3. Performance assessments such as essays, lab reports, and oral presentations (as you will find in *EDC Earth Science's* Address the Challenge) are effective tools for measuring students' synthesis and application of concepts, as well as their mastery of literacy skills and scientific practices.

There are several formative and summative assessment strategies and tools in *EDC Earth Science.* These are linked to the learning goals and learning outcomes identified in the book chapters, and ultimately to the science practices, crosscutting concepts, and core-content elements of the *Next Generation Science Framework* (NRC, 2012).

Formative Strategies

These are typically used during the CONSIDER–INVESTIGATE–PROCESS phases of the *EDC Earth Science* learning cycle. Examples include:

- **Literacy strategies,** such as the Anticipation Guide, Science Fact Triangles, and Three-Level Reading Guides, which provide feedback that can be used on a formative basis.
- **About the Reading** questions to see what students learn from the short content readings in the course.
- **Analysis questions** for formatively assessing students' learning from activities.
- **Students' science notebooks** that can provide formative feedback for teachers and students.
- **Discuss** questions in the PROCESS sections that provide useful feedback on whether the broad chapter learning goals have been met.

Summative Strategies

These typically come into play only after the PROCESS phase of the *EDC Earth Science* learning cycle. They include:

- **Multiple-choice** items, found at the end of each chapter (Assessment), as well as in electronic form in the ExamView® test-generation software.
- **Free- or constructed-response** items, to be scored with rubrics or scoring guides, also found in the end-of-chapter Assessment questions and ExamView® test item banks online.
- PROCESS or Address the Challenge tasks requiring **students' responses.**

In addition to using the formative strategies outlined in this section, teachers should review the Possible Misconceptions and Barriers to Understanding section for each chapter, as these are derived from research on students' misconceptions about science topics as well as field-test feedback.

Your time is valuable, so the supports for assessment are placed where you need them and when you need them. For example, you will find the following assessment supports at the beginning of each chapter in your teacher edition:

- **Identification of key ideas and key scientific practices.** These represent the learning goals against which formative and summative assessments should be measured.
- **Assessment outcomes** derived directly from the learning goals. These highlight what students should be able to do by the end of the chapter.
- **Assessment Strategies** table. This identifies specific assessment opportunities—embedded within the chapter—for evaluating prior existing knowledge, monitoring students' progress, and measuring students' learning.

These supports will quickly orient you to the chapter focus and goals. Beyond these introductory tools, *assessment explicitly related to the learning goals is built into the very structure of the lessons.* The following section describes the use of formative and summative assessment strategies in *EDC Earth Science.*

• INTRODUCING LEARNING GOALS AND ASSESSING PRIOR KNOWLEDGE

Each chapter of the student book begins by introducing students to the learning goals and why they are important, and asks students to reflect on what they already know about the ideas that will be covered. In a Brainstorming discussion, using questions as prompts, students generate as many ideas as possible with no discussion or criticism. Participants are encouraged to build on and extend the ideas of others, and any and all suggestions are accepted, even unusual or far-flung ones.

The goals of an *EDC Earth Science* Brainstorming are

1. to elicit knowledge that students may have about the concepts they will be exploring in the chapter, providing you with the opportunity to see what students know or think they know about the topics.
2. to help students start thinking about the concepts they will be exploring in the ensuing lessons.
3. to create a classroom culture for effective formative assessment. This culture promotes discussions in which ideas are presented clearly and succinctly; listening and building on the thinking of others is a major component; and ideas can be shared safely without risk of derision or criticism.

Each Brainstorming activity has three to five questions that students discuss with a partner, after which they share their responses in a whole-class discussion.

Opportunities	Information Gathered
Consider	
Brainstorming	Students' prior understandings of Earth's history and initial ideas about what could have caused climate to be different in the past
What's the Story—"Journey to a Different Time"	Students' initial understandings of the types of evidence used to reconstruct Earth's climate history, and review of how changes in Earth's energy balance can affect global temperature Assessment Outcome 1 (Assessment items 7, 8)
Investigate	
Activity 1—"Looking for Clues to the Past"	Assessment Outcome 2 (Assessment items 1–3)
Reading—"Evidence of Earth's Past"	Assessment Outcome 2 (Assessment items 1–3)
Activity 2—"Using Climate Proxies"	Assessment Outcome 2 (Assessment items 1–3)
Activity 3—"Investigating How Orbital Changes Have Affected Past Climate"	Assessment Outcome 3 (Assessment items 4, 5)
Reading—"The Carbon Cycle, Cretaceous Breadfruit Trees, and the Long Slide to the Ice Age"	Assessment Outcomes 4, 5 (Assessment item 6)
Reading—"How Fast Can the Climate Change?"	Assessment Outcome 6 (Assessment item 9)
Activity 4—"What's Happening Now and What's Projected for the Future?"	Assessment Outcome 7 (Procedure Part A, Steps 2, 3; Part B, Steps 1–3; Analysis Questions 1–5)
Reading—"Sorting Out Natural and Human-induced Climate Change"	Assessment Outcome 8 (Assessment item 7)
Address the Challenge	Students' abilities to synthesize what they have learned from their study of Earth's climate history and teach it to others through a museum exhibit
Process	
Share	Students' understandings of the key concepts covered in this chapter
Discuss	Students' ideas about how their thoughts about climate have changed since the beginning of this unit, and their abilities to synthesize what they have learned, relating phrases and terms used in this chapter to the concept of climate change
Assessment	Students' understandings of the range of concepts presented throughout the chapter; these questions can be used in class, for homework, or as a quiz at the end of the chapter.

Each Teacher Edition chapter clearly shows links between activities and assessment

Brainstorming is divided into three major steps:

1. Students discuss the questions with a partner and record their responses. They should write the responses in their science notebooks, but they may also write them on sticky notes or on a computer for sharing directly during the ensuing whole-class discussion. It is important to give students enough time to let their ideas surface and discuss them with a partner.
2. Students share their ideas in a whole-class discussion. Ideas should be recorded either on a flip chart or interactive whiteboard. Encourage students to build on the ideas of others to add to the list and, given time, to consider what other students have said. The emphasis should be placed on quickly capturing the ideas, not discussing them in depth or evaluating them. This is not the time to teach but rather to collect as many responses as possible without verbal or visual criticism or judgment.
3. At the end of the chapter, students return to their earlier Brainstorming responses and discuss how their ideas have changed and deepened.

