BPS Science Department Earth Science - Unit 6 - Plate Tectonics

Unit 6 - During this unit, students will evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. Students will develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. They will also develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. Students will plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. Students will also construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Driving Questions:

- How do we know the structure of Earth's interior?
- What evidence supports the claim that Earth's surface is made up of slabs of rock that are moving relative to each other?
- How does the flow of energy from Earth's interior affect its surface?
- How do plate motions affect people?

NYSSLS Standards:

Lesson 6.1: In this lesson, students argue from evidence about the structural and compositional layers of Earth (SEP Engaging in Argument from Evidence) and investigate how energy drives the cycling of matter (CCC Energy and Matter). They also learn how Earth's physical and chemical processes lead to a specific model of Earth (DCI ESS2.A Earth Materials and Systems) and how features change over time (CCC Stability and Change). Students learn that knowledge about Earth's interior is gained by experiments, field measurements, and observation of patterns (CCC Patterns) and how geologists use seismic waves to probe Earth's interior. (DCI PS4.A Wave Properties).

- **HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.**
  - **ESS2.A Earth Materials and Systems**
    - Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)
  - **ESS2.B Plate Tectonics and Large-Scale System Interactions**
    - (NYSED) Residual heat from Earth's formation and the radioactive decay of unstable isotopes in Earth's interior continually generate energy that is absorbed by Earth's mantle and crust, driving mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3)
  - **PS4.A Wave Properties**
    - Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (secondary to HS-ESS2-3)

Lesson 6.2: In this lesson, students use models to illustrate plate movements (DCI ESS2.B Plate Tectonics and Large-Scale System Interactions, SEP Developing and Using Models). They examine patterns in the overall structure of Earth's crust (CCC Patterns, CCC Structure and Function) and use information about mantle convection and plate movements to evaluate arguments about the causes and effects of continental drift, orogeny, volcanic activity, and the formation of terrains (DCI ESS2.B Plate Tectonics and Large-Scale System Interactions, CCC Cause and Effect, SEP Engaging in Argument from Evidence). Students also make observations about the ages of continental rocks and ocean-floor rocks (DCI ESS1.C The History of Planet Earth).

- **HS-ESS1-5 Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.**
  - **ESS1.C The History of Planet Earth**
    - Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5)
  - **ESS2.B Plate Tectonics and Large-Scale System Interactions**
    - Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE) (secondary to HS-ESS1-5)
- **HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.**
  - **ESS2.B Plate Tectonics and Large-Scale System Interactions**

        - The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3)

Lesson 6.3: In this lesson, students learn how plate tectonics explains the past and current movements at Earth's surface (DCI ESS2.B Plate Tectonics and Large-Scale System Interactions). They use evidence to identify patterns and examine a simple model of plate interactions and what that implies about the ages of continental and oceanic rocks (CCC Patterns, SEP Developing and Using Models, DCI ESS1.C The History of Planet Earth). Students use a model of mantle convection to explore how gravitational energy drives the cycling of matter (CCC Energy and Matter). Students examine the merits of explanations for plate motions (DCI ESS2.A Earth Materials and Systems, CCC Stability and Change).

- **HS-ESS1-5 Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.**
    - **ESS1.C The History of Planet Earth**
        - Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5)
- **HS-ESS2-1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.**
    - **ESS2.A Earth Materials and Systems**
        - Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1) (Note: This Disciplinary Core Idea is also addressed by HS-ESS2-2.)
    - **ESS2.B Plate Tectonics and Large-Scale System Interactions**
        - Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (HS-ESS2-1) (secondary to HS-ESS1-5)
- **ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.**
    - **ESS2.C: The Roles of Water in Earth's Surface Processes**
        - The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)

Lesson 6.4: In this lesson, students obtain, evaluate, and communicate information on plate tectonics, the formation of volcanoes, and the impact of volcanic activity on structures and functions on Earth's surface (CCC Structure and Function, DCI ESS2.B Plate Tectonics and Large-Scale System Interactions, SEP Obtaining, Evaluating, and Communicating Information).

