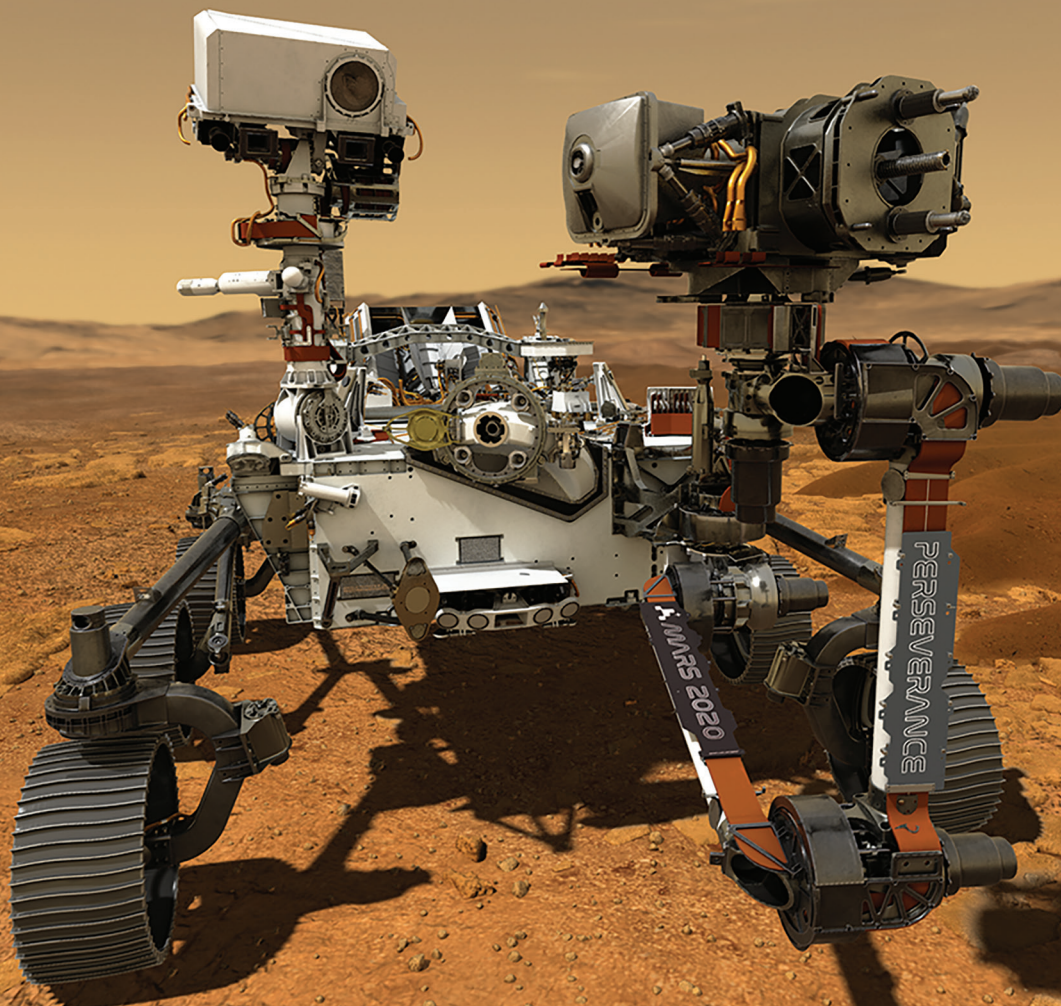


EARTH & SPACE SCIENCES

FOR NGSS



Contents

CLASSROOM GUIDE

The Concept Maps.....	CG3
The Contents: A Planning Tool.....	CG4
Pacing Guide.....	CG4
Identifying Learning Intentions and Goals	CG5
Scaffolded Learning with the 5Es	CG6
Practical Investigations	CG9
Engineering Design Solutions.....	CG10
Evaluating Student Performance	CG11
Teaching Strategies for Classroom Use	CG13
How are English Language Learners Supported?	CG15
Differentiated Learning.....	CG16
The Teacher Toolkit	CG17
Teacher's Notes.....	CG20
BIOZONE's Pedagogy	CG21
Identifying CCCs and SEPs by Number	CG22
Summary of BIOZONE's 3D Approach By Chapter	CG23
Identifying Common Core State Standard Connections	CG28

STUDENT EDITION

Student Edition with Answers in Place	i - 326
---	---------

APPENDIX

Answers to Long Answer Questions	A1
--	----

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FAQs ABOUT EARTH AND SPACE SCIENCES FOR NGSS



Where can I find the course overview?	CG3
What is its pedagogical approach?	CG4- CG8, CG21
Pacing Guides: How do I allocate time through the program?	CG4
Does it cater for all three dimensions of the NGSS?	CG22- CG27
How are the 5Es incorporated?	CG6-CG8
Are the Common Core State Standards addressed?	CG28- CG30
Are there practical investigations?	CG9
How is engineering design addressed?	CG10
How can I evaluate student performance?	CG11- CG12
Are there test banks?	CG12, CG19
How do I use the worktext in the classroom?	CG13- CG16
Are there tools for differentiated instruction?	CG15- CG16
How can I support English language learners?	CG15
Are there supporting resources for teachers?	CG17- CG19
Are there teacher's notes?	CG20

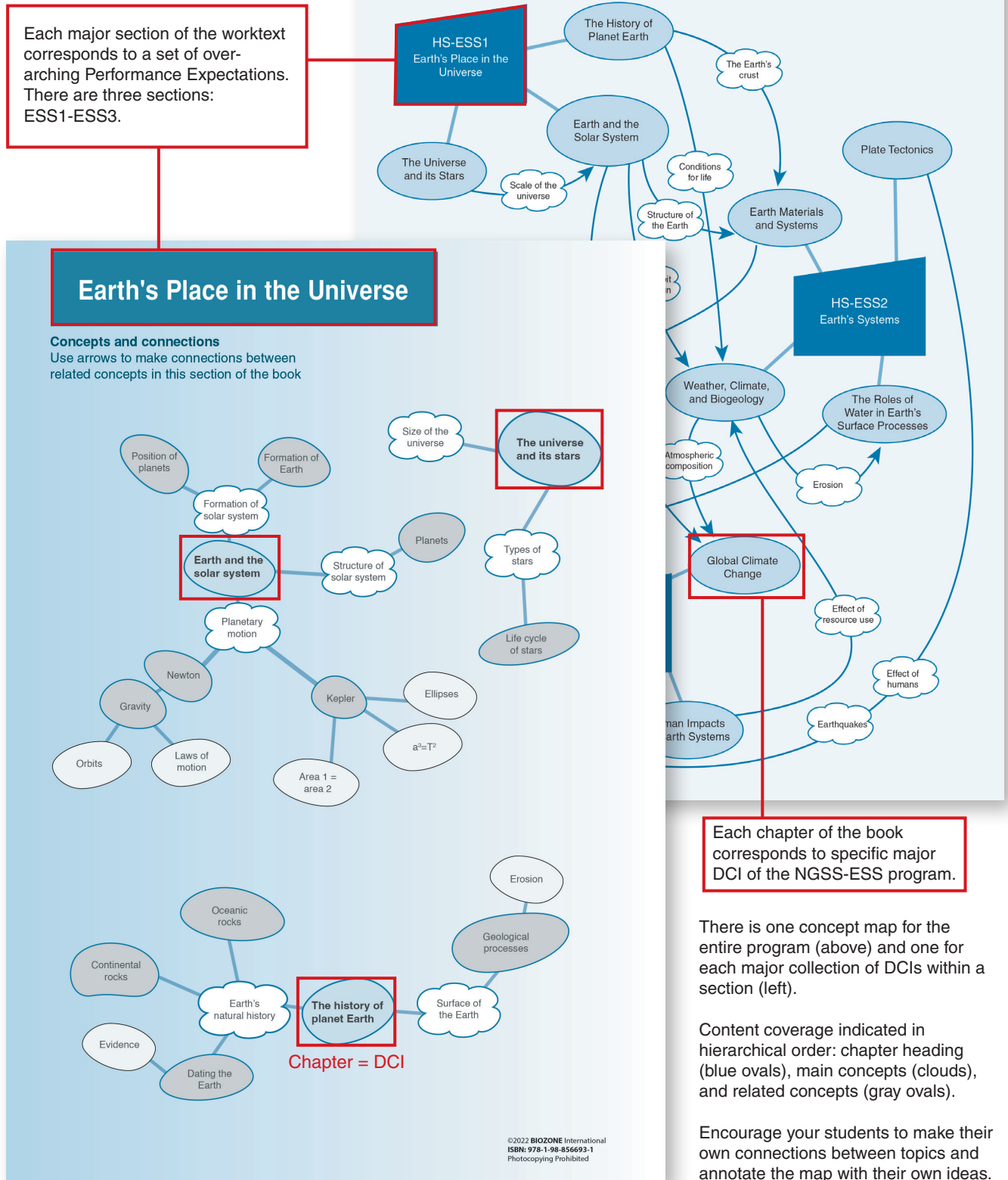
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The Concept Maps

The concept maps in *Earth and Space Sciences for NGSS* have two broad purposes: to provide a map of ideas covered in the program and to provide a vehicle for students to make their own connections between those ideas. They are particularly useful as graphic organizers for striving students and visual learners. The introductory map provides an overview of the structure of the *NGSS Earth and Space Sciences* program. Section concept maps divide the book into three parts, each providing a visual summary of one of three broad areas within the program, corresponding to ESS1-ESS3. Encourage students to draw their own connections between ideas on the concept maps as they work through the topics. This will help students to see their interrelatedness, and realize that they are not isolated, but connect with many other topics within the program.

Earth and Space Sciences: A Flow of Ideas

This map shows the structure of the NGSS Earth and Space Sciences program as represented in this workbook. The dark blue boxes indicate the book sections, each of which has its own concept map. The blue ovals are the chapters in each section. We have placed some major connections between topics. You can make more of your own.



The Contents: A Planning Tool

The contents pages are not merely a list of the activities in the student edition. Encourage your students to use them as a planning tool for their program of work. Students can identify the activities they are to complete and then tick them off when completed. The teacher can also see at a glance how quickly the student is progressing through the assigned material.

Contents

iii

Title Page i 35 Satellites 35

ISBN ii 36 Case Study: The Orbit 36

Contents iii 37 Moving Planets 37

Using This Book v 38 The Earth and the Moo 38

Using Biozone's Resource Hub viii 39 Cyclical Changes 39

Earth and Space Sciences: A Flow of Ideas x 40 Studying Exoplanets 40

1. **Sc** 1 2 3 4 5 6 7 8 9

2. **TH** 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

3. **Earth and the Solar System**
DCI: ESS1.B

Key Skills and Knowledge 66

Solar System Relationships 67

Exploring the Solar System 68

Formation of the Solar System 69

The Solar System 76

The Motion of Celestial Objects 80

Kepler's Laws and Orbits 83

Gravity and Newton's Laws 86

Applying Newton's Law to Kepler's Laws 87

4. **The History of Planet Earth**
DCI: ESS1.C

Key Skills and Knowledge 103

An Age Old Puzzle 104

The Earth 105

The Earth's Crust 106

Dating the Earth 107

Evidence for the Age of the Earth 110

What Can Mars Tell Us? 118

Information from Probe Missions 120

The Earth's History 122

The Goldilocks Planet 124

Review Your Understanding 125

Summing Up 126

5. **Earth's Systems**
DCI: ESS2.A

Key Skills and Knowledge 131

Constant Changes 131

Structure of the Earth 132

Evidence for Earth's Structure 132

Atmosphere and Asthenosphere 137

Factors That Shape the Earth 138

Feedback in Earth's Systems 140

Ice Sheet Melting 141

Dams and Erosion 143

Soil Erosion and Feedback 144

Short and Long Term Changes 145

Short-Term Changes to the Earth 146

Long-Term Changes to the Earth 149

Review Your Understanding 151

Summing Up 152

6. **Plate Tectonics**
DCI: ESS2.B

Key Skills and Knowledge 154

On The Move 155

The Nuclear Fires 156

The Heat of the Earth 157

Plate Tectonics 159

Plate Boundaries 162

Modeling Continental Drift 166

Chapter Review 173

Summative Assessment 174

CODES: Activity is marked: to be done when completed

Callout 1: Ticking off the activities as they are completed gives students a sense of progression and helps them to be more personally organized in their work.

Callout 2: Students can mark the check boxes to indicate the activities they should complete. This helps them to quantify the work to be done and plan their work.

Callout 3: The teacher can see at a glance how this student is progressing through this unit of work. Any concerns with progress can be addressed early.

Callout 4: The teacher has an alternative investigation of their own they wish to use, so they indicate to the students to skip this activity.

Pacing Guide

A pacing guide is available for teachers to download from the Resource Hub.

The 9-12 NGSS framework is fluid in terms of the grade in which each program is offered, so in many respects defies a rigid pacing guide. Within grade, other variables contribute to changes in pacing:

- There are opportunities for students to spend longer on some activities, e.g. in improving or refining their design solutions or in exploring simulations beyond the minimum. These elaborations will demand more time.
- The time allocated for investigations will depend on (1) how you choose to organize the class, which may be determined by available resources and (2) how far students take the investigation. Adjust your lesson plan to incorporate more or less material as needed. You may have investigations you already like to use, so you could choose to leave out equivalent investigations in the book. To help you, activities including a practical

investigation are identified with a green dot (●) in the contents of the student worktext.

- For spreadsheet modeling activities, completed models are available on [BIOZONE's Resource Hub](#). If you need to save time, students can use these spreadsheets instead of taking time to construct them.
- The pace may quicken as students complete more of the book and become more familiar with the style and information flow. Students gain increasing levels of competence and learn valuable skills that enable them to arrive at solutions more quickly.
- Depending on the ability of your students, you may need to use the Science Practices chapter more often to help develop math and science practice skills. Have students carry out the activities as homework if you are short on time.

Identifying Learning Intentions and Goals

In developing *Earth and Space Sciences for NGSS*, we have embraced the three dimensions of the NGSS framework, emphasizing the application of ideas and skills to new scenarios. The activities in *Earth and Space Sciences for NGSS* have been specifically designed to address the **Disciplinary Core Ideas (DCIs)**, **Science and Engineering Practices (SEPs)**, and **Crosscutting Concepts (CCCs)** in a way that helps students to meet specific **Performance Expectations (PEs)**.

In the Teacher's Edition, all three dimensions are embedded in the chapter introduction and color coded for easy identification (below). The Performance Expectations are also identified. It is important to note that *this coding is a tool for the teacher and is not present in the Student Edition*.

This identifies the chapter number.

This identifies the DCI(s) to which this chapter applies.

This identifies the relevant Science and Engineering Practices and are indicated in blue.

This identifies the relevant Crosscutting Concepts are indicated in green.

The relevant Performance Expectation is indicated in red.

The relevant Disciplinary Core Ideas are indicated in orange.

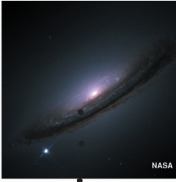
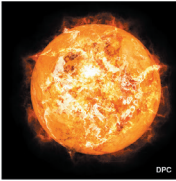

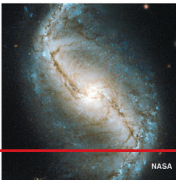

CHAPTER

2

25

The Universe and its Stars

Activity number

Anchoring Phenomenon

Hidden in Plain Sight: What caused the Crab nebula and what is hidden in it?