Other elements in the first part of each chapter include What's the Story and About the Reading questions, as well as, in some cases, initial learning tasks, all of which provide a rationale for the learning goals and motivation to meet them. A Challenge question encapsulates the learning goals, and an overview presents the activities students will perform in the chapter to gather the knowledge necessary to answer the challenge question.

• MONITORING STUDENTS' PROGRESS

Opportunities for formative assessment are provided throughout each chapter. These formative assessments reveal the state of students' understanding, and represent a chance for you to give students feedback and encourage them to follow certain strategies to improve their work. In some cases, they will alert you to needed adjustments in your teaching, such as allocating more or less emphasis to particular concepts or using alternative approaches to help students understand the ideas. The curriculum provides teaching strategies and additional background information at particular junctures to give you suggestions about how to make these adjustments when needed.

As students move through the activities and readings within a chapter, they regularly connect back to the Challenge question, which gives them the chance to monitor their progress as they gather knowledge to meet the challenge. Pre-activity discussions, often included, give students an explicit opportunity to reflect on their current knowledge and focus them on the learning goal of the activity. Think About It questions, which appear within activities and readings, give students a chance to stop and think about what they are learning and how it relates to their learning goals. The About the Reading and Analysis questions at the end of each reading and activity, respectively, ask students to synthesize what they have learned and think about what it means. Possible student responses to each About the Reading and Analysis question are provided.

These open-response questions also provide a window into students' thinking and reasoning, and give you a chance to give them feedback and adjust instruction when needed. Completed data tables, structured note sheets, and the oral sharing of group results associated with many of the activities are other tools for evaluating students' understanding. Your feedback should help students understand where they are relative to the learning goals and give them specific steps they can take to improve.

The *EDC Earth Science* teacher edition includes supports to help you make best use of these varied formative assessment opportunities. Teaching strategies offer suggestions at key points, such as:

- Optional demonstrations and activities to reinforce concepts.
- Verbal prompts and other strategies to help students think about a concept, question, or activity.
- Links and other referrals to supplemental activities and readings or sources of information to adapt the curriculum to your classes' interests and needs.

In some cases, you may find that sharing additional scientific information, beyond what is provided in the student book, is an effective way to respond to student interest and deepen understanding. Science background information is provided to you throughout the teacher edition to help you capitalize on these opportunities.

• DETERMINING STUDENT LEARNING— WHAT THEY KNOW AND ARE ABLE TO DO

For each of the chapters, you will find a rich source of materials for summative assessment that will allow you to evaluate students' mastery of scientific concepts and practices. At the end of each chapter, students synthesize what they have learned in Address the Challenge. They demonstrate their learning through written essays, position papers, newspaper articles, posters, museum exhibits, construction of 3-D models, and debates. In addition, Assessment questions at the end of each chapter (and in ExamView) provide an ample source of selected-response and open-ended items to gauge students' learning.

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CHAPTER OVERVIEW FOR *EDC EARTH SCIENCE* SHOWING LEARNING OBJECTIVES AND NGSS ALIGNMENT

Chapter	Learning Objective	DCI/SEP/CCC Alignment	Where Taught in *EDC Earth Science*
1	Earth consists of four major systems—the geosphere (solid Earth), hydrosphere (water), atmosphere (air), and biosphere (life). Interactions among these systems create the condi-tions that exist on Earth and make life on this planet possible.	ESS2.A.1, ESS2.E.1 Asking questions Constructing explanations	*Activity—"*Survival on Earth and Mars" Part A: "Brainstorming Survival Needs" Part B: "Differences between Earth and Mars"
	Other planets such as Mars are not as hospitable to life as Earth. For example, Earth has a thick oxygen-rich atmosphere that provides breathable air, comfortable temperatures, and protection from space radiation. Earth also has liquid water, an essential requirement for life.	ESS2.E.1 Asking questions Constructing explanations Engaging in argument from evidence Systems and system models	*Activity—"*Survival on Earth and Mars" Part B: "Differences between Earth and Mars"
2	Water, due to its abundance and unique qualities, is central to Earth's dynamics and to human survival.	ESS2.C.1, ESS2.C.2 Asking questions and defining problems Analyzing and interpreting data Using mathematics and computational thinking Patterns, scale, proportion, and quantity	*What's the Story?* "Water Running Dry" *Task 1*—_"How Much Water Do You Use?" *Task 2*—_"Thinking Beyond the Bathwater: Your Water Footprint" *Reading* —"The Unique Qualities of Water" *Final Reading* —"The Most Precious Resource"
	There are many potential pathways a molecule of water can take through the hydrosphere and into and out of freshwater reservoirs that humans can use.	ESS2.C.1, ESS3.A.1 Asking questions and defining problems Systems and system models	*Activity 1* —"Reservoir Roulette: A Journey Through the Water Cycle"
	Communities most often obtain their water from surface-water supplies such as rivers, or lakes, or from groundwater aquifers.	ESS3.A.1 Developing and using models Constructing explanations Cause and effect Systems and system models	*Activity* 2 —"Where's the Drinking Water?" Part A: "Modeling a Watershed" Part B: "Groundwater Model" *Activity 3*_—"Water Supply Case Studies" *Final Reading*—"_The Most Precious Resource"
	The amount of surface and groundwater available in a given area is a function of climate (the amount of rainfall and evaporation rates), the size of the watershed, and the rate at which freshwater resources are used by people.	ESS2.C.1 Developing and using models Constructing explanations Systems and system models Stability and change	*Activity 2* —"Where's the Drinking Water?" Part A: "Modeling a Watershed" Part B: "Groundwater Model" *Activity 3*_—"Water Supply Case Studies"