- **HS-ESS2-1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.**
    - **ESS2.B Plate Tectonics and Large-Scale System Interactions**
        - Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (HS-ESS2-1) (secondary to HS-ESS1-5)
- **HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.**
    - **ESS3.B Natural Hazards**
        - Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1)

Science & Engineering Practices (link to SEP break-down):	Crosscutting Concepts (link to guiding questions for CCC):
• Developing and Using Models • Planning and Carrying Out Investigations • Engaging in Argument from Evidence • Obtaining, Evaluating, and Communicating Information	• Stability and Change • Cause and Effect • Energy and Matter • Patterns • Structure and Function

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Opportunities for Student Collaboration p. 307J (Complete Collaboration Strategy Guide):
● **Group Discussion** pp. 308, 321, 349, 380 ● **Group Activity** pp. 350, 356, 357, 362, 369, 376 ● **Claims, Evidence, and Reasoning** pp. 310, 343, 365, 370 ● **Which is False?** p. 309 ● ● **See, Run, Do** p. 312 ● **One Moves** p. 315 ● **Jigsaw** pp. 329, 345 ● **Partner Discussion** p. 326 ● **Think, Pair, Share** pp. 316, 319, 333, 340, 351, 363, 365, 366, 379 ●

Time Frame	Lesson Framework	Instructional Sequence	Resources- HMH Dimensions- Earth & Space Science Textbook	Resources- HMH Dimensions Digital Component	Additional Resources
1/3/23-1/23/23	**Unit 6: Plate Tectonics**		• **Unit Opener (Pre-Assessment): Predict-** How might Iceland provide evidence to help understand Earth's structure and composition and the processes that affect Earth's surface? (pp. 306-307)	• **Unit Project: Modeling Subduction-** Students will conduct Internet research to locate a specific area where ocean crust is being destroyed. They will gather data about the region and use their findings to develop a model of subduction. Students may choose to develop their model as a diagram, physical model, or simple computational model.	
	Lesson 6.1 Earth's Dynamic Interior In this lesson, you will use models to illustrate and explain Earth's structure and how energy cycles through it. **Vocabulary**: crust lithosphere seismic wave mantle mesosphere asthenosphere core outer core inner core	**Engage**	• **Phenomenon: Can You Explain It?-** How would you evaluate the accuracy of Halley's model? (p. 308)		**ESRT:** • Inferred Properties of Earth's Interior (p.10) Inferred Properties of Earth's Interior: Three Level Guide to Diagram Interpretation
		Explore/ Explain	• **Exploration 1-** Evidence of Structure and Composition (pp. 309-316) • **Exploration 2-** Earth's Dynamic Interior (pp. 317-319)	• **Lesson 1- Earth's Dynamic Interior PPT (editable)** • **Exploration 2: Hands-On Lab- Liquid and Solid Cores-** In this lab, students model and investigate solid and liquid cores.	
		Elaborate	• **Continue Your Exploration- Guided Research:** Seismic Tomography (p. 320)	• **Continue Your Exploration:** ○ Interior of Other Worlds ○ **Exploration 1: Hands- On Lab- Modeling Earthquake Waves-** In this lab, students use a spring toy to model earthquake waves and observe their behavior. ○ Observations of Earth	
		Evaluate	• **Lesson Self Check** (pp. 321- 323)- Can You Explain It- Revisit • **Make Your Own Study Guide** (p. 323) • **Checkpoint Questions** (pp. 322-323)	• **Can You Explain It?** Revisit • **Checkpoint Questions** • **Make Your Own Study Guide** • **Unit 6- Lesson 1 Quiz**	
	Lesson 6.2 Tectonic Plates In this lesson, you will analyze evidence for plate motion and the structure and composition of Earth's plates. **Vocabulary**: fault epicenter continental margin	**Engage**	• **Phenomenon: Can You Explain It?-** Could part of California "break off" into the ocean at the San Andreas fault? (p. 324)		**ESRT:** • Tectonics Plates (p. 5) What's Driving the Plates? - Modeling Earth's Interior Processes • Model 1 video • Model 2 video • Model 3 video
		Explore/ Explain	• **Exploration 1-** Motion of Earth's Surface (pp. 325-329) • **Exploration 2-** Earth's Lithospheric Plates (pp. 330-333)	• **Lesson 2-Tectonic Plates PPT (editable)** • **Exploration 1: Hands-On Lab- Where do Earthquakes Happen?-** In this lab, students collect data and identify patterns in the occurrence of earthquakes.	