What evidence is there for the Big Bang?

- 1 Recognize that our understanding of the universe continues to increase as technology available to us advances [SEP-2]. Understand the differences in the use of various observatories. Produce an argument for the cost these projects represent.
- 2 Study and describe the latest theories on the scale of the universe [CCC-3]. The observable universe is possibly only part of a much larger universe and that the observable universe is itself much larger than it first appears. Recognize that the Milky Way galaxy is only one of hundreds of billions of galaxies and is part of much larger groups and clusters of galaxies.
- 3 Construct an explanation of the Big Bang theory based on evidence from sources and uniformitarianism, [SEP-6] [SEP-7]. Include reference to the cosmic microwave background, and the measured composition of stars and gases. Model the expansion of the universe [SEP-2] [SEP-3] [CCC-5]. Use the red-shift of galaxies to calculate their recessional velocity [SEP-5]. Explain how galaxies appear to be receding from any viewpoint anywhere in the universe [ESS1.A] [HS-ESS1-2].

How do stars change over time?

- 4 Describe how the study of stars' light spectra and brightness is used to identify their features, such as composition, mass, size, and temperature. Compare the spectra of several stars and explain the differences seen [SEP-2] [ESS1.A] [CCC-3] [CCC-5].
- 5 Develop and use an evidence-based model to illustrate the life span of the Sun, a main sequence star with a life span of ~10 billion years. Include reference to the changes during its existence, including variations in radiation, sunspot cycles, and non-cyclic variations. Use mathematical models to calculate the size and life span of the Sun [SEP-2] [SEP-3] [SEP-5] [ESS1.A] [CCC-3] [CCC-5] [HS-ESS1-1].
- 6 Describe the evidence for changes in a star's luminosity during its lifetime and explain differences between the lifetimes of stars of different masses. Use a Hertzsprung-Russell diagram to investigate the categorization of stars and that the position of a star on the diagram relates to its mass, luminosity, temperature, and position in its life cycle [ESS1.A] [CCC-3] [CCC-5] [HS-ESS1-1].
- 7 Describe the events that lead to a supernova. Understand that the outcome of a supernova is related to the mass of the star. Describe how elements are produced during a supernova. Explain how space-time is distorted by a black hole through the effects of gravity [SEP-2] [ESS1.A] [CCC-3] [CCC-5].

How are elements produced by nucleosynthesis?

- 8 Explain how nucleosynthesis creates new atomic nuclei from pre-existing nucleons (protons and neutrons) and releases electromagnetic energy. Distinguish between Big Bang, stellar, and supernova nucleosynthesis. Present information in multiple formats to clearly communicate scientific ideas about the way stars produce elements [SEP-2] [SEP-8] [ESS1.A] [CCC-5] [HS-ESS1-3].
- 9 Explain how nucleosynthesis and the different elements created varies as a function of the star's mass and the stage of its life cycle [ESS1.A] [CCC-3] [CCC-5] [HS-ESS1-3].

13

18 26

19-21

Guiding questions
The guiding questions help students identify important questions in the chapter.

The activity in the book related to this question or statement.

A red number indicates the summative assessment for this chapter, where an NGSS performance expectation is addressed.

Scaffolded Learning with the 5 Es

In developing *Earth and Space Sciences for NGSS*, we have utilized the **5Es Instructional Model** as a basis for scaffolding and developing material. This approach allows students to develop a deeper understanding of content as they work through a series of related activities. By successfully completing the activities, students can demonstrate competence in all three dimensions of the framework. This is central to meeting the Performance Expectations for *Earth and Space Sciences for NGSS* with confidence.



BIOZONE encourages the development of the NGSS learner profile using the 5Es instructional model

The Five Es

- Engage:** make connections between past and present learning experiences.
- Explore:** become actively involved in the activity.
- Explain:** communicate the learning experience.
- Elaborate:** expand on the concepts learned.
- Evaluate:** assess understanding of the concepts.

BIOZONE's NGSS series is **phenomenon-based**. Students engage with phenomena through their own investigations and observations, through modeling and data analysis, and through collaborative work and discussion.

Using phenomena to drive inquiry promotes discussion and the sharing of ideas. The scaffolded approach presents opportunities to look at phenomena from several different perspectives. This allows students of all abilities to expand their thinking and comprehension, increasing understanding as they progress through the program.

Each chapter begins with an **anchoring phenomenon** (right). In each instance, we have chosen a phenomenon that the student may be familiar with, but which they cannot explain (or cannot explain fully). Teachers can use this activity as formative assessment to find out what the students already know (or think they know) before delving into the content more fully. Teachers can also identify any gaps or misconceptions as they work through the material.

The subsequent activities in a chapter take the students, step by step, through phenomena that explore the ideas inherent in the anchoring phenomenon. By the time students revisit the anchoring phenomenon at the end of the chapter, they should be able to fully explain it.

26

11 Hidden in Plain Sight

Key Question: What caused the Crab Nebula and what is hidden at its center?

...lies this

63

25 Review Your Understanding

Key Question: What caused the Crab Nebula, and what is hidden at its center?

► At the beginning of this chapter, you were shown the Crab Nebula, the object at the center of it, and given some history of its recorded observations. You should now be able to explain what caused the nebula and describe the object in the middle of it.

Each chapter begins with an **anchoring phenomenon**, e.g. *Hidden in Plain Sight*. By the time the students have worked through the activities in the chapter, they should be able to fully explain it when it is revisited at the end of the chapter

- Describe the object seen clearly in the center of the nebula.

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The content of *Earth and Space Sciences for NGSS* is organized into 12 chapters, based on the DCIs of the High School Earth and Space Sciences framework. Chapter 1 addresses basic skills for students in Earth and Space Sciences. Chapters 2 - 12 address the content of the framework proper. Each chapter begins with an introduction outlining learning goals, and is immediately followed by the anchoring phenomenon. Activities make up the bulk of each chapter, with each one focusing on the student investigating and developing understanding of a phenomenon, applying that understanding to new scenarios, and developing or honing a skill or science practice, e.g. graphing, data analysis, modeling, or evidence-based explanation.

Annotated diagrams and photographs are a major part of most activities, and the student's understanding of the information is evaluated through questions and/or tasks involving data handling and interpretation. Tabs at the bottom of the page identify Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts, as appropriate. Resource Hub tabs indicate if the activity is supported via **BIOZONE's Resource Hub**, which provides online teacher and student support for specific aspects of the activity.

Concepts are presented as a logical sequence, which may be divided among several consecutive activities. Understanding is developed progressively through exploration and explanation.

ENGAGE

The first activity in a related sequence is often an introductory type activity. It may begin with a brief task, observation, or example to engage student thinking.


178

77 The Properties of Water


Key Question: How do the unique physical and chemical properties of water make it a central chemical in many biological and geological systems?

- Water has a simple chemical formula, containing just two hydrogen atoms and one oxygen atom (H₂O) held together by bonds. The electrons in these bonds are not shared equally between the atoms. On average, the electrons spend a greater amount of time near oxygen than near hydrogen. This gives the oxygen a slightly negative charge and the hydrogens a slightly positive charge, called a dipole. This is shown as δ⁻ and δ⁺ (right).
- This difference in charge produces a strong molecule. The positive hydrogen end of the molecule is attracted to the negative oxygen of other water molecules (hydrogen bonding). This attraction is strong and this feature gives many of its unique properties, including its surface tension and its chemical behavior as a powerful solvent.

Important properties of water




Water has the **highest** heat capacity of all liquids. It takes a lot of energy to raise its temperature. Water has a high boiling point because a lot of energy is needed to break the hydrogen bonds between water molecules and make water boil.



Water molecules, i.e., they stick together. This is due to hydrogen bonding. Cohesion allows water to form droplets and is responsible for surface tension. Hydrogen bonds between water molecules also allow water to be a powerful solvent.

One of the most important properties of water is that its solid state (ice, right) is less dense than its liquid state. This means that ice floats on water. When freezing, water molecules align into a crystal structure that increases its volume by about 9% compared to liquid water at the same temperature. Water is colorless and transparent.



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179


Comparing water and hydrogen sulfide

Hydrogen sulfide (H₂S) has the same molecular shape as water (right) but has a melting point of -82°C and a boiling point of -60°C, far lower than water's. This is because of the difference in electronegativity of sulfur and oxygen. Even though sulfur sits directly below oxygen on the periodic table, its outer electrons are further away from the nucleus and are held more weakly. This leads to a greater difference in polarity between a H₂O molecule and a H₂S molecule.

Property	Water	Hydrogen sulfide
Formula	H ₂ O	H ₂ S
Melting point	0°C	-82°C
Boiling point	100°C	-60°C

The **loose** H₂S water molecules form with each other require a lot of energy to break. This is why water has a much higher boiling point than hydrogen sulfide.

2. Below are two simple diagrams of a sodium ion and a chloride ion. Note the charge they carry. In the space around them, draw three to four water molecules per ion to show how the water molecules interact with them:



2. Explain the formation of hydrogen bonds between water molecules: _____

3. Explain why aquatic environments have relatively stable temperatures: _____

4. Why does ice float on water? _____

5. Explain why water has a high surface tension: _____

6. Why does hydrogen sulfide have a much lower melting point and boiling point than water? _____

Students are given enough information to complete the activity's questions or tasks.

Information to answer the questions is often on the page, but students may need to analyze data or information and draw conclusions to answer the questions. Sometimes, students are asked to carry out their own research or investigation.

Questions allow students to demonstrate their understanding. By inputting their answers directly to the worktext, students form a record of work, allowing for easy revision in context with the stimulus information.

Relevant SEPs, DCIs, and CCCs are identified through the tab system.

This activity also has supporting resources on **BIOZONE's Resource Hub** assigned to it.

After being introduced to the properties of water, students now begin to **EXPLORE** the movement and cycling of water by looking at the hydrologic (water) cycle.

Next, students are introduced to the role water plays in altering the Earth's surface. They can use knowledge about water's properties to **EXPLAIN** how water can melt rocks and cause erosion, thus changing the appearance of the Earth's surface.

78 The Hydrologic Cycle

Key Question: What processes allow water to cycle from the oceans to the land and back?

Earth's water

- About 97% of Earth's water is stored in the oceans, which contain more than 1.3 billion km³ of water. Less than 1% of Earth's water is freely available fresh water (in lakes, rivers, and streams).
- Water evaporates from the oceans and lakes into the atmosphere and falls as precipitation, e.g. rain, snow, or hail. Precipitation falling on the land is transported back to the oceans by rivers and streams or is returned to the atmosphere by evaporation or transpiration (evaporation from plant surfaces).
- Water can cycle very quickly if it remains near the Earth's surface, but it can also remain locked away for hundreds or even thousands of years, e.g. if trapped in deep ice layers at the poles, or in groundwater storage (aquifers).
- Humans intervene in the hydrologic (water) cycle by using water for their own needs. Withdrawing water from rivers and lakes for irrigation changes evaporation patterns, lowers lake levels, and reduces river flows.

Water is the only substance on Earth that is found naturally as a solid, liquid, or gas. It has an unexpectedly high boiling point compared to other similar molecules and requires a lot of energy to change state. This means it acts as a buffer against extreme temperature fluctuations in the environment.

Sodium chloride and water solution

Several solutions were made using fresh water and sodium chloride salt to produce concentrations of 0 g/L, 50 g/L, 100 g/L, 150 g/L, 200 g/L, and 250 g/L.

These were poured into identical beakers and placed into a freezer at -5°C. The temperature of each solution was measured to record its freezing (and melting) point.

The results are shown below:

Solution concentration (g/L)	Freezing/melting point (°C)
0	0
50	-3
100	-6.5
150	-10.9
200	-16.5
250	-24.5

Water and plate tectonics

As a tectonic plate descends in a subduction zone, it drags down water-laden sediment and rocks. The rocks are heated and squeezed, and at a depth of about 100 km the water is driven out and begins to rise through the rock as vapor.

As it rises, the vapor encounters hotter rocks above, that are close to their melting point. The water vapor enters these rocks, lowering their melting point and producing magma.

1. What is the main storage reservoir for water on Earth?
 2. Describe the feature of water that allows it cycle, as described above.
 3. Identify the two processes by which water moves from the land or oceans to the atmosphere.

80 Water's Role in the

Key Question: How does water allow rocks to melt into magma?

The lithosphere and asthenosphere are solid; they are above a hot spot or a subduction zone open up and below ground) oozes out of fissures along mid-ocean ridges. This implies that special conditions must be met for melting of rocks and the formation of magma.

- Heat: the most obvious, but not the most important.
- Decreased pressure: as hot material rises toward the surface, it moves toward lower pressure.
- Addition of water: water disrupts the bonds in silicate minerals and (silicates). In the presence of water, the rock's melting point is lowered. The addition of water is responsible for most magma formation.

Sodium chloride and water solution

Several solutions were made using fresh water and sodium chloride salt to produce concentrations of 0 g/L, 50 g/L, 100 g/L, 150 g/L, 200 g/L, and 250 g/L.

These were poured into identical beakers and placed into a freezer at -5°C. The temperature of each solution was measured to record its freezing (and melting) point.

The results are shown below:

Solution concentration (g/L)	Freezing/melting point (°C)
0	0
50	-3
100	-6.5
150	-10.9
200	-16.5
250	-24.5

Weathering and erosion

Weathering and erosion are important processes that shape the Earth's surface. They usually work closely together and can be confused. It is important to remember that weathering and erosion are different processes.

Weathering

- Weathering is the chemical, physical, and biological process of breaking rocks and minerals down into smaller pieces.

Physical weathering

- Physical weathering occurs when rocks break apart without any change to their chemical structure. Physical weathering includes changes in pressure and temperature affecting the rock. These combine to put constant physical stress on the rock until it shatters. One way this occurs, especially in high mountains, is the process of freeze-thaw, causing frost wedging (above right and right).

Chemical weathering

- Chemical weathering is the breakdown of rock by chemical changes to the minerals it contains. This includes processes such as dissolving and oxidation. Rainwater is slightly acidic: it has a pH of about 6, due to dissolved carbon dioxide forming carbonic acid. Chemical reactions occur when it comes in contact with the minerals in rocks. An example is the weathering of limestone: the calcium carbonate in the limestone reacts with the excess hydrogen ions in the water, forming bicarbonate ions which are soluble and washed away. Another form of chemical weathering is oxidation: oxygen in the air or water reacts with iron in rocks, forming oxides or rust, which can slowly break down a rock.

Biological weathering

- Biological weathering is any weathering process carried out by a living organism. It can therefore also be chemical, e.g. by organic acids produced by organisms, or it can be physical, e.g. tree roots lifting pavements. Lichens and algae growing on the surface of rocks can slowly etch them, producing a greater surface area and slowly allowing other processes to take hold.

Weathering and erosion

Use the boxes below to distinguish between weathering and erosion (following page), including examples:

Weathering

Examples:

Erosion

Examples:

Students have many opportunities to explore concepts through a variety of activities including practical investigations, creating models, analyzing or using second hand data, or interpreting diagrams. This allows students to explain phenomena by building on what they discovered through exploration. In this example, students use a simple, practical investigation to **EXPLAIN** water's role in erosion via frost wedging.