Chapter	Learning Objective	DCI/SEP/CCC Alignment	Where Taught in *EDC Earth Science*
	A variety of technologies help communities obtain and store valuable freshwater, such as groundwater pumping wells, dams used to create artificial reservoirs along rivers, and desalination plants.	ESS3.A.2 Asking questions Planning and carrying out investigations Constructing explanations Systems and system models	*Activity* 2 —“Where’s the Drinking Water?” Part A: “Modeling a Watershed” Part B: “Groundwater Model” *Activity 3*_—“Water Supply Case Studies”
	There are a number of ways that water supplies can be threatened: as a result of drought, population growth, and failure to protect water supplies from contamination	ESS3.A.1, ESS3.B.3 Analyzing and interpreting data Engaging in argument from evidence Obtaining, evaluating, and communicating information Patterns Cause and effect Systems and system models	*Activity 3*_—“Water Supply Case Studies” *Activity 4*_—“Follow the Flow: Researching Your Water Supply” *Final Reading* —“The Most Precious Resource”
3	Students understand that the water in Earth’s oceans is continually circulating in ocean currents, which carry water from one area of an ocean to another.	ESS2.D.1 Asking questions Planning investigations Developing and using models Cause and effect Systems and system models	*What’s the Story?:* “A Crazy Idea” *Activity 1*—_“The Effect of Wind on Ocean Currents”
	Students understand that the flow of ocean currents follows predictable patterns. For example, in each major ocean basin, currents flow in circular gyres.	ESS2.D.1 Asking questions Analyzing and interpreting data Patterns Systems and system models	*Activity 2*—_“Natural Patterns”
	Students understand that the uneven heating of Earth by the Sun provides the energy that drives the ocean currents. Movements of the air in the atmosphere and water in the oceans redistribute heat from the equator toward the poles.	ESS2.C.2, ESS2.D.1, ESS2.D.2 Analyzing and interpreting data Constructing explanations Patterns Cause and effect Energy and matter	*Reading*—_“Patterns in Surface Ocean Currents”
	Students know that wind is the primary driving force of surface currents. Once set in motion, the direction of a current is affected by Earth’s rotation (the Coriolis effect) and the position of continents.	ESS2.D.2 Asking questions Constructing explanations Cause and effect	*Activity 1*—_“The Effect of Wind on Ocean Currents” *Reading*—_“Striving for Equilibrium: The Forces that Drive Ocean Currents”
	Students know that it is primarily density dif-ferences that drive deep ocean currents. These density differences are	ESS2.D.2 Planning and carrying out investigations Constructing explanations	*Activity 3*—_“The Effect of Density on Ocean Currents” *Reading*—_“Striving for Equilibrium: The Forces that Drive Ocean Currents”

Chapter	Learning Objective	DCI/SEP/CCC Alignment	Where Taught in *EDC Earth Science*
	related to variations in temperature and salinity of the ocean water.		
	Students know that currents have a significant effect on the climate of the continents they flow past.	ESS2.D.2 Planning and carrying out investigations Cause and effect	*Activity 3*—_"The Effect of Density on Ocean Currents" *Reading*—_"Striving for Equilibrium: The Forces that Drive Ocean Currents"
	Students know that changes in the flow patterns of ocean currents, for example, during El Niño events, can significantly alter regional and global climate, and have far-reaching effects on Earth's biosphere.	ESS.2D.2 Engaging in argument using evidence Obtaining, evaluating, and communicating information Cause and effect	*Reading*—_"Striving for Equilibrium: The Forces that Drive Ocean Currents"
4	Students know that climate is defined as a long-term (30 years or more) average of weather conditions of a place or area. Climate is measured primarily in terms of temperature and precipitation, although scientists also track other components of weather.	ESS2.D.1 Asking questions Analyzing and interpreting data Using mathematics and computational thinking Patterns Stability and change	*Activity 1*—"Looking at Climate Data"
	Students know that the climate conditions of a region have a profound effect on the plants and animals that live there. Organisms have evolved a wide variety of adaptations that enable them to survive in their particular climate.	ESS2.E.1 Analyzing and interpreting data Constructing explanations Asking questions Obtaining and evaluating information Patterns Cause and effect	*What's the Story?*—"A Scientific Explorer" *Activity 2*—"Observing Landscapes"
	Students know that the uneven heating of Earth causes temperatures to generally be higher at lower latitudes. Convecting air masses within the atmosphere play a significant role in redistributing this heat from the equator toward the poles. Patterns of rising and sinking air in each convection cell create wet and dry areas on Earth's land surfaces.	ESS2.D.5 Analyzing and interpreting data Developing and using models Constructing explanations Obtaining and evaluating information Patterns Cause and effect Systems and system models	*Activity 3*—"Looking for Patterns in a World Climates Map" *Reading*—"Sharing the Warmth"
	Students know that interactions between the oceans and land have a significant impact on regional climate as well.	ESS2.C.1, ESS2.C.2, ESS2.D.1 Planning and carrying out investigations	*Activity 4*—"Comparing the Heat Capacity of Different Materials" *Activity 5*—"Interactions Between Ocean and Atmosphere"

Chapter	Learning Objective	DCI/SEP/CCC Alignment	Where Taught in *EDC Earth Science*
	Warm and cold ocean currents flowing along the margins of continents affect temperatures in coastal cities. Because water has a higher heat capacity than land, the climate in coastal cities is generally more moderate than that of inland cities with greater temperature extremes in inland areas.	Developing and using models Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations Cause and effect Systems and system models Engaging in argument from evidence	
	Students know that the direction of prevailing winds is also important to regional climate. If the prevailing winds in a particular area flow toward that area from a water body, the area is more likely to have a relatively wet climate. On the other hand, if the winds blowing into an area come from the interior of a continent, the climate is more likely to be dry.	ESS2.D.1 Obtaining and evaluating information Analyzing and interpreting data Constructing explanations Cause and effect	*Reading*—"Winds and Mountains"
	Students know that the elevation of an area affects its temperature, and the presence of mountains can affect precipitation patterns in an area.	ESS2.D.1 Obtaining and evaluating information Analyzing and interpreting data Constructing explanations Cause and effect	*Reading*—"Winds and Mountains"
5	Students know that Earth's climate system is driven primarily by energy received from the Sun in the form of light energy, or electromagnetic radiation. Some of this energy is absorbed by the clouds and Earth's surface, and some is reflected back into space.	ESS2.D.1 Asking questions Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations Engaging in argument from evidence Obtaining, evaluating and communicating information Patterns Cause and effect Systems and system models Energy and Matter Stability and Change	*Reading*—"Following the Path of Light Energy" *Activity 1*_—"The Greenhouse Effect" *Activity 2*_—"The Albedo Effect"
	Students know that most of the light energy that is	ESS2.D.1	*Activity 1*_—"The Greenhouse Effect"