	tectonic plate			• **Exploration 1:** **Hands-On Lab- Eggshell Tectonics-** In this lab, students model Earth's tectonic plates using a hard-boiled egg and investigate plate movements using the model.	• Mantle moving apart video
		Elaborate	• **Continue Your Exploration- Data Analysis:** Relative and Absolute Plate Motion (p. 334)	• **Continue Your Exploration:** ○ Sampling Oceanic Crust ○ Transition Crust ○ Plate Motion, Stresses, and Earthquakes	
		Evaluate	• **Lesson Self Check** (pp.335-337)- Can You Explain It- Revisit • **Make Your Own Study Guide** (p. 337) • **Checkpoint Questions** (pp.336-337)	• **Can You Explain It?** Revisit • **Checkpoint Questions** • **Make Your Own Study Guide** • **Unit 6 - Lesson 2 Quiz**	
	Lesson 6.3 Plate Interactions In this lesson, you will use models to explain different modes and mechanisms of plate interactions. **Vocabulary**: divergent boundary convergent boundary transform boundary mid-ocean ridge subduction oceanic trench mantle convection slab pull ridge push	**Engage**	• **Phenomenon: Can You Explain It?-** How can a sonar image of the East Pacific Rise reveal information about plate motions? (p.338)		**You Solve It Simulation- How Can You Explain the Ages of Crustal Rock?** Students will use a model to show how the specific movements of tectonic plates can be used to explain the ages of crustal rock for three of the five given sequences.
		Explore/ Explain	• **Exploration 1-** Divergent Boundaries (pp. 339-344) • **Exploration 2-** Convergent Boundaries (pp. 345-350) • **Exploration 3-** Transform Boundaries (pp. 351-354) • **Exploration 4-** Causes of Plate Motion (pp. 355-357)	• **Lesson 3- Plate Interactions PPT (editable)** • **Exploration 2:** **Hands-On Lab- Earthquakes and Subduction Boundaries-** In this lab, students construct profiles across two subduction zones and compare and contrast the behavior of two subducting plates.	
		Elaborate	• **Continue Your Exploration- Careers in Science:** Geophysicist (p. 358)	• **Continue Your Exploration:** ○ **Hands-On Lab- Design a Plate Boundary-** In this lab, students examine different static and dynamic ways to model plate boundaries, and then choose one concept to implement, one to modify, or one to develop their own. ○ Rifting Research	
		Evaluate	• **Lesson Self Check** (pp. 359-361)- Can You Explain It- Revisit • **Make Your Own Study Guide** (p. 361) • **Checkpoint Questions** (pp. 360-361)	• **Can You Explain It?** Revisit • **Checkpoint Questions** • **Make Your Own Study Guide** • **Unit 6 - Lesson 3 Quiz**	
	Lesson 6.4 Natural Hazards In this lesson, you will examine evidence and construct explanations about volcanoes and earthquakes.	**Engage**	• **Phenomenon: Can You Explain It? -** How are the eruptions of Kilauea and Mount St. Helens different? (p. 362)		**ESRT:** • Earthquake P-Wave and S-Wave Travel Time (p. 11) Earthquake Wave Seismogram: Three Level
		Explore/ Explain	• **Exploration 1-** Mount St. Helens (pp. 363-366) • **Exploration 2-** Hawaiian Islands and Hotspots (pp. 367-371)	• **Lesson 4- Natural Hazards PPT (editable)** • **Exploration 2:** **Hands-On Lab- Explore Volcanoes-** In this lab, students develop and design a method to explore and model volcanoes.	