Students are encouraged to use scientific principles and logical reasoning to construct explanations and devise solutions to the problems presented to them. After sound explanations of phenomena are developed, students have an opportunity to **ELABORATE**, applying their understanding to new phenomena or using their experience to develop or refine engineering solutions to relevant problems. Where incorporated, **EVALUATE** sections can be used for formative assessment if you wish. In this example, students apply their knowledge of erosion and deposition to explain their effects on agriculture along a flood plain.

82 Investigating Frost Wedging

Key Question: How do the processes of weathering and erosion shape earth's surface?

Investigation 7.2 Investigating frost wedging

See appendix for equipment list.

- Set up three boxes, as shown in the diagram below:

- Allow the plaster to set, then place all three boxes in a freezer overnight.

- Remove the boxes from the freezer and record observations below:
 - (a) Box A: _____
 - (b) Box B: _____
 - (c) Box C: _____
- Which box(es) acted as the control for the test?
- It is expected that plastic in one of the boxes has split. Explain why this has occurred.
- How well does this model in the investigation represent the process of frost wedging, and why?
 - (b) In what ways does the model differ from frost wedging?
- Use the findings from the investigation to summarize the role water plays in rock formation.

83 Modeling Erosion

Key Question: How does modeling help us understand how erosion shapes the landscape?

Water as an agent of erosion

Water, including water as snow and ice, is able to erode (remove) rock and soil. Water moves weathered rock to the lowest elevation possible, and transports it either in solution (dissolved), in suspension, or carried along the base of water courses as bed load. The erosive force of water on land is clearly seen where soil is removed along drainage lines by surface water runoff, or where the sea meets coastal cliffs. Erosion rates are variable. River banks and coastal cliffs may be very gradually undercut and then, once unstable, may slump, forming a flat surface as a large volume of material is removed.

Modeling the effect of water on the landscape

Stream trays or tables are a simple way of modeling and observing how rivers develop and change the land by erosion and deposition of sediment. Any long tray can be used, as long as there is a water supply and an outlet for the water is drilled at the lower end.

You will use your stream tray set-up to explore how water affects the landscape and what features of the landscape influence the landforms that result.

Investigation 7.3 Modeling the process of erosion

See appendix for equipment list.

- You may work in groups. Set up the tray by placing it on a slight angle with the outlet at the lower end. Place your substrate, e.g. gravel, silt, or sand in the tray and work the sediment so that it becomes thinner near the lower end.
- The simplest set-up is to make a sediment "mountain" near the upper end of the tray by initially blocking water flow, forming a "lake". See photo (right) for set-up.
- Answer question 1 below and then begin your investigation. Record your results on the next page.

1. Before you do the modeling, record your predictions for the following:

- The effect of flow velocity (rate and direction) on erosion:
- Where most of the erosion will occur in a meandering (snake-like) stream:
- Where the sediment that is moved will be deposited:

Practical Investigations

Throughout *Earth and Space Sciences for NGSS*, students are given opportunities to explore phenomena through experimentation. These **investigative phenomena** are opportunities for students to develop competency in laboratory procedures, to practice and refine skills in observation and analysis, and to manipulate data. Some investigations act as stimulus material, while others require students to take what they have already learned and apply their knowledge to a more complex scenario.

The investigations provide an excellent opportunity for collaborative work and will stimulate discussion and the sharing of ideas. You may wish to pair students of different abilities together. Confident students can guide and encourage less able students and, in this relaxed environment, striving students will be encouraged to share their own observations and thoughts. Collaboration through paired practical work provides an excellent opportunity for English language learners to interact in meaningful ways to extend their English language and scientific vocabulary.

Each investigation is clearly numbered sequentially through the chapter.

The investigations provide students with health and safety information at the start of the investigation.

- ▶ Ensure your students read through the procedure fully *before beginning* the investigation.
- ▶ Highlight any hazardous or important steps, and make sure the students follow your directions.

10 Planning and Carrying Out an Investigation

Key Question: How does surface area affect dissolving time?

▶ Rainwater is very slightly acidic. When it comes in contact with limestone, it reacts with it to form carbon dioxide gas, and calcium ions in solution. This causes the limestone to dissolve.

▶ Limestone that is already partially eroded, presents a greater surface area for rain to fall on and therefore a greater surface area for reaction.

▶ This reaction is very slow, and generally not noticeable. In the investigation below, you will use hydrochloric acid (HCl) in place of water to speed up the reaction to a measurable rate.

1. Write a hypothesis for the experiment below: _____

Investigation 1.1 Investigating surface area and dissolving time.

See appendix for equipment list

Caution. HCl is corrosive. You should wear protective eyewear and gloves.

- Select nine pieces of limestone (calcium carbonate, CaCO₃) that are roughly similar in shape. These should weigh about 1 gram each. Weigh them on a balance to obtain masses as close as reasonably possible.
- Fill each of _____
- In each beaker, add _____
- Record the _____
- Carefully, _____
- Take three _____
- Add each _____
- Record how long it takes for each of the crushed limestone pieces to dissolve (fully react), or for the reaction to stop producing bubbles, and record the times in table 1.
- Again, carefully dispose of any leftover acid and limestone and rinse with distilled water. Refill the beakers with 100 mL of 1 mol/L HCl.
- Take the last three limestone pieces and keeping them separate, crush them using the mortar and pestle into a powder or fine grains. Have a stopwatch or timer ready.
- Add each powdered limestone piece to one of the beakers and immediately start timing.
- Again, record how long it takes for each of the powdered limestone pieces to dissolve (fully react), or for the reaction to stop producing bubbles and record the times in table 1.
- Again, carefully dispose of any leftover acid and limestone and rinse with distilled water.


	Single piece	Crushed	Powdered
1			
2			
3			
Mean			

Controlling variables


To carry out an investigation fairly, all the variables (factors that could be changed) are kept the same, except the factor that is being investigated. These are called **controlled variables**. The variable that is being changed by the investigator is called the **independent variable**. The variable being measured is called the **dependent variable**.

11 Modelling the process of erosion

▶ How can we help us understand how erosion shapes the landscape?



▶ How can we model the process of erosion?



▶ How can we use a model to investigate the process of erosion?

▶ Before you do the modeling, record your predictions for the following:

- The effect of flow velocity (rate and direction) on erosion: _____
- Where most of the erosion will occur in a meandering (snake-like) stream: _____
- Where the sediment that is moved will be deposited: _____

Equipment list

Appendix: Equipment list		
<p>1: Science Practices</p> <p>INVESTIGATION 1.1 Investigating surface area and dissolving time</p> <p>Per student/pair Limestone (CaCO₃) chips 1 mol/L HCl 3 x 200 mL beakers Timer Electronic balance Mortar and pestle</p> <p>2: The Universe and its Stars</p> <p>INVESTIGATION 2.1 Modelling expansion</p> <p>Per student/pair Rubber bands Thumb tacks</p> <p>INVESTIGATION 2.2 Measuring the size of the Sun</p> <p>Per student/pair Aluminum foil Push pin Card to make a frame for the foil Ruler</p> <p>3: Earth and the Solar System</p> <p>INVESTIGATION 3.1 Elliptical orbits</p> <p>Per pair String (15 cm) Two thumbtacks Pencil Corkboard or card</p> <p>INVESTIGATION 3.2 Modelling orbits</p> <p>Per pair 1 bowl 4-5 balls of various sizes 4-5 cotton pads Sheet of material to cover bowl</p> <p>INVESTIGATION 3.3 Parallax</p> <p>Per group of four Protractor (a 180° is easiest to use) Corkboard or thick card Tape Push pins Plastic straw Measuring tape</p>	<p>4: The History of Planet Earth</p> <p>INVESTIGATION 4.1 Modelling half-lives</p> <p>Per pair/group M&M's Liquor container</p> <p>5: Earth Materials and Systems</p> <p>INVESTIGATION 5.1 Modelling ice sheet melting</p> <p>Per pair/group 2 x Florence or Erlenmeyer flasks Black paint Aluminum foil Tie cables 2 x thermometers 60W tungsten lamp (optional) Timer</p> <p>6: Plate Tectonics</p> <p>INVESTIGATION 6.1 Continental drift</p> <p>Per student/pair Scissors Tape or paste</p> <p>INVESTIGATION 6.2 Modelling drift over time</p> <p>Per student/pair Scissors Tape or paste</p> <p>7: The Roles of Water in the Earth's Surface Processes</p> <p>INVESTIGATION 7.1 Determining properties of rocks</p> <p>Per pair/group Samples of sedimentary, igneous, and metamorphic rock Graduated cylinder Electronic balance</p> <p>INVESTIGATION 7.2 Investigating frost wedging</p> <p>Plaster of Paris 3 x balloons Graduated cylinder 3 x Disposable containers Freezer</p>	<p>INVESTIGATION 7.3 Modelling the process of erosion</p> <p>Per group 1 x plastic tray (at least A3 in size) with a water inlet and outlet Hose and connectors Substrate (gravel, silt, sand, clay) Large rocks Vegetation</p> <p>8: Weather, Climate, and Biogeography</p> <p>INVESTIGATION 8.1 Measuring energy</p> <p>Per student Torch Clamp stand Protractor Grid paper</p> <p>INVESTIGATION 8.2 Modelling carbon cycle changes</p> <p>Per student/pair Computer Spreadsheet application e.g. Excel</p> <p>9: Natural Resources</p> <p>INVESTIGATION 9.1 Investigating soil types 1</p> <p>Per student/pair Samples of sand, silt, and clay Measuring cylinders Stirring rods</p> <p>INVESTIGATION 9.2 Investigating soil types 2</p> <p>Per student/pair Three different soil samples Measuring cylinders Stirring rods</p> <p>12: Global Change</p> <p>INVESTIGATION 12.1 Investigating how dry ice affects pH</p> <p>Per pair/group 200 mL conical flasks Universal indicator Dry ice 1 mol/L NaOH</p>

No kits are required for the investigations.

The investigations have been designed using everyday materials and equipment found in most high school laboratories.

A list of the equipment and chemicals required for each investigation is provided in the appendix of the Student Edition.

Engineering Design Solutions

At high school, students are expected to analyze major global issues and apply strategic thinking and problem solving to design possible solutions to a specific problem. Often, their solutions include taking into consideration scientific knowledge, the use of technology, and the impact of the solution on society.

Engineering Design (ETS) standards are indicated throughout the NGSS framework. They are incorporated into this title through the integration of engineering and design challenges, where appropriate. Typical Engineering Design tasks include analyzing problems, developing solutions using engineering, evaluating a design solution based on costs and benefits, or modeling a design solution. These activities provide students with an opportunity to apply their knowledge within a design challenge and think outside the box to come up with potential solutions.

The ETS components are indicated in the chapter introduction of the Teacher's Edition, and also in the 3D summary tables in the Classroom Guide. They are also identified through the tab system on the activity itself (bottom of page and margin). Such tasks are usually examples of ELABORATE or EVALUATE as they involve the students applying what they have learned to solve a problem. As such, they also make good tasks for formative or summative assessment.



The ETS icon at the bottom of the page and in the margin identifies when an ETS is covered.

310

154 Technological Solutions to Climate Change

Key Question: How can technology and innovation be used to mitigate or adapt to climate change?

How can new technologies be used to slow climate change?

- ▶ If greenhouse gas production was to completely stop today, the Earth's temperature would still continue to rise slightly. To prevent continued climate change, climate scientists agree that we need to reduce our level of greenhouse gas emissions to slow the most damaging effects.
- ▶ There are many possible ways to achieve this. They include improving energy efficiency, increasing the use of renewable energy sources, and using carbon capture technologies.
- ▶ We can also capture carbon naturally by planting more trees and reducing the rate of deforestation.

Large-scale carbon producers

- ▶ Burning fossil fuels in power stations to generate electricity produces CO₂. Even power stations using high quality coal produce CO₂ so that it can be stored or used for CO₂ capture systems are shown in the diagram below.
- ▶ Other large contributors are the transport industry (30%). Concrete is the final set product of cement mixed with aggregates. Manufacturing techniques aim to reduce the emissions.

Schematics of three processes

Pre-combustion capture: The coal is converted to CO₂ and H₂ using a gasification process. The CO₂ is recovered while the H₂ gas is combusted.

Post-combustion capture: CO₂ is washed from the combustion products. It is desorbed to regenerate the sorbent and then compressed.

312

Case study: Lowering emissions in the cement industry

- ▶ Cement and concrete are essential to the building industry and the global economy. 4.1 billion tonnes of cement were produced in 2015. This is expected to increase to 4.8 billion tonnes by 2030. This is important to the global climate because producing one tonne of cement also produces about one tonne of CO₂ (and uses the equivalent of 200 kg of coal).
- ▶ The most common cement used is called Portland cement, which is very strong when set. It requires a lot of energy to make it. 40% of the CO₂ emissions come from burning fossil fuels to heat limestone (CaCO₃) and other minerals to 1400°C. At this temperature, the limestone breaks down and releases CO₂. This step produces about 50% of the CO₂ emissions. Portland cement reabsorbs about half of this CO₂ as it hardens over the life time of the cement.
- ▶ Reducing the CO₂ emissions for cement manufacture can be done at three steps in the process:
 - ▶ Reducing the amount of fossil fuels needed to heat the raw materials
 - ▶ Reducing the amount of CO₂ released by the raw materials
 - ▶ Increasing the amount of CO₂ absorbed when setting.
- ▶ New types of cement using magnesium silicates instead of limestone are being trialed. These do not need to be heated to such high temperatures and they do not release CO₂ when heated. Total CO₂ emissions are up to 0.5 tonnes per tonne of cement produced (half that of Portland cement). During setting, CO₂ is absorbed at a greater rate than in traditional cement (about 1.1 tonnes per tonne of cement produced). This type of cement is called carbon negative cement because it absorbs more CO₂ than is produced making it (about 0.6 tonnes of CO₂ absorbed for every tonne of cement produced).

Cement factory

5. (a) Approximately how many tonnes of CO₂ were produced by the cement industry in 2015? _____
 (b) Where is this CO₂ produced in the manufacture of cement? _____

 (c) Explain why carbon negative cement is carbon negative: _____

 (d) Based on the 2015 figures, how much carbon would carbon negative cement absorb? _____

6. The Centre for Climate Repair, based at the University of Cambridge, has proposed an idea to mitigate (prevent or reverse) climate change. Technology would be used to fertilize the oceans to encourage more algae growth, which could then absorb more CO₂. What could be some potential issues with 'greening' the ocean as a mitigation technology?

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Evaluating Student Performance

Earth and Space Sciences for NGSS provides ample opportunity for students to demonstrate their understanding and proficiency in all three dimensions of the standards. Opportunities for both formative and summative assessment are provided.

Activities and assessments have been designed to be three-dimensional in their approach, with the goal of enabling achievement of specific Performance Expectations (PEs). Performance Expectations are not always met through completion of one activity or assessment, but may be accomplished through the completion of a connected suite of tasks (as intended by the framework).

Assessments involve a variety of tasks appropriate to a 3D approach, e.g. constructing models, analyzing and interpreting data, explaining, and communicating understanding through short and long answers, drawings, calculations, group work, design, and problem solving. The structure of the tasks is such that students use specific Science and Engineering Practices and apply relevant Crosscutting Concepts to demonstrate their understanding of Disciplinary Core Ideas.