Chapter	Learning Objective	DCI/SEP/CCC Alignment	Where Taught in *EDC Earth Science*
	absorbed by Earth's surface is reradiated as longer-wavelength heat energy. Certain gases in Earth's atmosphere, called greenhouse gases, trap the longer-wavelength heat energy, which warms Earth. Without this greenhouse effect, Earth would not be habitable.	Asking questions Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations Engaging in argument from evidence. Obtaining, evaluating, and communicating information Systems and system models Cause and effect Energy and matter Stability and change	
	Students know that the level of greenhouse gases in the atmosphere affects Earth's temperature. As the concentrations of these gases increase, Earth's average temperature increases.	ESS2.D.1 Asking questions Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations Engaging in argument from evidence. Obtaining, evaluating, and communicating information Systems and system models Cause and effect Energy and matter Stability and change	*Activity 1*_—"The Greenhouse Effect"
	Students know that another factor that influences Earth's temperature is the albedo effect. Albedo is a measure of the percentage of incoming light energy that is reflected. As Earth's albedo changes—the amount of heat energy absorbed versus reflected changes—the temperature at Earth's surface rises and falls. This causes regional, seasonal, and long-term global changes in Earth's temperature.	ESS2.D.1 Planning and carrying out investigations Analyzing and interpreting data Constructing explanations Engaging in argument from evidence Obtaining, evaluating, and communicating information Patterns Cause and effect Systems and system models Energy and matter Stability and change	*Activity 2*_—"The Albedo Effect"
	Students understand the major processes by which carbon moves from one reservoir to another in Earth's carbon cycle and how these processes affect the level of CO_2 in the atmosphere.	ESS2.D.1, ESS2.D.2 Developing and using models Planning and carrying out investigations Analyzing and interpreting data Constructing explanations Engaging in argument from evidence Obtaining, evaluating, and communicating information Cause and effect Systems and system models Energy and matter	*Activity 3*_—"Moving Carbon Around" *Activity 4*_—"Calling All Carbons"

Chapter	Learning Objective	DCI/SEP/CCC Alignment	Where Taught in *EDC Earth Science*
		Structure and function Stability and change	
	Students understand that Earth's climate system is affected by negative and positive feedback loops. Negative feedbacks have a stabilizing effect and tend to keep conditions the same. Positive feedbacks are destabilizing and tend to accelerate changes in conditions.	ESS2.D.2 Developing and using models Constructing explanations Engaging in argument from evidence Obtaining, evaluating, and communicating information Cause and effect Systems and system models Stability and change	*Reading* —"The Greenhouse Effect, the Albedo Effect, the Carbon Cycle, and Feedback Loops" *Address the Challenge*
6	Students understand that Earth's climate has changed dramatically in the past.	ESS2.D.4 Asking questions Developing and using models Constructing explanations Patterns Cause and effect Systems and system models Scale, proportion, and quantity Energy and matter Stability and change	*What's the Story?*—_"Journey to a Different Time" *Activity 3*—_"Investigating How Orbital Changes Have Affected Past Climate" *Reading*—_"The Carbon Cycle, Cretaceous Breadfruit Trees, and the Long Slide to the Ice Age" "How Fast Can the Climate Change?
	Students know that scientists investigate Earth's climate history by studying records of past climates stored in tree rings, coral, rocks, sediment, and ice, as well as more recent human records of weather data.	ESS2.D.2 Analyzing and interpreting data Using mathematics Constructing Explanations Engaging in Argument from Evidence Patterns Cause and effect Stability and change	*Activity 2*—_"Using Climate Proxies" *Activity 4*—_"What's Happening Now and What's Predicted for the Future?" *Reading*—"_Evidence of Earth's Past"
	Students know that periodic changes in the tilt of Earth as well as its orbit have caused changes in the distribution of solar input, which has affected global climate in the past.	ESS2.D.2 Developing and using models Patterns Cause and effect Systems and system models Energy and matter Stability and change	*Activity 3*—_"How Orbital Changes have Affected Past Climate
	Students know that historical fluctuations in global average temperature have corresponded with fluctuations in atmospheric CO_2 levels, related to factors such as the movement of tectonic plates over millions of years.	ESS2.D.1, ESS2.D.3, ESS2.D.4 Analyzing and interpreting data Constructing explanations Engaging in argument from evidence Patterns Cause and effect Systems and system models Energy and matter Stability and change	*Readings*—_ "The Carbon Cycle, Cretaceous Breadfruit Trees, and the Long Slide to the Ice Age" "How Fast Can the Climate Change?" "Sorting Out Natural and Human-induced Climate Change"
	Global climate models predict that temperatures will continue to rise, and that the amount of temperature change predicted is related to future CO_2 emissions. These temperature increases are already causing sea level rise, the melting of glacial and polar ice, and	ESS2.D.5, ESS2.D.6 Analyzing and interpreting data Using mathematics Using Models Engaging in Argument from Evidence Patterns Cause and effect	*Activity 4*—_"What's happening now and what's projected for the future?" *Reading*—_"What's Happening Now and What's Predicted for the Future?"