FORMATIVE ASSESSMENT

Formative assessments can be chosen by the teacher to determine how a student's knowledge is progressing within a selected topic. We suggest that 'ELABORATE' and 'EVALUATE' activities be used for formative assessment. These may incorporate some aspect of a Performance Expectation, with the goal being to build confidence. Teachers can revise their instruction, revisit material, or set further tasks if a student is having difficulty with the material. The anchoring phenomenon activity and revisiting the anchoring phenomenon (Review Your Understanding) near the end of each chapter, and the Test Banks (CG12) also provide ways to evaluate student understanding.

60 Ice Sheet Melting 141

Key Question: How can the melting of sea ice cause a positive feedback loop that exposes more heat absorbing surface?

Changes in polar sea ice

The surface temperature of the Earth is partly regulated by the amount of ice on its surface which reflects a large amount of heat into space. However, the area and thickness of the polar sea-ice is rapidly decreasing. From 1980 to 2008 the Arctic summer sea-ice minimum almost halved, decreasing by more than 3 million km². The 2012 summer saw the greatest reduction in sea-ice since the beginning of satellite recordings.

This melting of sea ice can trigger a cycle where less heat is reflected into space during summer, warming seawater and reducing the area and thickness of ice forming in the winter. At the current rate of reduction, it is estimated that there may be no summer sea-ice left in the Arctic by 2050.

Arctic sea-ice summer minimum 1980: 7.8 million km²

The high **albedo** (reflectivity) of sea-ice helps to its presence. Thin sea-ice has a lower albedo than thick ice. More heat is reflected when sea-ice is thick at greater area. This helps to reduce the sea's temperature.

- Calculate the difference in summer sea-ice area between 1980 and 2012.
- How does low sea-ice albedo and volume affect the Arctic's temperature?
- What type of feedback system is operating here?

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Investigation 5.1 Modeling ice sheet melting 142

See appendix for equipment list.

- Work in pairs or groups of three. Collect two 500 mL Florence or Erlenmeyer flasks. Paint one of the flasks black and wrap the second flask in aluminum foil.
- Weigh out six ice cubes (~60-90 g). Record the weight on the table below. Weigh out a second lot of ice cubes, if must have the same mass as the first.
- To each flask, add 200 mL of 20°C water and the weighed ice cubes.
- Seal the flasks and insert a thermometer into each. Record the temperature (time zero) on the table.
- Place the flasks in a sunny spot and record the temperature every two minutes for 10 minutes. If it is not a sunny day use a 60W tungsten lamp placed 15 cm from the flasks as the heat source.
- After 10 minutes, remove the ice cubes and reweigh them. Record the values on the table below.

Time (minutes)	Temperature - black flask (°C)	Temperature - foil coated flask (°C)
0		
2		
4		
6		
8		
10		
Initial mass of ice (g)		
Final mass of ice (g)		

- Plot the temperature changes on the grid:
- Which flask has the greatest albedo?
- Calculate the change in mass of the ice cubes for both the black and foil coated flasks.
- Why is it important to start with the same total mass of ice in both flasks?
- What would you change if you wanted to show the effect of a different heat source?
- Write a conclusion for the investigation:

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66 Review Your Understanding 151

Key Question: What are the processes that continually shape the Earth's surface?

The surface of the Earth is constantly changed by factors such as erosion, mountain building, and volcanic activity. In this chapter you have studied the effect of these on the Earth's surface.

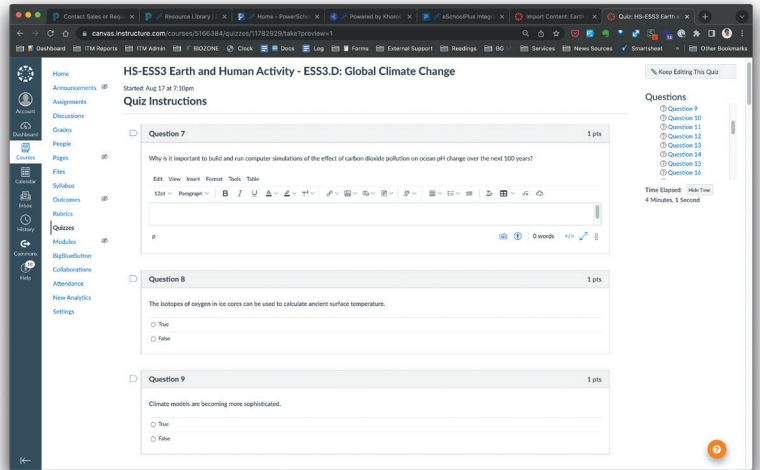
- List some destructive factors that shape the Earth's surface. What do these tend to do to the surface of the Earth?
- List some constructive factors that shape the Earth's surface. What do these tend to do to the surface of the Earth?
- The rocks making up Mt. Roraima in Venezuela (right) are 2 billion year old sandstones laid down on the bottom of what was once an ancient sea. Use constructive and destructive forces to explain Mt. Roraima's formation:

- On the photograph (right), identify, label, and describe the factors that are changing the landscape:
 -
 -
 -
 -
- Feedback loops are important drivers that both stabilize and change the climate.
 - What kind of feedback loop stabilizes the climate? Give an example:
 - What kind of feedback loop causes the climate to change? Give an example:

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TEST BANKS

- ▶ BIOZONE's Test Banks have been designed to test student understanding of the DCI content within each chapter. They are flexible in how they can be used: select questions for students to complete at the end of each activity, or set a test at the end of a chapter.
- ▶ These test content knowledge, and take the form of:
 - Multiple choice
 - Modified True/False
 - Matching
 - Yes/No
 - True/False
 - Multiple response
 - Short answer
 - Numeric response
- ▶ Test bank questions are formatted for ingestion into test generator software such as ExamView and Illuminate.
- ▶ Questions can be edited and can be used in other formats such as Google forms, Quizlet, or Kahoot for variation.



SUMMATIVE ASSESSMENT

Summing up tasks at the close of each chapter can be used as a formal summative testing moment to evaluate student skills, understanding, and application of knowledge. These tasks are designed to meet part, or all of, one or more Performance Expectations. Material to address specific Performance Expectations is identified with a red tab in the margin throughout the Teacher's Edition. Performance Expectations are also identified in the chapter introduction, and in the tables summarizing BIOZONE's 3D approach by chapter (CG23).

Note: All coding associated with assessment is hidden from the student and is available only in teachers' materials.

174 **75 Summing Up**

ESS3-3 1. Earthquakes normally occur along plate boundaries. Measuring the depths of these earthquakes can give an idea of the shape of the boundary and how the plates are interacting. The data below shows earthquake depths for the Tonga Trench in the Pacific Ocean and along the coast of Chile.

(a) Plot a scatter graph of the data on the grids provided:

Tonga trench		Chile coast	
Longitude (°W)	Depth (km)	Longitude (°W)	Depth (km)
176.2	270	67.5	180
175.8	115	68.3	130
175.7	260	62.3	480
175.4	250	62.0	600
176.0	160	69.8	30
173.9	60	69.8	
174.9	50	67.7	
179.2	650	67.9	
173.8	50	69.2	
177.0	350	68.5	
176.8	580	68.1	
177.4	420	65.2	
176.0	520	69.7	
177.7	560	68.2	
177.7	465	66.2	
179.2	670	66.3	
175.1	40	68.5	
176.0	220	68.1	130

(b) Add a line of best fit through the data points.

(c) What type of plate boundary appears to be present at the locations plotted?

(d) Draw a diagram in the space below to show how the layers of the Earth are moving at the Tonga Trench:

The specific Performance Expectation addressed is identified with a red tab in the margin of the Teacher's Edition. **Students do not see this coding.**

ESS2-3 2. Draw a diagram in the space below to show the mechanisms of plate tectonics that shift the plates of the Earth's crust. You should make sure your diagram has divergent and convergent boundaries and the layers of the Earth that are significant in plate tectonics.

3. Explain the significance of radioactive decay to plate tectonics: _____

4. The diagram (right) shows the Pacific plate and the Nazca plate. The white dotted line shows the location of the plate boundaries. The red dotted line shows the location of subduction zones along those boundaries.

(a) On the diagram, circle the area that would likely be a divergent plate boundary.

(b) Where would you expect to find volcanoes on this diagram?

(c) Explain why volcanoes form in the places you have indicated in (b): _____

Summative assessments are three dimensional assessments of student understanding, including but not restricted to:

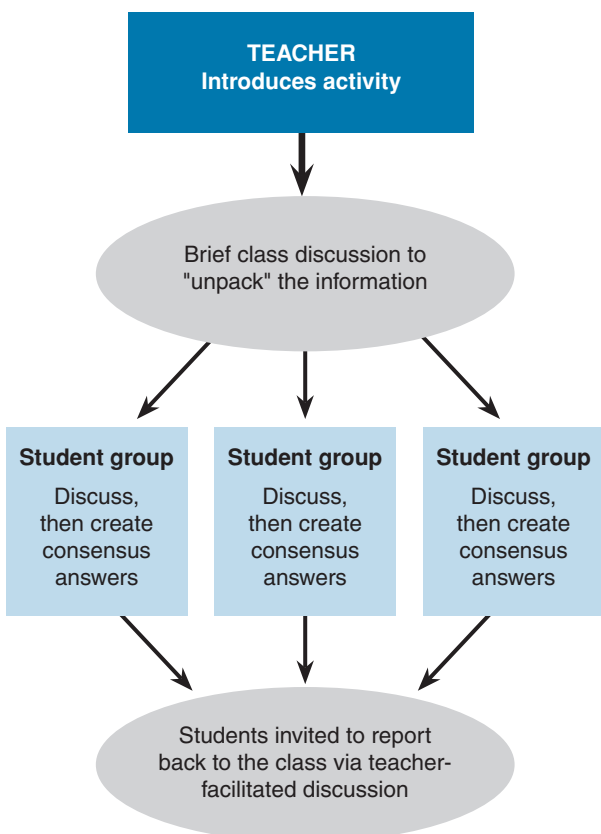
- Short answer questions
- Long answer questions
- Graphing
- Data analysis and interpretation
- Modeling

Teaching Strategies for Classroom Use

Achieving effective differential instruction in classes is a teaching challenge. Students naturally have mixed abilities, varying backgrounds in the subject, and different language skills. Used effectively, BIOZONE's worktexts and supporting resources can make teaching a mixed ability class easier. Here, we suggest some approaches for differential instruction.

MAKING A START

Regardless of which activity you might be attempting in class, a short introduction to the task by the teacher is a useful orientation for all students. You may want to use BIOZONE WORLD for this. For collaborative work, the teacher can then divide the class into appropriate groups, each with a balance of able and less able students. Depending on the activity, the class may regroup at the end of the lesson for discussion and to review answers.



Using collaboration to maximize learning outcomes

- The structure of *Earth and Space Sciences for NGSS* allows for a flexible approach to unpacking the content with your students.
- The content can be delivered in a way to support collaboration, where students work in small groups to share ideas and information to answer and gain a better understanding of a topic, or design a solution to a problem.
- By working together to ask questions and evaluate each other's ideas, students maximize their own and each other's learning opportunities. They are exposed to ideas and perspectives they may not have come up with on their own.
- Collaboration, listening to others, and voicing their own ideas is valuable for supporting English language learners and developing their English and scientific vocabularies.
- Use a short, informal, collaborative learning session to encourage students to exchange ideas about the answer to a question. Alternatively, collaboration may take a more formal role that lasts for a longer period of time, e.g. assign groups to work together for a practical activity, to research an extension question, or design a solution to a problem.



The teacher introduces the topic. They provide structure to the session by providing background information and setting up discussion points and clear objectives. Collaboration is emphasized to encourage participation from the entire group. If necessary, students in a group can be assigned specific tasks.



Students work in small groups so that everyone's contribution is heard. They collaborate, share ideas, and engage in discourse. The emphasis is on discussing questions and formulating a consensus answer, not just sharing ideas.



At the end of the session, students report back on their findings. Each student should have enough knowledge to report back on the group's findings. Reporting consists primarily of providing answers to questions, but may involve presenting a report, model, or slide show, or contributing to a debate.



Peer to peer support

- **Peer-to-peer** and **collaborative learning** is emphasized throughout the book, and is particularly valuable for more challenging activities in which the content is more complex, or the questions require students to draw on several areas of their knowledge to solve a problem.
- Stronger students can assist their peers and both groups benefit from verbalizing their ideas. Students for whom English is a second language can ask their classmates to explain unfamiliar terms and this benefits the understanding of both parties.
- **Practical investigations** are an ideal vehicle for peer-to-peer learning. Students can work together to review their results, ask and answer questions, and describe phenomena. There are also opportunities for students to collaborate using models, shown below.

166 **73 Modeling Continental Drift**

Key Question: How has continental drift affected the positions of the continents, over time?

Continental drift, the movement of the Earth's continents relative to each other, is a measurable phenomenon and has continued throughout Earth's history. Movements of up to 2-11 cm a year have been recorded between continents, using GPS. The movements of the Earth's seven major crustal plates are driven by a geological process known as **plate tectonics**. Some continents are drifting apart, while others are moving together. Many lines of evidence show that the modern continents were once joined together as "supercontinents". One supercontinent, **Gondwana**, was made up of the southern continents, some 200 mya (million years ago).

Students work in pairs or small groups to model continental drift. Sharing ideas and observations promotes scientific dialogue.

Investigation 6.1 Continental drift

See appendix for equipment list.

- Cut out the southern continents on page 167, as close to the coastline marks as possible.
- Arrange the cut-outs onto the outline of Gondwana on page 169. Take into account the following:
 - The location of ancient rocks and periods of mountain folding during different geological ages.
 - The direction of ancient ice sheet movements.
 - The geomagnetic orientation of old rocks (the way that magnetic crystals are lined up in ancient rock gives an indication of the direction of the magnetic pole at the time the rock was formed).
 - The distribution of fossils of ancient species such as *Lystrosaurus* and *Glossopteris*.

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211 **99 Modeling the Carbon Cycling**

Key Question: How can modeling be used to show us the cycling of carbon through the hydrosphere, geosphere, and biosphere?

Modeling changes to the carbon cycle

Scientists have been able to estimate the mass of carbon stored in the Earth's various reservoirs (e.g. rocks). They have also been able to estimate the rate at which carbon cycles from reservoir to reservoir.

This data can be used to produce a crude but informative model of the **carbon cycle**. The table below shows the quantity and exchanges of carbon in each reservoir.

Reservoir	Amount in reservoir (gigatonnes (Gt))	Exchanges
Atmosphere	840	Movements included absorption and release by the ocean, and living organisms. Combustion of fossil fuels is adding carbon dioxide to the atmosphere.
Biomass	2610 (610 in plants and animals, ~ 2000 in soil)	Approximately 123 Gt per year is absorbed by photosynthesis, with 120 Gt per year being released by respiration.
Ocean	41,000	About 92 Gt per year is absorbed but 90 Gt per year is released.
Sedimentary rocks	60 million	Exchanges between rocks and other reservoirs and generally very small.
Fossil fuels	10,000	About 9 Gt per year into atmosphere from combustion of fossil fuels.

Investigation 8.2 Modeling carbon cycle changes

See appendix for equipment list.

- Open a spreadsheet and type in headings for the rates of exchange and their values (below). Enter column headings for year and the mass of carbon and the effect of this on surface temperature. Enter headings for the other reservoirs in the cells below this (below).

	A	B	C	D	E	F
1	Exchanges (Gt)	Year	Atmospheric carbon dioxide (Gt)	Cumulative gain in temperature (°C)		
2						
3						
4						
5						
6						
7						
8						
9						
10						

Students carry out a computer simulation to model aspects of the carbon cycle. Any new ideas or questions can easily be tested on the simulation.

2. The change in atmospheric carbon is the sum of the exchanges between the reservoirs. This can be written as a simple spreadsheet formula. In cell D2 enter the value for atmospheric carbon (840). Now, in cell D3 enter the formula for the change in atmospheric carbon: =D2+\$A4+\$A5+\$A6+\$A7+\$A8+\$A9+\$A10. It is important that the cells and \$ symbol are entered correctly so that cell references remain constant.

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The Earth's crust is broken into 15 major tectonic plates.

Continental drift has moved the continents to their current positions.

The ice sheet over Antarctica formed about 95 million years ago.

Most of the Earth's volcanic activity occurs along plate boundaries.

The Earth is geologically active. Convection currents in the mantle below the crust drive continuous continental drift and help form volcanoes and mountains.

Earth's liquid outer core surrounds a solid, iron inner core. The movement of the liquid metal produces electric currents which generate a magnetic field. This field's polarity has reversed many times.

Earth's atmosphere is 78% nitrogen, 20.9% oxygen. The oxygen was produced by photosynthetic organisms about 2.3 billion years ago.

- What process moves the continents across the surface of the Earth? *Crustal movements, driven by convection currents in the mantle, move the continents on the Earth's surface (continental drift).*
- What is a consequence of the convection currents in the mantle? *Convection currents in the mantle create the geological activity on Earth, driving continental drift and forming volcanoes, spreading ridges, and mountains.*
- What cause the Earth's magnetic field?
- Where did the Earth's atmospheric oxygen come from?

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Interactive revision of tasks in class

Review answers in class via BIOZONE WORLD

The teacher view in BIOZONE WORLD has model answers which can be toggled on and off using the show/hide buttons on an activity page.

View activities in BIOZONE WORLD on a shared screen and reveal the answers as required. This is ideal for:

- Providing a concise model answer after a group or class discussion.
- Self marking by students. Students can amend their answer if necessary, providing a powerful secondary learning moment.
- Providing a quick review of answers if time is short.

Students benefit from the feedback in class, where questions can be addressed, and teachers benefit by having students self-mark their work and receive helpful feedback on their responses.

This approach is particularly suited to activities with questions requiring a discussion, as students will be able to clarify some aspects of their responses. Stronger students can benefit by contributing to the explanatory feedback and class discussion.

NGSS for collaboration and discovery

- BIOZONE's *Earth and Space Sciences for NGSS* provides multiple chances for collaboration and discovery. By working together and sharing ideas, students are exposed to different perspectives and levels of knowledge about phenomena.
- NGSS requires deeper student engagement, with less emphasis on facts and more on understanding. By exploring principles and concepts within a context, students are more easily able to apply these principles to new phenomena.
- BIOZONE's *Earth and Space Sciences for NGSS* provides a range of activities to develop student understanding, based on the NGSS framework. These include encouraging students to think about and share what they already know and then build on this knowledge by exploring and explaining phenomena.



Student A is capable. He helps to lead the discussion and records the discussion in a structured way.

Students B and C are also capable but less willing to lead discussion. They will add ideas to the discussion but need a little direction from A to do so.

Student D is less able but gains ideas and understanding from the discussion of students A, B, and C. She may add to the discussion as she gains confidence in the material being studied.

How are English Language Learners Supported?

BIOZONE has several support mechanism in place to support English Language Learners (ELLs) in your classroom. In the printed books, a **glossary** of important key terms is provided in English and Spanish. In the digital platform, a **translation function** supports ELLs in their learning journey. More information on these features is provided below.



...the feeding a significant proportion of the world's water supply, and it is driving up the cost of food.

Preparation and preparedness can reduce the impact of a drought

Drought is sometimes called a **creeping hazard** because it develops over a period of time. It is therefore possible to plan ahead to reduce its impact. Often, being well prepared for a drought is more effective and costs less money than an emergency response, such as supplying aid. The African Climate Policy Center has been established to provide information and strategies to help African countries adapt to shifting rainfall patterns and drought. Some of these strategies are described below.



Rainwater harvesting from rooftops (above) during the rainy season allows water to be stored and used in times of shortage. The water can be used for drinking and cooking, and also to supplement the watering of crops or livestock.

In areas of Kenya, the use of drought resistant strains of sorghum and millet has seen harvest yields double. Yields can also be increased by using fast maturing crops, or through planting less traditional crops which are quite resilient to a range of conditions, e.g. potatoes.

Infiltration pits are trenches to capture and store water when it rains. The simplest are holes dug around a plant, others are larger, lined, and filled with rocks. Rainwater soaks down through the pit instead of running off across the soil. These pits also reduce erosion.

Encourage all students to use the **glossary** to build scientific literacy and become comfortable with using the terms appropriately. The glossary is available in English and Spanish to help students learn key terms.

Key terms, which have been **bolded** within an activity, are included in the glossary. Key terms are only bolded the first time they appear within an activity.

Translation function

BIOZONE WORLD, our digital platform, provides a translation feature to support to students who have English as a second language. The content can be translated into ~150 languages.

Simply activate the translation feature, select the language for translation, and roll the cursor over the text to be translated. A pop up box of the translated text appears on the page. The English text is still visible. Having both languages visible supports students with their English language development while having the reassurance of their first language accessible.

Differentiated Learning

The structure of *Earth and Space Sciences for NGSS* promotes differentiated instruction and has been designed to cater for students of all abilities. BIOZONE's collaborative approach to science inquiry encourages all students to share their ideas and knowledge with their peers, while at the same time broadening their own understanding of phenomena. There are several ways you can use *Earth and Space Sciences for NGSS* to implement differential instruction in your classroom:

52 Review Your Understanding

Key Question: How do you estimate how old something is?

There are many techniques for working out how old something is. Relative dating helps you estimate the order of things but does not give you an actual date. Absolute dating gives you actual dates for an object.

At the start of this chapter you were asked how you might date an object. You would have to develop a set of criteria about the materials they were made of and how they were used. For example, we know plastics were not fully developed until the early 1900s. Therefore plastic objects are likely to be younger than non-plastic objects. But we also know that other things must be considered such as the intended use and type of artefact, style, and function.

1. When using relative dating to date layers of a building to make sense?

2. When dating rocks using radiometric dating, what measure is to be correct, in order for the dating to make sense?

3. Give a brief description of how radiometric dating works.

4. For each of the half-lives (t_{1/2}) the proportion of radioactive atoms left (N) is equal to 0.5 of the original amount (N₀). This can be rearranged to give t = t_{1/2} × (2)^{N/N₀ - 1}. The half-life of the isotope used to date the rock is 1.25 billion years. Calculate the age of the rock if the proportion of the isotope left is 0.25.

Extension Questions: Red flag codes beside a section or question (in the Teacher's Edition) indicate the material is suitable as extension material for more able students. All students may attempt this material, but some students may need extra guidance from the teacher.

Dating the formation of the Earth

Absolute ages of rocks

1. The main uses of geochronology are relative dating methods that can be used to date the Earth and oldest of its history. The dates in the next series of tables provide evidence for a history of the formation of the Earth.

2. The dates in the table below are the age of various rocks and fossils from Earth and other bodies of the solar system. The values are in billion years before present.

Location	Approximate age (Ga)	Material	Dating method
Chondritic meteorite	4565	0.7	238U
Chondritic meteorite	4565	0.8	235U
Mars meteorite	4460	25	147Sm
Mars meteorite	4470	40	147Sm
Mars meteorite	4490	100	147Sm
Mars meteorite	4500	200	147Sm
Mars rock fragment	4340	5	40K
Mars rock fragment	3900	65	40K
Mars rock fragment	3910	20	40K
Earth - Australia	4400	8	40K
Earth - Australia	4404	68	238U
Earth - Australia	4420	8	40K
Earth - Australia	4411	0	238U
Earth - Australia	3910	31	40K
Earth - Canada	3800	7	147Sm
Earth - Canada	3727	20	147Sm

NEED HELP? See activity 7 & 8

Need Help? Icon: The red NEED HELP? icon identifies where material is available in the Science Practices chapter to support a particular math or science practice skill. You can set these activities as homework as a refresher before the students attempt the activity needing the skill. Encourage students to refer to the Science Practices chapter often.

73 Modeling Continental Drift

Key Question: How has continental drift affected the positions of the continents, over time?

Continental drift: The movement of the Earth's continents relative to each other, is a measurable phenomenon and has occurred throughout Earth's history. Movements of up to 2.1 cm a year have been recorded between continents, since 1975. The movements of the Earth's seven major crustal plates are driven by a geophysical process known as plate tectonics. Some continents are drifting apart, while others are moving together. Masses of continents and the isolated continents are often called together as 'supercontinents'. One supercontinent, *Pangaea*, was made up of the southern continents, since 200 million years ago.

Continental drift is a slowly paced but significant process that has shaped the Earth's surface. It is driven by the forces of plate tectonics, which are caused by the uneven heating of the Earth's mantle.

Investigation 4.1 Continental drift

- Cut out the southern continents on page 167, as close to the coastline marks as possible.
- Arrange the continents on the outline of Gondwana on page 168. Take into account the following:
 - The location of ancient rivers and periods of mountain building during different geological ages.
 - The direction of ancient sea level movements.
 - The geographical orientation of old rocks (the way that magnetic crystals are fixed in ancient rock gives an indication of the direction of the magnetic pole of the time the rock was formed).
 - The distribution of fossils of ancient organisms such as *Lystrosaurus* and *Glossolepis*.

Collaboration Icon: A group symbol indicates where students can work together. Group work provides opportunities for student collaboration and peer-to-peer support to explore phenomena. Working in groups, students can experience the benefits of collaboration in the scientific process of discovery. By speaking and listening to each other, communication skills and scientific vocabulary are extended.

45 The Earth's Crust

Key Question: What are the different properties of continental and oceanic crust?

The Earth's crust is thin compared to the bulk of the Earth, averaging just 35-70 km thick below the continents, and about 10 km thick below the oceans. The crust can be divided into **continental crust** and **oceanic crust**.

Continental crust is made of igneous, sedimentary and metamorphic rocks. It is thicker, older and less dense than oceanic crust. Oceanic crust is made of igneous rocks. It is thinner, younger and more dense than continental crust.

Water precipitation from the atmosphere and the oceans, which flows down to the ocean, ending the hydrological cycle in the process.

Continental crust makes up more than 60% of the Earth's surface, and is composed of relatively heavy basaltic rock covered by a thin layer of sediment. The oceanic crust is relatively young even in the oldest parts of the ocean floor, and is less than 200 million years old.

Resource Hub: the Resource Hub content is designed to support learners of all abilities and learning styles engage with the content of *Earth and Space Sciences for NGSS* (CG18). Use the 3D models, videos, games, and animations to help striving learners with their understanding of content. Tags identify material suitable for gifted and talented students and material for teachers.

Appendix: English/Spanish Glossary

Each glossary term is first provided in English, then followed by the Spanish translation directly beneath (in a box).

abrupto (steep): The fraction of the mountain described by a given horizontal distance is known as the slope. The slope of a mountain is described by its angle of inclination. The angle of inclination is the angle between the horizontal and the line of the mountain's slope.

abrupto (steep): La fracción de la montaña descrita por un determinado ángulo de inclinación se conoce como la pendiente. El ángulo de inclinación es el ángulo entre la horizontal y la línea de la pendiente de la montaña.

aceleración: The acceleration of an object is the rate of change of its velocity. Acceleration is a vector quantity and is measured in m/s².

aceleración: La aceleración de un objeto es la tasa de cambio de su velocidad. La aceleración es una cantidad vectorial y se mide en m/s².

adhesión: The tendency of certain particles to bond together is known as adhesion. Adhesion is a force that acts between particles of different materials.

adhesión: La tendencia de ciertas partículas a unirse entre sí se conoce como adhesión. La adhesión es una fuerza que actúa entre partículas de diferentes materiales.

afecto: A measure of how much light is reflected from a surface is known as albedo. Albedo is a dimensionless quantity ranging from 0 to 1.

afecto: Una medida de cuánto luz se refleja en un objeto se conoce como albedo. El albedo es una cantidad sin unidades y varía entre 0 y 1.

agrupación (grouping): An arrangement of objects or people into a group or organization.

agrupación (grouping): Un arreglo de objetos o personas en un grupo o una organización.

atmósfera: The atmosphere is the layer of gases that surrounds the Earth. It is composed of various gases, including nitrogen, oxygen, and carbon dioxide.

atmósfera: La atmósfera es la capa de gases que rodea a la Tierra. Está compuesta por varios gases, incluido el nitrógeno, el oxígeno y el dióxido de carbono.

carbon cycle: The process by which carbon is exchanged between the atmosphere, land, and oceans. It involves the exchange of carbon between the atmosphere, land, and oceans.

carbon cycle: El proceso por el cual el carbono es intercambiado entre la atmósfera, la tierra y los océanos. Incluye el intercambio de carbono entre la atmósfera, la tierra y los océanos.

challenge question: How did the reasonably mild Colorado River manage to create the vast Grand canyon, and is this process still happening?

Glossary: Glossaries have been provided in the back of the Student Edition to help improve scientific literacy. Encourage students to refer to the glossary whenever they are unsure about the meaning of a key term. Key terms are identified by **bold black text**. The glossary is provided in both English and Spanish (CG15).

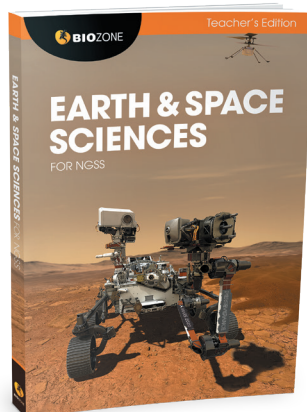
Challenge question: How did the reasonably mild Colorado River manage to create the vast Grand canyon, and is this process still happening?

The Teacher Toolkit

BIOZONE's **Teacher Toolkit** is a suite of resources specifically developed to help you plan and deliver an engaging NGSS program. Additional assessment tools are provided, allowing teachers to easily assess student understanding. A brief description of the tools is provided below and in the following pages.