Chapter	Learning Objective	DCI/SEP/CCC Alignment	Where Taught in *EDC Earth Science*
	changes in precipitation and ocean acidity. Students know that CO_2 increases over the past 100 years are largely attributable to human activities.	Systems and system models Energy and matter Stability and change	
7	The *Mid-Year Challenge: Broadcast from the Future* uses project-based strategies to have students review the main themes and ideas from the first semester. No new DCI, SEP, or CCC are introduced.		
8	How radioactive dating techniques are used to determine the age of Earth and the solar system	ESS1.C.1 Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Obtaining, evaluating, and communicating information Constructing explanations Engaging in argument from evidence Patterns Stability and change Scale, proportion, and quantity	*Activity 1*—_"The Dating Game"
	That the creation of heavy elements and planet formation are linked to the life cycles of stars	ESS1.A.1, ESS1.A.2 Obtaining, evaluating, and communicating information Stability and change Energy and matter Patterns Structure and function	*Reading*—_"The Life Cycle of Stars"
	How to recognize the observable physical and dynamical properties of the solar system, and that a successful theory for the formation of the solar system must explain these patterns	ESS1.B.2 Developing and using models Planning and carrying out investigations Analyzing and interpreting data Constructing explanations Engaging in argument from evidence Patterns Systems and system models Stability and change	*Activity 2*—_"Solar System Census"
	The current theory for the formation of the solar system—the solar nebula condensation theory	ESS1.B.1 Developing and using models Constructing explanations Engaging in argument from evidence Obtaining, evaluating, and communicating information Systems and system models Stability and change	*Reading*—_"Solar Nebula Condensation Theory" *Activity 3*—_"Model of a Spinning Nebula"
	Kepler's laws of motion for orbiting bodies	ESS1.B.2 Planning and carrying out investigations Developing and using models Analyzing and interpreting data Using mathematics and computational thinking Obtaining, evaluating, and	*Activity 4*—_"Explaining Patterns with Kepler's Laws of Motion"

Chapter	Learning Objective	DCI/SEP/CCC Alignment	Where Taught in *EDC Earth Science*
		communicating information Systems and system models Patterns	
	How spectroscopy is used to identify chemical elements in stars	ESS1.A.4 Analyzing and interpreting data Constructing explanations Obtaining, evaluating, and communicating information Patterns	*Activity 5*—_"Spectroscopy"
9	Students understand that Earth is made of rocky material, and its interior can be divided into three major layers based on chemical composition—the crust, the mantle, and the core.	ESS2.A.3 Asking questions and defining problems Developing and using models Using mathematics and computational thinking Constructing explanations Obtaining, evaluating, and communicating information Structure and function	Questions for *What's the Story?— "*Burrowing to the Depths" *Reading*— "A Dense Interior" *Activity 1*— "Modeling Earth's Interior Structure"
	Students understand that the crust and uppermost part of the mantle are relatively cool and rigid, and are also called the lithosphere. This lithosphere is the plate of plate tectonic theory. The plates move on the hotter, more plastic asthenosphere, which lies within the mantle below.	ESS2.A.3, ESS2.B.2 Developing and using models Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations Obtaining, evaluating, and communicating information Energy and matter Scale, proportion, and quantity Structure and function Stability and change Cause and effect Systems and system models	*Activity 1*— "Modeling Earth's Interior Structure" *Reading*— "Energy in Earth's Interior"
	Students understand that most of Earth is solid; however, the outer core is liquid (molten metallic material).	ESS2.A.2 Developing and using models Using mathematics and computational thinking Defining problems Obtaining, evaluating, and communicating information Scale, proportion, and quantity Systems and system models Cause and effect Structure and function	*Reading*— "A Dense Interior" *Activity 1*— "Modeling Earth's Interior Structure" *Reading*— "How Do Scientists Explore Earth's Interior?"
	Students understand that evidence indicates that Earth's layers formed early in the solar system's history when Earth's interior was still molten. The process of gravitational differentiation caused heavy metals to sink inward to form the core and lighter, less dense materials to float toward the surface to form the crust.	ESS2.A.2, ESS2.A.3 Obtaining and evaluating information Developing and using models Energy and matter	*Reading*— "A Dense Interior"
	Students understand that temperature and pressure increase with depth within Earth.	ESS2.A.3 Developing and using models Analyzing and interpreting data	*Activity 1*— "Modeling Earth's Interior Structure" *Reading*— "Energy in Earth's Interior"

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		Using mathematics and computational thinking Defining problems Obtaining, evaluating, and communicating information Constructing explanations Scale, proportion, and quantity Energy and matter Systems and system models Cause and effect Stability and change Structure and function	
	Students understand that there are two sources of heat energy in Earth's interior: heat left over from impacts during the early history of the solar system and heat generated by the decay of radioactive isotopes in crust and mantle rocks.	ESS2.B.1 Obtaining and evaluating information Energy and matter Cause and effect	*Reading*— "Energy in Earth's Interior"
	Students understand that heat is transferred from Earth's interior toward the surface primarily through convection within the mantle. This convection occurs very slowly through the gradual movement of solid rock. This convection is believed to be a primary cause of the movement of tectonic plates on Earth's surface.	ESS2.B.2 Developing and using models Obtaining and evaluating information Constructing explanations Energy and matter Cause and effect Stability and change Systems and system models	*Reading*— "Energy in Earth's Interior"
	Students know that seismic waves from earthquakes travel great distances through Earth and can be detected by seismographs at locations around the world. Because these seismic waves behave differently in different types of materials, they reveal information about the materials that make up Earth's interior. These seismic waves can also be used to locate an earthquake's epicenter.	ESS2.A.1, ESS2.A.6 Planning and carrying out investigations Developing and using models Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations Patterns Energy and matter Cause and effect Structure and function Systems and system models	*Reading*— "How Do Scientists Explore Earth's Interior?" *Activity 2*— "See What You Can't See" *Activity 3*— "Body Waves" *Activity 4*— "Locating an Earthquake Epicenter"
10	Students understand that field observations, such as displaced surface features and global-positioning-system measurements, provide evidence of horizontal plate movement at slow, but measurable rates along transform plate boundaries, such as the San Andreas fault system.	ESS2.B.2, ESS3.B.1, ESS3.B.4 Analyzing and interpreting data Using mathematics and computational thinking Obtaining, evaluating, and communicating information Constructing explanations Patterns Cause and effect	*Reading*—_"Clues in the Landscape" *Activity 1*—_"Using GPS Data and Geologic Markers to Track Plate Motion"
	Students understand that most earthquakes occur along the boundaries of the tectonic plates, where plates are moving toward each other	ESS2.B.1, ESS2.B.2 Analyzing and interpreting data Constructing explanations	*Reading*—_"What Do Tectonic Plates Have to Do with Earthquakes?" *Activity 2*—_"Looking for Patterns in a World Map"