BIOZONE WORLD

- BIOZONE WORLD, our digital science platform, brings our digital worktexts and rich collection of digital resources together in a single location for easy use. Click on an activity to access the additional resources provided. These include: presentation slides, interactive 3D models, and curated videos and weblinks. Educators can easily plan lessons, assign work, and grade student responses using BIOZONE WORLD.
- Students' access to BIOZONE WORLD allows them to use tools to markup, highlight, and bookmark content. They can also answer questions online, and submit their work for review or grading. Students have access to the curated collection of digital resources (presentation slides, 3D models, and curated videos and weblinks).
- Teacher access to BIOZONE WORLD includes the features available to students plus teacher-only additional features, including:
 - Managing class student enrolments.
 - The ability to view, grade, and give feedback on submitted student work.
 - Forced hand-in feature.
 - Ability to display the content on a shared screen (e.g. interactive whiteboard) to introduce or review an activity, or highlight areas of particular importance, e.g. an important step in a practical investigation.
 - Model answers in place. Show/hide buttons toggle answers on and off; ideal for sharing data or answers with students. Students do not have access to model answers on BIOZONE WORLD.
- The translation tool within BIOZONE WORLD translates the content into over 150 languages.
- Find out more: biozone.com/us/biozone-world



TEACHER'S EDITION - PRINT

The *Earth and Space Sciences for NGSS* Teacher's Edition is the teacher's companion to the student worktext. Use this resource to gain insight into the features of *Earth and Space Sciences for NGSS* and how to use them in your planning, delivery, and assessment.

The **Classroom Guide** provides a guide to best use of BIOZONE's resources. It includes teacher notes (CG20), covers strategies for teaching in a differentiated classroom, information about the assessment tools, the benefits of collaborative learning, and supporting delivery of the three dimensions and Common Core State Standards. An overview of the Teacher Toolkit is also provided. The Teacher's Edition follows the same flow as the Student Edition, and all suggested model answers are in place. Additional teacher coding identifies G&T extension material, Common Core State Standards, and Performance Expectations. Long answers, requiring more space than is allowed on the page, are included at the back of the Teacher's Edition.

RESOURCE HUB

The BIOZONE **Resource Hub** is a **free resource**, available to both students and teachers. It offers a curated collection of Open Educational Resources (OER) specifically chosen to support the content of the worktext. Resources include videos, animations, games, 3D models, spreadsheets, and source material.

Content on the BIOZONE **Resource Hub** can be accessed by both print and digital users. **Print users** can access the material using the QR code in the worktext or bookmark the link provided (below right). For **BIOZONE WORLD users**, these same resources are ingested into the platform and automatically appear with the selected activity.

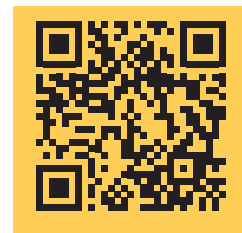
The BIOZONE **Resource Hub** is an effective tool to engage students of all abilities within a differentiated classroom. Most resources can be used by students of all abilities. 3D models, videos, games, and simulations are great tools for engaging students in a topic, or supporting striving students in their learning journey.

Some components have been tagged as extension material and can be used to extend more capable or gifted students. These types of resources may require more reading or synthesis of information. Our spreadsheet models can be used as is, or you can have students graph the information themselves. You may wish to challenge more capable students to build their own models, or manipulate the ones provided to observe the outcomes.

Some material is tagged as a teacher resource. Teacher resources often provide background or additional material to an activity. Capable students, or students with a particular interest in the topic can be assigned this material at your discretion.



BIOZONE **Resource Hub** content is easily shared with your students through your LMS. You can provide notes and guidance about what you want students to do with the resource. The BIOZONE **Resource Hub** can be accessed directly via the QR code below:

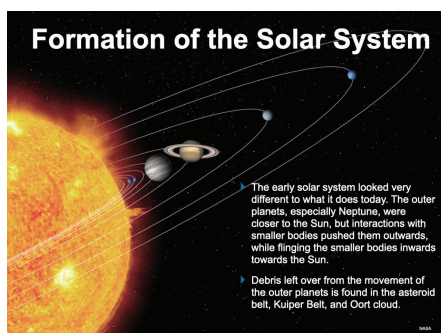


Or bookmark the following link:

www.BIOZONEhub.com

Then enter the code in the text field

NES2-6931

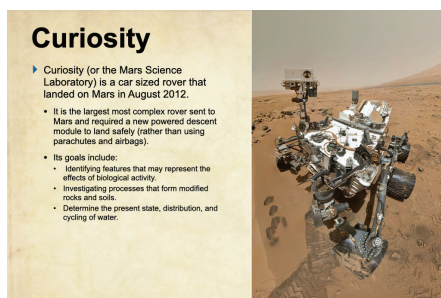


PRESENTATION SLIDES

Presentation Slides are a very popular way for teachers to deliver a lesson in a presentation style format. Presentation Slides are a useful delivery tool in both face to face or remote teaching.

The Presentation Slides are a sizeable collection of slides specifically designed to support and enhance the content of the worktext. A set of slides is available for each chapter of *Earth and Space Sciences for NGSS*. In some instances, the slide sets contain extra material or examples not contained within the worktext, and are excellent for providing new scenarios for students to work on.

The Presentation Slides are fully ingested into BIOZONE WORLD and automatically appear with the selected activity.



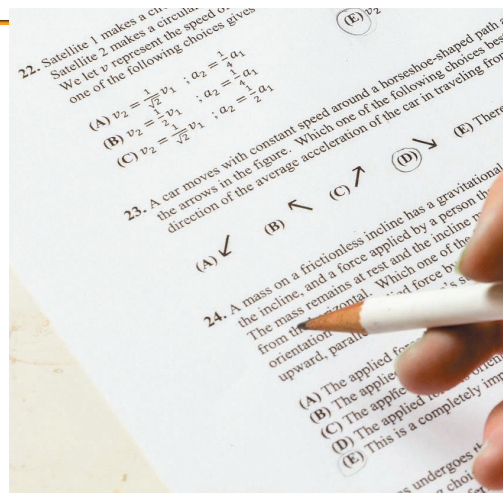
TEST BANKS

Assessments within *Earth and Space Sciences for NGSS* have been designed on the most part to be fully three dimensional, to assess the Performance Expectations specified in the NGSS framework. However, we understand that a variety of assessment tools are useful within a differentiated classroom. A range of opportunities to test student understanding enables teachers to identify gaps and misconceptions and to be able to address these before a formal assessment moment.

BIOZONE's Test Banks have been specifically curated to test student understanding of the DCI content of the material. The test bank questions are not three dimensional; however, they complement the three dimensional assessments with the worktext.

A range of question types is available (CG16). The Test Banks are provided in QTI and RTF formats, providing teachers with flexibility in how they deliver and use the questions. Questions are fully editable, teachers can pick and mix questions from the entire suite of questions and edit the wording to customize the tests for individual classrooms.

- ▶ Test banks can be ingested into test generator software such as Illuminate and ExamView.
- ▶ Encourage student participation by converting the questions into a Kahoot or Quizlet format. Students can work individually, in pairs, or small groups to learn and share ideas in a fun environment. Multiple choice and true/false questions are easily converted to Kahoot quizzes. Review the answers with the class for a quick refresher of key ideas and correct any commonly occurring misconceptions.
- ▶ Questions can be easily ingested into LMS in a number of formats, e.g. Google forms, or a Google or word document.
- ▶ Test Banks can be used to gauge student understanding at the end of activities, a set of related activities, or at the end of a chapter.



60 Evidence for Earth's Structure

Questions

1. Describe two differences between P-waves and S-waves.
2. What causes the P-wave shadow between 103° and 142° from an earthquake's focus?
3. How do we know that the mantle is a solid that behaves like a viscous fluid rather than liquid?

4. 1

5. 1

6. 1

7. 1

83 Modeling Erosion

Questions

1. (a) Before you do the modeling, predict the following: the effect of flow velocity on erosion, where the most erosion will occur in a meandering stream, the effect of layering materials of different hardness. Record your predictions on the sheet with the results of your modeling (see b). Were your predictions supported?
(b) On a separate sheet, draw the river flow through the different river models you have made. Include notes on how the model changes over time and how features such as large rocks and vegetation affect the river's shape.
2. Study the notes on this page and your river models and use them to explain the pattern of deposition and erosion in a meandering river.

QUESTION LIBRARY

The Question Library provides all of the questions from the Student Edition worktext in a format that can be ingested into a range of LMS or other digital delivery tools.

Questions within the worktext are generally scaffolded: easier questions are asked first, to build student confidence, and the questions may become more complex or difficult as students progress through an activity.

The Question Library content is **fully editable**, providing teachers with flexibility and control in assigning questions within a differentiated classroom. The questions can be customized to match a student's learning ability or reading level.

Question Library questions are provided in QTI and RTF formats.

Teacher's Notes

Extended teacher's notes are found at the front of each chapter in the Teacher's Edition of *Earth and Space Sciences for NGSS*. These notes provide context for the material and additional detail for the learning points, matched point for point. Where appropriate, opportunities to incorporate group work, practical activities, or design challenges are explained. Suggestions for differentiated instruction are also provided, including ways to support striving learners, e.g. through peer-to-peer support. Most activities are supported by material on **BIOZONE's Resource Hub**. The Resource Hub provides access to a large collection of free resources to supplement your teaching. It is identified with a hub icon in the margin of both the Student Edition and Teacher's Edition. Where the resource is integral to the delivery of the activity, e.g. online data sets, computer simulations, or spreadsheets, we have indicated this in the teacher's notes.

The **anchoring phenomenon** provides a context for the chapter. We have included some questions you may wish to ask your students to engage them in the topic, and ideas for student engagement.


The **guiding questions and numbering of learning aims** is the same as in each chapter introduction of the Student Edition and Teacher's Edition (learning aims are matched point for point).

Opportunities for **group work** are identified. They provide opportunities for collaboration and can be used to develop ELA/ELD skills such as speaking and listening, developing language, and research and presentation skills.

Chapter number and name

Teacher's
Notes

8. Weather, Climate, and Biogeography



Anchoring phenomenon

The anchoring phenomenon of It's getting Hot in Here introduces increasing global temperature, which students may have encountered through social media, their peer groups, or previous educational opportunities, allowing them to consider the science principles involved, and the link between anthropomorphic carbon dioxide emissions and the greenhouse effect, leading to climate change.

How does energy flow in and out of Earth change the climate?

1. Teachers may wish to begin this activity by explaining the difference between short wave (light) solar radiation and longer wave (infrared / heat) radiation, and make sure the students understand the terms reflect, absorb, and emit. Some students may need support with the mathematical calculations required.
2. Students may have encountered the concept of seasons in previous grades. Teachers could start the activity by forming small groups to discuss several statements handed out on cards (they can be both correct and incorrect) about how seasons occur, to identify any misconceptions. The groups then reconvene for a whole class discussion. This activity can also be supported using media from the **Resource Hub**. Students then move onto an investigation, where a clamp stand, or even a student holding the torch, can be used if unable to obtain wooden stands. Students could extend the investigation by placing a thermometer on the card of each set up, and manipulating the time it is held, or distance of light from the paper, to test the hypothesis that sloped light rays have less energy (temperature) per area.
3. This activity touches on the phenomena of auroras. This area can be extended by using media from the **Resource Hub**. Students may wish to research at a deeper level to explore why the temperature increases of ice more in the thermosphere, and the composition of gases in each atmosphere layer.

Possible **extension** ideas or activities are identified.

the terms 'enter cells, healthy cells, or the Coriolis effect, just the general idea that air circulates in 'cells', but some extension students may wish to research at a deeper level.

How has life and Earth's systems coevolved over time?

5. There is a lot of information to unpack in the time line. Teachers may wish to write each event on cards, and in smaller groups, students can place the cards on a drawn time line to consider how they may be ordered. The key aspect is the interlinkage between the events occurring in living organisms and the parallel events occurring in the environment, and that one could not occur without the other.
6. Students need to understand that there are both short and long term cycles of atmospheric changes. A distinction between natural cycles of carbon dioxide, and anthropomorphic change (human induced) is introduced, but teachers may want to expand on this with a small group activity where students put forward suggestions about the different sources or processes that add the gas to the atmosphere.

Practical investigations or design challenges are identified. These can be used to deepen a student's understanding of a concept or idea. Practical activities are essential for developing competency over a range of science skills and help students to become comfortable working in a STEM environment.

significantly the largest reservoir, students could reconstruct the model to clearly show the comparative stores in another

Your attention is drawn to materials on the **Resource Hub** when the resource is integral to the delivery of the activity or provides an alternative delivery option.

result of enhanced greenhouse effect due to increasing amounts of carbon dioxide being added to the atmosphere. They can draw back on this process when they reach that chapter. Students should now have all the information they require to provide a coherent answer in the review activity.

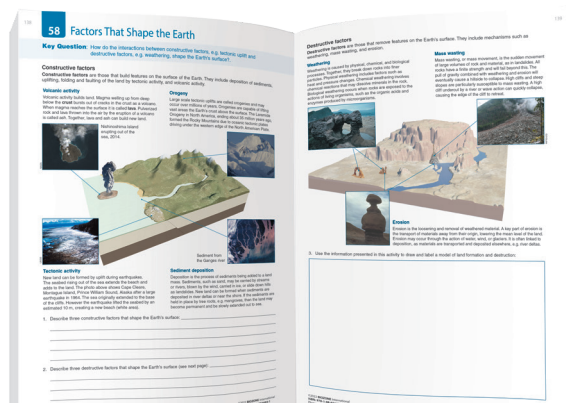
Important **learning aims** are specified.

BIOZONE's Pedagogy

A worktext approach

BIOZONE's delivery method is a departure from a traditional textbook. We combine the very best features of a textbook with the utility of a workbook, producing a worktext resource. Importantly, the worktext is owned by the student: it is their own resource to utilize. Whether they are using the print or digital version, students customize their worktext with notes and annotations, checking off their progress in the contents and chapter introductions, and input their answers on the pages as they work through the activities.

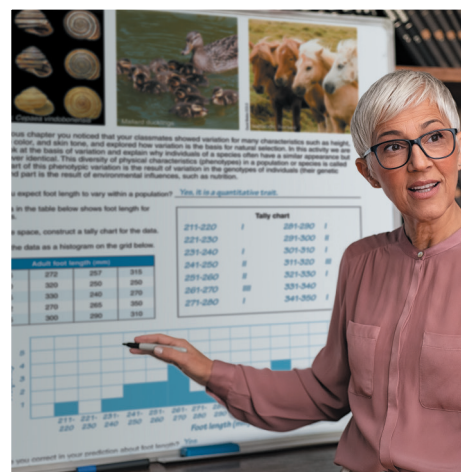
Using a highly graphical approach and short blocks of text, we deliver textbook quality information in an accessible and engaging way, ensuring students are not overwhelmed by large amounts of information. As students interact with the stimulus material and work through activities, they are encouraged to input their answers directly onto the page. This simple act reinforces the learning moment and forms a record of work as they progress through the material. Students find revision a breeze because the stimulus material, questions, and their answers are in one place.



We have included a wide range of activity types in this title. These include practical activities (experimental investigations, modelling, and simulations), research activities, and assessment tasks. The variety of activity types provides flexibility in the way teachers can assign them. For example, work can be assigned to be carried out as homework, completed in class, or set for revision. Teachers can assign students to work on activities individually or set work as a group. The activity based approach simplifies assigning work, and teachers can utilize this approach to set work for substitute teachers in their absence

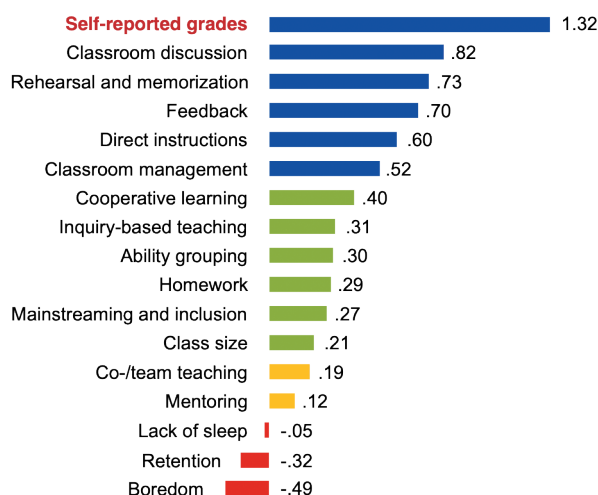
Not all answers need to be graded!