Chapter	Learning Objective	DCI/SEP/CCC Alignment	Where Taught in *EDC Earth Science*
	(convergent boundaries), moving away from each other (divergent boundaries), or slid-ing past each other (transform boundaries).	Engaging in argument from evidence Obtaining, evaluating, and communicating information Planning and carrying out investigations Patterns Cause and effect	
	Students understand that earthquakes occur along faults, where stress builds up in rock until it ruptures suddenly. Earthquakes vary in intensity. The Richter scale of earthquake magnitude is a logarithmic scale commonly used to describe the size of an earthquake.	ESS2.B.1, ESS2.B.2 Developing and using models Using math and computational thinking Constructing explanations Engaging in argument from evidence Obtaining, evaluating, and communicating information Patterns Cause and effect Scale and quantity Structure and function	*Reading*—_“What Do Tectonic Plates Have to Do with Earthquakes?” *Activity 3*—_“What Is Happening Along the San Andreas Fault?”
	Students understand that physical and computer models are important tools for gaining a better understanding of earthquakes. Physical models can be used to better understand the type of motion that occurs along faults and how this motion produces earthquakes. Computer models can simulate complex fault systems and project faults’ behaviors over long periods of time. Models can also help assess the amount of damage that will occur to surface structures when earthquake waves travel through different types of soil and bedrock materials.	ESS3.B.1, ESS3.B.2, ESS3.B.4 Developing and using models Analyzing and interpreting data Constructing explanations Engaging in argument from evidence Obtaining, evaluating, and communicating information Patterns Cause and effect Systems and system models Energy and matter Stability and change Scale, proportion, and quantity Structure and function	*Reading*—_“Measurements and Computer Models” *Activity 3*—_“What Is Happening Along the San Andreas Fault?” *Activity 4*—_“Studying Earthquake Computer Models”
	Students understand that predicting exactly when and where earthquakes will occur is not possible and that other strategies, such as engineering buildings to withstand them, are a better approach for saving lives.	ESS2.B.4 Developing and using models Obtaining, evaluating, and communicating information Systems and system models Stability and change Scale, proportion and quantity	*Reading*—_“Measurements and Computer Models”
11	know that volcanoes occur where magma from Earth’s mantle moves to the surface. Many volcanoes are associated with convergent boundaries, where two tectonic plates are moving toward each other.	ESS2.B.3 Constructing explanations Obtaining, evaluating, and communicating information Cause and effect Energy and matter	*Reading*—_“Could Mount Rainier Erupt?”
	Students know that subduction zones occur along convergent boundaries, where one plate (the one composed of denser rock) is pushed beneath the other and descends into the mantle. As the plate descends, water expelled from the plate	ESS2.C.1 Developing and using models Obtaining, evaluating, and communicating information Cause and effect Energy and matter	*Reading*—_“Could Mount Rainier Erupt?” *Reading*—_“How Do Convergent Boundaries Shape Earth’s Surface Features?”

Chapter	Learning Objective	DCI/SEP/CCC Alignment	Where Taught in *EDC Earth Science*
	changes the melting point of surrounding mantle rock, and mantle rock melts, forming magma.		
	Students know that patterns in the distribution of earthquake hypocenters along convergent boundaries reveal the subsurface structure of subduction zones.	ESS2.B.1 Analyzing and interpreting data Constructing explanations. Patterns	*Activity 1*—_"Detecting a Subducting Plate"
	Students know that magma is a complex mixture with gases dissolved in it. As magma moves toward the surface, the pressure on the magma decreases and gas comes out of solution. Eruptions along subduction zones tend to be more explosive than those in Hawaii or along divergent boundaries, and form more steep-sided stratovolcanoes.	ESS2.B.2 Asking questions Developing and using models Obtaining, evaluating, and communicating information Energy and matter Cause and effect	*Activity 2*—_"A Lava Flow or An Explosion?" *Activity 3*—_"What Might an Eruption of Rainier Be Like?"
	Students know that magma that forms near a subducting plate rises toward the surface because it is less dense than the surrounding rock. Some of this magma erupts, and a line of volcanoes forms on the surface that parallels the plate boundary.	ESS2.B.2 Obtaining, evaluating, and communicating information Patterns	*Reading*—_"Could Mount Rainier Erupt?" *Activity 2*—_"A Lava Flow or An Explosion?"
	Students understand that scientific measurements of earthquake activity, ground deformation, and gas emissions can be used to monitor the movement of magma beneath the surface and to predict when a volcano is likely to erupt.	ESS3.B.3 Analyzing and interpreting data Constructing explanations Developing and using models Obtaining, evaluating, and communicating information 12Asking questions Cause and effect	*Activity 4*—_"How Do Scientists Monitor Volcanoes??" *Activity 5*—_"Monitoring Mount Rainier"
	Students understand that complex dynamic systems have multiple interacting factors that cause a volcanic eruption and make it difficult to predict exactly when an eruption will occur.	ESS3.B.3 Analyzing and interpreting data Constructing explanations Engaging in argument from evidence Obtaining, evaluating, and communicating information Patterns Cause and effect	*Activity 5*—_"Monitoring Mount Rainier"
	Students know that the study of volcanic deposits in the vicinity of a volcano provides evidence of its eruptive history.	ESS1.C.1 Data analysis and interpretation Engaging in argument from evidence Patterns Stability and change	*Reading*—_"Has Rainier Erupted in the Past?"
	Students know that volcanoes are not the only surface feature that typically forms along subduction zones. Deep ocean trenches and folded mountains also form as two plates collide	ESS2.B.3 Obtaining, evaluating, and communicating information Constructing explanations Cause and Effect	*Reading*—_"How Do Convergent Boundaries Shape Earth's Surface Features?" *Activity 6*—_"Features Along Convergent Boundaries"