Within the activities, there are plenty of opportunities for students to record answers to the questions. This approach reinforces the learning moment, provides space for students to record their work, and acts as a revision tool when students are preparing for assessments. This approach does not mean that teachers are expected to review or grade all student responses. We suggest that only key activities or questions are graded. This might be assessment tasks at the end of each chapter or at the conclusion of a unit. You may also choose to grade activities with content that students have traditionally found challenging, or where there is often a misunderstanding of the topic. Teachers can also choose to share answers with students. Sharing the model answers allows students to self report grades: an exercise known to be a powerful pedagogical learning tool (Hattie(2009)). Having access to model answers also allows students to refine their initial response if needed. This provides a powerful second learning moment to consolidate and extend understanding. Teachers can utilize the show/hide model answer feature in the digital platform to share answers.



Features to accelerate student learning

Student learning can be influenced by many factors. A synthesis of more than 1,400 meta studies by Hattie (2009) involving over 80,000 individual studies and 300 million students has revealed some of the major influences to student learning. Some factors negatively influence student learning (red, right) while others have positive effects (yellow, green, and blue, right). BIOZONE's approach incorporates many of the factors shown to positively influence student learning, these are underlined in red on the diagram (right). By utilizing Earth and Space Sciences for NGSS, these factors are organically incorporated into content delivery and enhance the teacher and learner experience.



Hattie, J. (2009). Visible Learning. Routledge

Identifying CCCs and SEPs by Number

CROSCUTTING CONCEPTS (CCCs)

CCCs are unifying ideas that apply across all disciplines of science. A CCC connects topics where the same unifying concept underpins the content. A statement for each numbered CCC is provided below. CCCs are identified by number in the tables following and in the embedded coding in the chapter introductions (Teacher's Edition). Statements are paraphrased.

1: Patterns

In grades 9-12, students observe patterns in systems at different scales and cite patterns as evidence for causality in supporting explanations of phenomena. They recognize that classifications or explanations at one scale may need revision using a different scale, thus requiring improved investigations and experiments. They identify and analyze patterns, and use analysis to re engineer and improve designed systems.

2: Cause and effect

In grades 9-12, students understand that empirical evidence is required to differentiate between cause and correlations and to make claims about cause and effect. They suggest cause and effect relationships to explain and predict behaviors in natural and designed systems. They also propose causal relationships by examining what is known about smaller-scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.

3: Scale, proportion, and quantity

In grades 9-12, students understand that the significance of a phenomenon depends on the scale, proportion, and quantity at which it occurs. They recognize that patterns observable at one scale may not be observable or exist at other scales and that some systems can only be studied indirectly. Students use orders of magnitude to understand how a model at one scale relates to a model at another scale. They use algebraic thinking to examine scientific data and predict the effect of a change in one variable on another.

4: Systems and system models

In grades 9-12, students investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They use models to simulate the flow of energy, matter, and interactions within and between systems at different scales. They also use models and simulations to predict the behavior of a system and recognize why these predictions have limited precision and reliability. They also design systems to do specific tasks.

5: Energy and matter

In grades 9-12, students learn that the total amount of energy and matter in closed systems is conserved. They can describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed, only transferred and transformed. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

6: Structure and function

In grades 9-12, students investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal a system's function and/or solve a problem. They infer the functions and properties of natural and designed objects and systems from their structure, the way their components are shaped and used, and the molecular substructures of their various materials.

7: Stability and change

In grades 9-12, students understand that much of science deals with constructing explanations of how things change and how they remain stable. They quantify and model changes in systems over short or very periods of time. They see that some changes are irreversible and that negative feedback can stabilize a system, while positive feedback can destabilize it. They recognize that systems can be designed for more or less stability.

SCIENCE & ENGINEERING PRACTICES (SEPs)

SEPs for NGSS are overlapping and interconnected practices that students should know and understand. A statement for each numbered SEP is provided below. SEPs are identified by number in the tables following and in the embedded coding in the chapter introductions (Teacher's Edition).

1: Asking questions and defining problems

"Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations."

2: Developing and using models

"Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s)."

3: Planning and carrying out investigations

"Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual mathematical, physical, and empirical models".

4: Analyzing and interpreting data

"Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data."

5: Using mathematics and computational thinking

"Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and non-linear functions, including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simulations are created and used based on mathematical models of basic assumptions."

6: Constructing explanations and designing solutions

"Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories".

7: Engaging in argument from evidence

"Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science."

8: Obtaining, evaluating, and communicating information

"Obtaining, evaluating, and communicating information in 9-12 builds on K-8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs."

Summary of BIOZONE's 3D Approach By Chapter

Science and Engineering Practices (SEPs), Crosscutting Concepts (CCCs), Disciplinary Core Ideas (DCIs), and Performance Expectations (PEs) for each chapter of *Earth and Space Sciences for NGSS* are listed in the tables following. An introductory "Science Practices" chapter is also included. Performance Expectations are met within the chapter and/or the *Summing Up* activity.

1: SCIENCE PRACTICES

Activity	SEP	DCI	CCC	PE
1	1,2	NA	4	NA
2	2	NA	4	NA
3	5	NA		NA
4	2, 5	NA	5	NA
5	1	NA		NA
6	5	NA		NA
7	4	NA	2	NA
8	4, 6, 7	NA		NA
9	4	NA		NA
10	3, 4, 6, 8	NA		NA



2: THE UNIVERSE AND ITS STARS

Activity	SEP	DCI	CCC	PE
12	2	ESS1.A		
13	2	ESS1.A PS4.B	3	
14		ESS1.A	3	
15	2, 6	ESS1.A	5	
16	2, 7	ESS1.A	5, 7	
17	2, 3, 5	ESS1.A	5, 7	
18	2, 3, 5	ESS1.A PS3.D	3, 5	
19 - 21	2	ESS1.A	3, 5	
22	2	ESS1.A	3, 5	
23	2	ESS1.A	5	
24	2, 8	ESS1.A	3, 5	HS-ESS1-3
26	2, 6	ESS1.A	3, 5	HS-ESS1-1, HS-ESS1-2



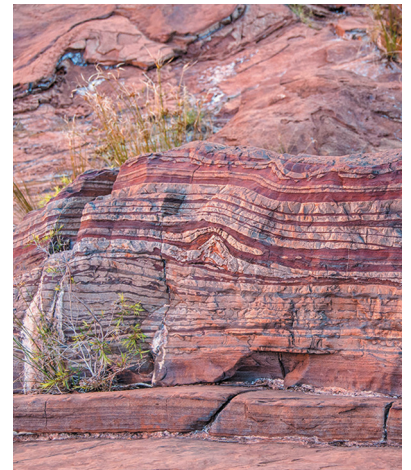
3: EARTH AND THE SOLAR SYSTEM

Activity	SEP	DCI	CCC	PE
29			7	
30	2, 5	ESS1.B		
31	2, 3, 5	ESS1.B	3	
32	2, 5	ESS1.B	3	HS-ESS1-4
33	2, 3, 5	ESS1.B	3	
34 - 35	2, 5	ESS1.B	3	HS-ESS1-4
36	2, 5	ESS1.B	3	
37	2, 3, 5	ESS1.B	3	
38	2, 5	ESS1.B	2, 7	
39	2	ESS1.B	2, 7	
40	2			
42	2	ESS1.B	3	HS-ESS1-4



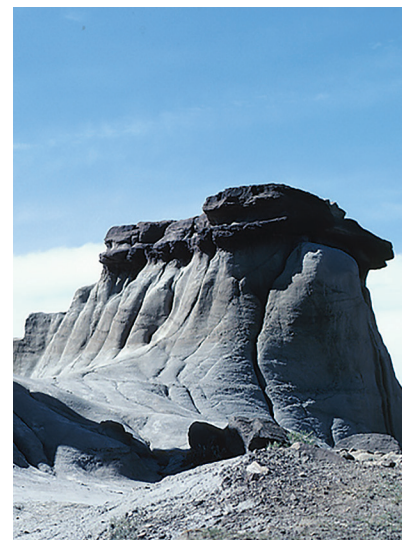
4: THE HISTORY OF PLANET EARTH

Activity	SEP	DCI	CCC	PE
44		ESS1.C ESS2.B	1, 7	
45	6, 7	ESS1.C ESS2.B	1, 7	
46	2, 7	ESS1.C PS1.C	1, 7	
47	2, 3, 6, 7	ESS1.C PS1.C	1, 7	HS-ESS1-5, HS-ESS1-6
48	6, 7	ESS1.C	7	
49	6, 7	ESS1.C	1, 7	
50	6, 7	ESS1.C	1, 7	
53	6, 7	ESS1.C	1, 7	HS-ESS1-5



5: EARTH MATERIALS AND SYSTEMS

Activity	SEP	DCI	CCC	PE
55	2	ESS2.A	5	
56	2, 4	ESS2.A		
57	2	ESS2.A	5	
58	2	ESS2.A	2, 7	HS-ESS2-1
59	2	ESS2.A	2, 7	
60	2, 3, 4	ESS2.A	5, 7	HS-ESS2-2
61	2	ESS2.A	7	
62	2	ESS2.A	2, 7	
63	4	ESS2.A	2, 7	
64	2, 4	ESS2.A	2, 7	
65	4	ESS2.A	2, 7	
67	2	ESS2.A ESS2.D	2	HS-ESS2-4



6: PLATE TECTONICS

Activity	SEP	DCI	CCC	PE
69	2	ESS2.A ESS2.B	5	
70 - 71	2, 4	ESS2.A	5	
72	2	ESS2.B	5	
73	2, 3	ESS2.A	7	
74	2	ESS2.A ESS2.B	2	HS-ESS2-3
75	2	ESS2.A ESS2.B	2	HS-ESS2-3



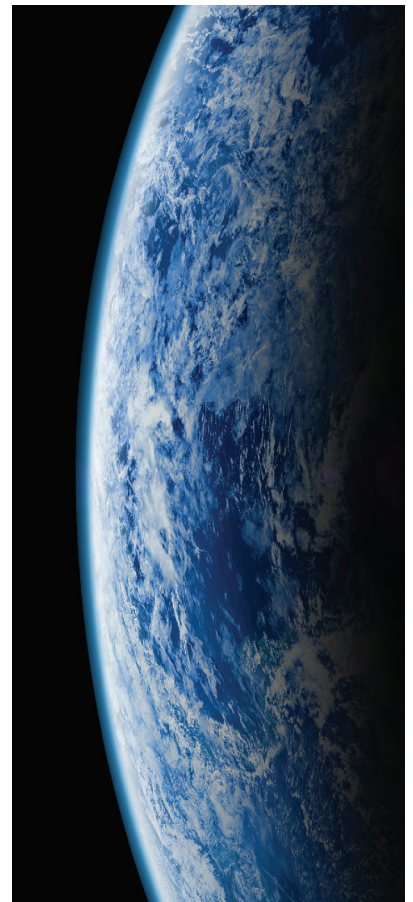
7: THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES

Activity	SEP	DCI	CCC	PE
77 - 78	2, 6	ESS2.C	6	
79	2, 3	ESS2.C	6	HS-ESS2-5
80	2, 4	ESS2.C	6	
81	2	ESS2.C	6	
82	1, 2, 3	ESS2.C	6	HS-ESS2-5
83	1, 2, 3	ESS2.C	6	HS-ESS2-5
84	4	ESS2.C	6	
85	2	ESS2.C	6	
86	2, 4	ESS2.C	6	



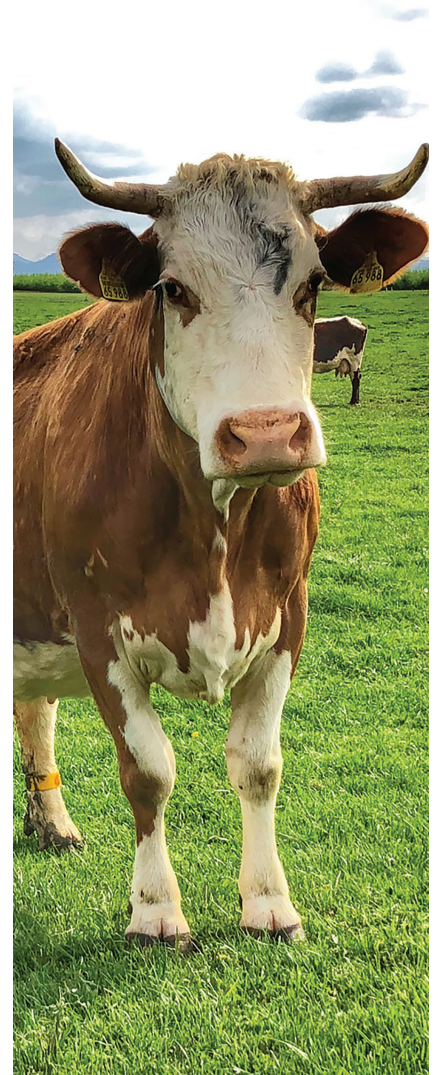
8: WEATHER, CLIMATE, AND BIOGEOLOGY

Activity	SEP	DCI	CCC	PE
88	2	ESS2.D	2	HS-ESS2-4
89	2, 3	ESS1.B ESS2.A ESS2.D	2	HS-ESS2-4
90	2	ESS2.A ESS2.D	2	
91	2	ESS1.B ESS2.A ESS2.D	2	HS-ESS2-4
92	2, 7	ESS2.D ESS2.E	7	HS-ESS2-7
93	2, 7	ESS2.D ESS2.E	7	HS-ESS2-7
94	2, 7	ESS2.D ESS2.E	7	HS-ESS2-7
95	2, 7	ESS2.D ESS2.E	7	HS-ESS2-7
96	7	ESS2.E	7	HS-ESS2-7
97	7	ESS2.E	7	
98	2	ESS2.D	5	HS-ESS2-6
99	2, 3	ESS2.D	5	HS-ESS2-6
100	2	ESS2.D	5	
101	2, 7	ESS2.A ESS2.D	2, 5, 7	
102	2, 7	ESS2.D ESS2E	5, 7	HS-ESS2-6, HS-ESS2-7