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	and the lithosphere crumples and thickens.		
12	Students understand that although scientists, such as Alfred Wegener, envisioned that continents had changed their positions, this theory wasn't widely accepted until new technologies emerging after WW II allowed scientists to begin studying the features on the ocean floor. Using these new data, scientists pieced together the processes of plate tectonics.	ESS2.A.3; ESS2.B.1, ESS2.B.2, ESS2.B.3 Analyzing and interpreting data Using mathematics and computational thinking Developing and using models Constructing explanations Engaging in argument with evidence Obtaining, evaluating, and communicating information Patterns Cause and effect Stability and change Systems and system models	*What's the Story*—_"An Explorer with Big Ideas" *Activity 1*—_"Using Sound Waves to Map an Ocean Floor" *Activity 2*—_"Studying Maps of Earth's Oceans" *Reading*—_"The Missing Piece of the Plate Tectonics Puzzle" *Activity 3*—_"Plotting a Magnetic Map of the Ocean" *Activity 4*—_"How Are Ocean Basins Formed by Seafloor Spreading"
	Students know that maps of the ocean floor show in the middle of the oceans long volcanic mountain ranges with rift valleys where new crust is forming.	ESS1.B.2; ESS2.B.2 Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations Patterns Cause and effect	*Activity 1*—_"Using Sound Waves to Map an Ocean Floor" *Reading*—_"Into the Depths"
	Students understand that as new crust forms along a ridge the crust (and lithosphere) on either side of the ridge moves apart like conveyor belts. Students understand that Earth's oceanic crust is continually recycled through the process of plate tectonics. Oceanic crust is consumed in subduction zones along con-vergent boundaries, and new crust is formed at seafloor spreading centers along divergent boundaries.	ESS2.B.1 Analyzing and interpreting data Developing and using models Constructing explanations Engaging in argument from evidence Patterns Cause and effect Systems and system models Stability and change Energy and cycles	*Activity 2*—_"Studying Maps of Earth's Oceans" *Reading*—_"The Missing Piece of the Plate Tectonics Puzzle" *Activity 3*—_"Plotting a Magnetic Map of the Ocean" *Activity 4*—_"How Are Ocean Basins Formed by Seafloor Spreading"
	Students understand that rift valleys can also form on continents at young divergent boundaries. Eventually, these continental rift valleys might lead to the formation of new oceans.	ESS2.B.2 Developing and using models Analyzing and interpreting data Patterns Cause and effect	*Activity 4*—_"How Are Ocean Basins Formed by Seafloor Spreading"
	Students understand the processes that occur along convergent, transform, and divergent boundaries, the physical features that form along each type of boundary, and why volcanic activity and earthquakes are associated with plate movements.	ESS2.B.1, ESS2.B.2, ESS2.B.3, ESS2.B.4 Obtaining, evaluating, and communicating information Cause and effect Systems and system models	*Reading*—_"Pulling It All Together— Earth's Machinery"
13	Students understand that rivers and their tributaries continually erode and carry sediment from the land toward the ocean.	ESS2.A.4; ESS2.C.2, ESS2.C.4 Developing and using models Obtaining, evaluating, and communicating information Mathematics and computational	*Reading*—_"How Do Rivers Build Land?" *Activity 2*—_"Modeling a River Delta"

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		thinking Engaging in argument from evidence Cause and effect Systems and system models Stability and change	
	Students understand that the gradient of a river affects the speed of the water and the rate of erosion and transport. Water flows faster and erosion rates are higher when the gradient is steeper.	ESS2.A.4; ESS2.C.2, ESS2.C.4 Obtaining, evaluating, and communicating information Constructing explanations Energy and matter Cause and effect Systems and system models	*Reading*—_"How Do Rivers Build Land?"
	Students understand that the velocity of water flow affects the amount and size of particles (clay, silt, sand, and gravel) that the water can carry. When the water is flowing faster, it can carry a greater sediment load, including larger, denser particles. Due to an abrupt decrease in the velocity of water at a river's end, sediment settles and accumulates in deltas where rivers and streams meet a larger body of water, such as an ocean basin.	ESS2.C.2, ESS2.C.4 Developing and using models Obtaining, evaluating, and communicating information Constructing explanations Energy and matter Cause and effect Systems and system models	*Activity 1*—_"Modeling River Deposits" *Reading*—_"How Do Rivers Build Land?" *Activity 2*—_"Modeling a River Delta" *Activity 3*—_"What Does a Real Delta Look Like?"
	Students understand that the size and shape of a delta is affected by the amount of sediment load and interactions between the river and ocean water. As long as sediment is carried to the mouth of the river faster than it is eroded and carried away by ocean water, the river will gradually build land out into the ocean basin.	ESS2.A.4, ESS2.C.4 Constructing explanations Analyzing and interpreting data Obtaining, evaluating and communicating information Systems and systems models Cause and effect	*Activity 3*—_"What Does a Real Delta Look Like?" *Reading*—_"Layer by Layer"
	Students understand that many layers of sediment build up over time in a delta. As these layers settle, compress and dewater, the land surface on a delta subsides. The surface is built up again as new sediment layers are deposited on top.	ESS2.A.3 Making and using models Analyzing and interpreting data Constructing explanations Obtaining, evaluating, and communicating information Scale, proportion, and quantity Cause and effect Systems and systems models	*Reading*—_"Layer by Layer" *Activity 4*—_"A View Beneath the Surface" *Reading*—_"Why Is the Mississippi Delta Region Sinking?" *Activity 5*—_"Settling Sediments"
	Students understand that over thousands and millions of years, sediment layers many kilometers in thickness can accumulate in a delta. As these layers are buried deeper and deeper, they are compressed and cemented together into sedimentary rocks.	ESS2.A.3 Making and using models Analyzing and interpreting data Constructing explanations Obtaining, evaluating, and communicating information Scale, proportion, and quantity Systems and systems models Energy and matter	*Reading*—_"Why Is the Mississippi Delta Region Sinking?" *Activity 5*—_"Settling Sediments"

Chapter	Learning Objective	DCI/SEP/CCC Alignment	Where Taught in *EDC Earth Science*
	Students understand that there are hazards associated with living in a delta region where land is actively forming and changing. Human interventions with a river sometimes have unintended consequences. Science can help to inform public policy decisions about human activities in a delta region.	ESS3B.1, ESS3B.2 Constructing explanations Engaging in argument from evidence Obtaining, evaluating, and communicating information Cause and effect Systems and systems models	*Reading*—_"Why Is the Mississippi Delta Region Sinking?" *Reading*—_"Have People Played a Role in the Subsidence of New Orleans?"
14	Students know that Earth's crust is composed of relatively few chemical elements. These elements are combined with each other to form a great variety of chemical compounds.	ESS2.A.3 Obtaining, evaluating, and communicating information Structure and function	*Reading*—_"Elements of Earth's Crust"
	Students know that there are two kinds of crust—continental and oceanic—which differ in chemical composition. The continental crust is less dense than oceanic crust because it has a higher proportion of silicon and oxygen, which are lighter elements. Because of this difference in density, oceanic crust sits lower in elevation than continental crust, and oceanic plates dive beneath continental plates when they meet at a convergent plate boundary.	ESS2.B.2, ESS2.B.3 Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations Obtaining, evaluating, and communicating information Structure and function Cause and effect Energy and matter	*Reading*—_"Elements of Earth's Crust" *Activity 1*—_"Can Rocks Really Have Different Densities?"
	Students know that minerals, the building blocks of the rocks of Earth's crust, are naturally occurring solid materials that have a specific chemical composition and a characteristic internal crystal structure.	ESS1.C.1 Analyzing and interpreting data Obtaining, evaluating, and communicating information Structure and function Energy and matter	*Reading*—_"Minerals—The Building Blocks of Earth's Crust" *Activity 2*—_"Identifying Minerals by Their Physical Characteristics"
	Students understand that the rocks of Earth's crust can be categorized into three basic rock types—sedimentary, igneous, or metamorphic —based on the way in which the rock formed. By studying these rocks and the evidence preserved within them, scientists are able to decipher Earth's history.	ESS1.C.1, ESS1.C.2, ESS2.A.3 Analyzing and interpreting data Constructing explanations Obtaining, evaluating, and communicating information Energy and matter Cause and effect Systems and systems models	*Activity 3*—_"Clues in the Rock-Forming Process" *Reading*—_"Piecing Together Earth's History"
	Students know the order of major events in Earth history and are able to articulate ideas about the relationships between them, applying what they have learned about Earth's systems and how they interact.	ESS1.C.3 Obtaining, evaluating, and communicating information Constructing explanations Systems and systems models	*Activity 4*—_"Timeline of Major Events in Earth's History"
15	Students understand that the majority of the minerals that modern civilization relies on are relatively rare in Earth's crust. Such minerals are	ESS3.A.1, ESS3.A.2 Analyzing and interpreting data Planning and carrying out investigations Using mathematics and computational	*Activity 1*—_"Where Are the Mineral Ores?" *Activity 2*—_"Prospecting for Mineral Ore"

Chapter	Learning Objective	DCI/SEP/CCC Alignment	Where Taught in *EDC Earth Science*
	concentrated into economically viable ore deposits by natural geologic processes. Scientists use their understanding of these geologic processes to locate mineral resources.	thinking Constructing explanations Engaging in argument from evidence Obtaining, evaluating, and communicating information Scale, proportion, and quantity Systems and systems models Energy and matter	
	Students know that mineral ores are extracted from Earth in a variety of ways, including surface pit mining, dredging, and deep mining by tunneling below Earth's surface. The minerals are then purified and processed into useful materials by refining and smelting techniques. These methods are expensive, are energy intensive, and have associated environmental impacts.	ESS3.A.3 Using mathematics and computational thinking Planning and carrying out investigations Constructing explanations Engaging in argument from evidence Obtaining, evaluating, and communicating information Cause and effect Energy and matter	*Reading*—_"From Rocks to Riches—Mining and Processing Mineral Ore" *Activity 3*—_"Refining an Ore"
16	Students know that people depend heavily on such fossil fuels as oil, natural gas, and coal. These fuels form from plant and animal matter through natural processes within Earth, and are preserved within Earth's crust only under only certain conditions.	ESS3.A.1, ESS3.A.2, ESS3.A.3 Analyzing and interpreting data Developing and using models Planning and carrying out investigations Constructing explanations Obtaining, evaluating, and communicating information. Patterns Energy and matter Systems and system models	*Task*—_"Energy Connections" *Activity 1*—_"How Do Oil Reservoirs Form?" *Reading*—_"A Convergence of Conditions—the Rub' al-Khali"
	Students know that oil and associated natural gas, once formed in the source rock, will tend to rise to the surface because of density differences with water also contained in subsurface rock. The oil and gas may migrate long distances from the source rock.	ESS3.A.1, ESS3.A. 2, ESS2.C.1 Developing and using models Planning and carrying out investigations Constructing explanations Obtaining, evaluating, and communicating information Energy and matter Systems and system models	*Activity 1*—_"How Do Oil Reservoirs Form?"
	Students know that traditional oil reservoirs form in areas where oil does not migrate all the way to the surface but becomes trapped beneath low-permeability sedimentary rock layers and associated structures.	ESS3.A.1 Developing and using models Planning and carrying out investigations Constructing explanations Obtaining, evaluating, and communicating information Energy and matter Systems and system models	*Activity 1*—_"How Do Oil Reservoirs Form?"
	Students appreciate that the conditions in which organic matter is transformed into oil and trapped in reservoirs are rare, and the process of oil formation typically takes millions of years. This means that oil is only found in certain parts of the world where the right conditions existed for its	ESS3.A.2 Obtaining, evaluating, and communicating information Constructing explanations Energy and matter Systems and system models	*Reading*—_"A Convergence of Conditions—the Rub' al-Khali" *Final Reading*—_"The Recipe for Oil"

Chapter	Learning Objective	DCI/SEP/CCC Alignment	Where Taught in *EDC Earth Science*
	formation and preservation.		
17	The *Final Challenge: A Different Earth* uses project-based strategies to have students review the main themes and ideas from the first semester. No new DCI, SEP, or CCC are introduced.		