9: NATURAL RESOURCES

Activity	SEP	DCI	CCC	PE
103	6			
104	6	ESS3.A	2	
105	2, 6	ESS3.A	2	HS-ESS3-1
106	4, 6	ESS3.A		
107	2, 6	ESS3.A	2	
108	6, 7	ESS3.A ETS1.B	2	HS-ESS3-1, HS-ESS3-2
109	7	ESS3.A ETS1.B		HS-ESS3-2
110	2, 6	ESS3.C ETS1.B	2	HS-ESS3-2
111	2, 4, 7	ESS3.A ETS1.B		HS-ESS3-2
112	2, 7	ESS3.A ETS1.B		HS-ESS3-2
113	2, 7	ESS3.A ETS1.B	2	HS-ESS3-2
114	7	ESS3.A ETS1.B		HS-ESS3-2
115	2, 3, 4, 7	ESS3.A ETS1.B	2	
116	4, 7	ESS3.A ETS1.B	2	HS-ESS3-2
117	7	ESS3.A	2	
118	2, 4, 7	ESS3.A ETS1.B	2	
119	2, 7	ESS3.A ETS1.B		HS-ESS3-2
120	7	ESS3.A ETS1.B		
121	2, 6, 7	ESS3.A ETS1.B	2	HS-ESS3-1, HS-ESS3-2



10: NATURAL HAZARDS

Activity	SEP	DCI	CCC	PE
123 - 125	2, 6	ESS3.A ESS3.B	7	
126 - 127	6	ESS3.A ESS3.B	7	HS-ESS3-1
128	4, 6	ESS3.A ESS3.B	7	
129	2, 4, 6	ESS3.A ESS3.B	7	HS-ESS3-1
130	6	ESS3.A ESS3.B	7	HS-ESS3-1
131	4, 6	ESS3.A ESS3.B	7	HS-ESS3-1



11: HUMAN IMPACTS ON EARTH SYSTEMS

Activity	SEP	DCI	CCC	PE
133	5, 7	ESS3.C	7	HS-ESS3-3
134	4, 5	ESS3.C	7	
135	1	ESS3.C	7	
136	2, 4, 6	ESS3.C ETS1.B	7	HS-ESS3-4
137	2, 6	ESS3.C ETS1.B	7	HS-ESS3-4
138	2, 6	ESS3.C ETS1.B	7	HS-ESS3-4
139	1, 2	ESS3.C	7	
140	2, 6	ESS3.C ETS1.B	7	HS-ESS3-4
141	4, 5	ESS3.C	7	
142	6	ESS3.C	7	
143	2	ESS3.C ETS1.B	7	
144	2, 6	ESS3.C ETS1.B	7	HS-ESS3-4
146	2, 5	ESS3.C	7	HS-ESS3-3



12: GLOBAL CLIMATE CHANGE

Activity	SEP	DCI	CCC	PE
148	1	ESS2.D ESS3.D	4, 7	
149	2	ESS2.D ESS3.D	4, 7	
150	2, 4	ESS2.D ESS3.D	4, 7	HS-ESS3-5
151	2, 3, 4, 5	ESS2.D ESS3.D	4, 7	HS-ESS3-6
152	2, 4	ESS2.D	7	
153	4	ESS2.D ESS3.D	7	
154	2, 4, 6	ESS3.C ETS1.B	7	
156	4, 5	ESS2.D ESS3.D	4, 7	HS-ESS3-5, HS-ESS3-6



Identifying Common Core State Standards Connections

The activities in *Earth and Space Sciences for NGSS* provide many opportunities to address the **Common Core State Standards (CCSS)** for numeracy, and literacy, and English language development (ELD). The incorporation of these standards allows students to practice and develop these key skills while exploring science.

Activities incorporating representative citations of the CCSS Math Connections, ELA/ literacy, and ELD Connections specified in the NGSS Science Framework are identified by codes (right) in the **Teacher's Edition** and **Teacher's Digital Edition**. Note that this coding is a tool for the teacher and is not present in the Student Edition.

- ▶ A red calculator indicates a math connection.
- ▶ A blue pencil indicates an ELA/literacy or ELD connection.

A list of the specific Math Connections, ELA/ Literacy Connections and ELD Standards addressed in the NGSS framework can be found in the tables at the bottom of this page and on the following pages.

BIOZONE recognizes that ELD Standards are not to be used in isolation, and are intended to be implemented in conjunction with ELA/Literacy and other academic content standards. This is why you will see them appearing along with the relevant ELA/literacy connection in the following tables.

260

126

Case Study: The Western United States Drought


Key Question: How is the likelihood of increasing frequency and severity of droughts influencing decision-making and behavior in human populations?

The western U.S. 20 year drought

- ▶ The "mega drought" gripping the western United States in 2022 was the longest recorded dry spell in the area going back at least 1200 years. Data from annual tree rings, thinner in dry seasons, was able to verify the historical drought claims.
- ▶ The two largest lakes used as reservoirs on the Colorado River system, Lake Mead (right) and Lake Powell, reached their lowest recorded water level in recorded history at around 30% capacity.

What caused this?

- ▶ The dead loss of wildlife



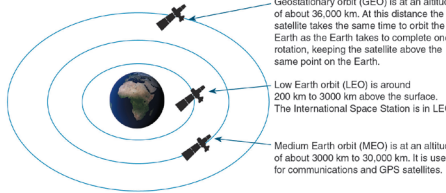
35
Satellites
91

Key Question: How do satellites orbit? Can we apply Newton's and Kepler's laws to them?

ESS1-4 There are hundreds of satellites orbiting the Earth. The majority are used in communications (e.g. carrying television signals) but others are used in monitoring weather or surveying the Earth's surface. Satellites orbit the Earth at different altitudes and at different inclinations, some orbit around the Earth's equator, others have a polar orbit.

Orbiting the Earth

There are three basic orbital heights in which satellites are placed:



Geostationary orbit (GEO) is at an altitude of about 36,000 km. At this distance the satellite takes the same time to orbit the Earth as the Earth takes to complete one rotation, keeping the satellite above the same point on the Earth.

Low Earth orbit (LEO) is around 200 km to 3000 km above the surface. The International Space Station is in LEO.

Medium Earth orbit (MEO) is at an altitude of about 3000 km to 30,000 km. It is used for communications and GPS satellites.

Orbital speed

▶ The closer a satellite is to the Earth, the faster it has to move in order to stay in orbit. Satellites that orbit too close to the Earth encounter drag from the Earth's atmosphere and slow down, falling to a lower orbit. Occasionally these need to be manoeuvred to maintain their altitude. We can use **Kepler's laws** to estimate the speed and orbital period of a satellite.

Calculating orbital speed and period

The international space station (ISS) orbits at about 400 km above the Earth. How long does it take to complete one orbit and at what speed is it moving?

- ▶ First we must add the Earth's radius to the altitude of the ISS to determine the distance of the ISS from the center of the Earth: $6,371 \times 10^3 \text{ m} + 4 \times 10^5 \text{ m} = 6,771 \times 10^3 \text{ m}$. The mass of the Earth is $5.972 \times 10^{24} \text{ kg}$. Applying Kepler's third law we find that $T^2 = 30,752,275 \text{ s} = 5,545 \text{ s} = 92 \text{ minutes}$, or about 1.5 hours.
- ▶ The ISS orbit is almost circular, so calculating the circumference of a circle the size of its orbit using $c = 2\pi r = 42,543,448 \text{ m}$. Dividing distance by time = $42,543,448 \text{ m} / 5545 \text{ seconds} = 7672 \text{ m/s}$

1. Explain why a geostationary satellite is useful for carrying a continuous television signal from one side of the planet to the other.

2. (a) The Hubble Space Telescope orbits 559 kilometers above the surface of the Earth. Calculate the time (in hours) it takes to orbit the Earth:

(b) Calculate the HST's orbital speed:

1: SCIENCE PRACTICES

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
3	Mathematics and Computation	MP2, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3	
4	Useful Concepts	MP4, HSN.Q.A.1, HSA-CED.A.4	
6-8	Tables, Graphs, Interpreting Data	MP4, HSN.Q.A.1	
9	Descriptive Statistics	MP4, HSN.Q.A.1, HSS.ID.A.1	
10	Planning an Investigation	MP4, HSN.Q.A.1, HSS.ID.A.1	SL.11-12.1.B, RST.11-12.3

2: THE UNIVERSE AND ITS STARS

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
13	Studying Stars	MP2, MP4, HSA-CED.A.4	RST.11-12.1, WHST.11-12.9
14	The Known Universe	MP2	SL.11-12.1, RST.11-12.2
17	Modelling Expansion of Universe	MP4, HSA-CED.A.4	SL.11-12.1.B, RST.11-12.3
18	The Sun	MP2, MP4, HSN.Q.A.1, HSA-CED.A.4,	SL.11-12.1.B, RST.11-12.3, WHST.11-12.9
24	Nucleosynthesis		SL.11-12.4, WHST.11-12.7
26	Summing Up	MP4	RST.11-12.2, RST.11-12.3, WHST.11-12.1

3: EARTH AND THE SOLAR SYSTEM

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
28	Exploring the Solar System		RST.11-12.2
29	Formation of the Solar System	MP4, HSN.Q.A.1, HSA-CED.A.4	
30	The Solar System	MP2, MP4, HSN.Q.A.1, HSS.ID.A.1	RST.11-12.4
31	The Motion of Celestial Objects	MP4	SL.11-12.1.B, RST.11-12.3
32	Kepler's Laws and Orbits	MP.2, MP.4, HSA-CED.A.4, HSN-Q.A.1,	RST.11-12.4
33	Gravity and Newton's Laws	MP4, HSA-SSE.A.1	SL.11-12.1.B, RST.11-12.3
34	Newton's Laws to Kepler's Laws	HSA.SSE.A.1.A, HSA-CED.A.4	RST.11-12.7
35	Satellites	HSA.SSE.A.1.A, HSA-CED.A.4	
36	The Orbit of Halley's Comet	MP.2, MP.4, HSA-CED.A.4, HSN-Q.A.1,	
37	Moving Planets	MP4, HSA-CED.A.4, HSA.SSE.A.1.A	SL.11-12.1.B, RST.11-12.3

4: THE HISTORY OF PLANET EARTH

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
46	Dating the Earth		RST.11-12.2, WHST.11-12.1
47	Evidence for the Age of the Earth	MP2, MP4, HSS-ID.B.6.C, HSN.Q.A.1,	SL.11-12.1.B, RST.11-12.3, WHST.11-12.1
50	The Earth's History		RST.11-12.4
52	Review Your Understanding	HSA-CED.A.4	
53	Summing Up	MP4	RST.11-12.1, RST.11-12.4, WHST.11-12.1

5: EARTH MATERIALS AND SYSTEMS

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
56	Evidence for Earth's Structure	MP4, HSN.Q.A.1, HSS.ID.A.1	
58	Factors That Shape the Earth		RST.11-12.4, RST.11-12.5
60	Ice Sheet Melting	MP4, HSN.Q.A.1	SL.11-12.1.B, RST.11-12.3
64	Short-Term Changes to the Earth	MP4	RST.11-12.2, WHST.11-12.9
67	Summing Up	MP4	

6: PLATE TECTONICS

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
70	The Heat of the Earth	MP4, HSN.Q.A.1	RST.11-12.3
71	Plate Tectonics	MP2, HSS.ID.A.1, HSN.Q.A.1, HSN.Q.A.3	SL.11-12.1, RST.11-12.1
72	Plate Boundaries		RST.11-12.2
73	Modeling Continental Drift	MP4, HSN.Q.A.1,	SL.11-12.1.B, RST.11-12.3
74	Review Your Understanding		RST.11-12.1, RST.11-12.2, WHST.11-12.1, WHST.11-12.9
75	Summing Up	MP4, HSN.Q.A.1, HSS.ID.A.1	

7: THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
79	The Rock Cycle		SL.11-12.1.B, RST.11-12.3
80	Water's Role in Melting of Rocks	MP4, HSN.Q.A.1	
81	Weathering and Erosion		RST.11-12.2, RST.11-12.5,
82	Investigating Frost Wedging		SL.11-12.1.B, RST.11-12.3
83	Modeling Erosion		SL.11-12.1.B, RST.11-12.3
84	Moisture Content and Soil Erosion	MP4, HSN.Q.A.1	
85	Review Your Understanding		RST.11-12.2, RST.11-12.4
86	Summing Up	HSN.Q.A.1, MP4	

8: WEATHER, CLIMATE, AND BIOGEOLOGY

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
88	Energy From the Sun	MP2, HSN.Q.A.1, HSN.Q.A.3	RST.11-12.1, WHST.11-12.9
89	Seasons		SL.11-12.1.B, RST.11-12.3
98	Carbon Cycling		RST.11-12.2, RST.11-12.4
99	Modeling the Carbon Cycle	MP2, HSN.Q.A.1, HSN.Q.A.2	SL.11-12.1.B, RST.11-12.3, WHST.11-12.2, WHST.11-12.7
100	Atmospheric Changes		RST.11-12.1, WHST.11-12.9
101	Review Your Understanding		RST.11-12.2, WHST.11-12.9
102	Summing Up	MP4	RST.11-12.2

9: NATURAL RESOURCES

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
105-106	Resources; Energy, Technology		RST.11-12.1,
110	Environmental - Oil Extraction		SL.11-12.1, WHST.11-12.1
111-114	Oil, Gas, Coal, Agriculture		RST.11-12.2, WHST.11-12.1,
115	Soil Management	MP4, HSN.Q.A.2	SL.11-12.1.B, RST.11-12.3,
116	Soils, Agriculture, and Solutions		SL.11-12.1.B, WHST.11-12.1
119	Living with Limited Resources	MP4, HSN.Q.A.2, HSN.Q.A.3	RST.11-12.1, WHST.11-12.1
120	Review Your Understanding		WHST.11-12.1, WHST.11-12.7
121	Summing Up	MP4, HSN.Q.A.1, HSN.Q.A.2	RST.11-12.1, WHST.11-12.1,

10: NATURAL HAZARDS

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
125	Natural Hazards and Migration	MP4	RST.11-12.4, WHST.11-12.9
126	Case Study: The Western United States Drought		RST.11-12.7, WHST.11-12.9,
128	Wildfires	MP4	RST.11-12.1, RST.11-12.4
129	Flooding	MP4	RST.11-12.4, WHST.11-12.9
130	Review Your Understanding		RST.11-12.1, WHST.11-12.9
131	Summing Up	MP4	WHST.11-12.1, RST.11-12.2

11: HUMAN IMPACTS ON EARTH SYSTEMS

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
134	Human Sustainability	MP2, HSA.CED.A.1, HSN.Q.A.1, HSN.Q.A.2	RST.11-12.4
136	Fishing and Sustainability		RST.11-12.4, WHST.11-12.9
138	The Problem With Oil	MP4,	RST.11-12.2, WHST.11-12.9
140	Deforestation		RST.11-12.7, WHST.11-12.7
141	The Availability of Land	MP2, HSN.Q.A.1	
144	Evaluating Technological Solutions		RST.11-12.7, WHST.11-12.7
146	Summing Up	MP2, HSN.Q.A.1, HSN.Q.A.2	RST.11-12.4

12: GLOBAL CLIMATE CHANGE

Activity number	Activity	CCSS Math connection	CCSS ELA/Literacy & ELD connection
149	The History of Climate Modeling		SL.11-12.1, WHST.11-12.9
150	Models of Climate Change	MP4, HSN.Q.A.2	RST.11-12.4, RST.11-12.8,
151	Ocean Acidification	MP4, HSN.Q.A.2	SL.11-12.1.B, RST.11-12.3
154	Tech Solutions to Climate Change	MP2	RST.11-12.2, WHST.11-12.9,
155	Review Your Understanding		WHST.11-12.1, WHST.11-12.7
156	Summing Up	MP2, MP4, HSN.Q.A.1	RST.11-12.4