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	Vocabulary: lava seismogram		• **Exploration 3-** 1816: The Year Without a Summer (pp. 372-374) • **Exploration 4-** Earthquake Hazards (pp. 375-378)	• **Exploration 4:** **Hands-On Lab- Earthquake-Safe Buildings-** In this lab, students will investigate the effects of an earthquake on an unreinforced building and a reinforced building. • **Exploration 4:** **Hands-On Lab- Finding and Epicenter-** In this lab, students analyze P-waves and S-waves to determine the distance from a city to the epicenter of an earthquake, and determine the location of an earthquake epicenter using the distance from three different cities to the epicenter.	Reading Guide to Diagram Interpretation **Mystery Epicenter Investigation:** • Student worksheet • Student map • Lag Time graph *In the Community- Hazard Mapping (p. 307J) *In the Community- Story Telling (p. 307J) *At Home- Emergency Preparedness (p. 307J)
		Elaborate	• **Continue Your Exploration- Careers in Science:** Volcanologist (p. 379)	• **Continue Your Exploration:** ○ Human Bottleneck Event ○ Human Response to Disasters	
		Evaluate	• **Lesson Self Check** (pp. 380-381)- Can You Explain It- Revisit • **Make Your Own Study Guide** (p. 381) • **Checkpoint Questions** (pp.381)	• **Can You Explain It?** Revisit • **Checkpoint Questions** • **Make Your Own Study Guide** • **Unit 6- Lesson 4 Quiz**	
	Thing Explainer		• **Big Flat Rocks We Live On** (pp. 382-385)		
	Enrichment: Unit Connection Activities (Optional)		• **Engineering-** Exploring Deep-Sea Vents • ***Literature-** Earthquakes and Volcanic Eruptions in Folklore • **Biology-** Using Earth's Magnetic Field		
	Unit Close		• **Synthesize the Unit** (p.387) • **Driving Questions** (revisit) • **Practice and Review Questions** (pp. 387-388) • **Unit Project** Revisited (p. 388) • **Unit Performance Task** (p. 389)	• **Assessment Guide**: ○ Unit Test A- provides an in-depth assessment of the Performance Expectations aligned to the unit. ○ Unit Test B can be used to assess students who need extra support	Castle Learning HMH Earth & Space Science Unit 6- Plate Tectonics (Editable item bank available under Public Assignments in Castle Learning)

Resources

http://ngss.nsta.org/Classroom-Resources.aspx - Searchable NYSSLS/NGSS aligned resources curated by NSTA
BPS Earth Science Website– BPS Earth Science curriculum resource hub
BPS Science Department Recommended Virtual Labs – Virtual lab resources with embedded links to virtual labs and student sheets. Must be logged into BPS google account through BPS Gmail account to access.
BPS Science Department CER Student Writing Template (BPS Science Department CER Practice with a Graph)
NYSED's Office of State Assessment webpage - Access to Released Regents Earth Science Examinations
Science Learning Standards (HS) – NYSSLS High School Standards for Earth Science
NYSED Bilingual Glossaries – NYS Statewide Language Regional Bilingual Education Resource for NYSED approved bilingual glossaries.

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English Language Learners (ELL) Enhancements To access hyperlinked material, you must be logged into your BPS Google Drive	**Listening** • **Cross- Linguistic Practices:** Gives students opportunities to make connections between what they hear and their home language (For example, allow students to listen to a passage and identify cognates.) • **Build background knowledge** • **Activating Prior Knowledge** • **Activating prior knowledge** means both eliciting from students what they already know and building initial knowledge that they need in order to access upcoming content • **Visuals** - GIFs, pictures- will assist students in understanding what they are listening to. **Visual thinking strategies** set the lens for learning. • Video to review/ introduce a topic – use **closed captioning** so students see the words and pronunciations while they listen to the content. • **Word stretching / Vowel stretching** allows student to listen closely to the pronunciation words • **Performance Level Descriptors** - this document provides teachers with a description of what output they can expect from students based on earned NYSESLAT levels in the modality of listening Scroll for grades 9-12.	**Speaking** • **Sentence Frames** - to begin a sentence - such as *Evolution is…* or *I think that evolution is…* • **Academic Conversation Starters:** Have a visual of a list of academic sentence starters that students can refer to in a discussion such as *I expect __ to happen.* or *My data shows that…* This aids students in having more science focused dialogue. • **Choral Reading** - Build fluency, self-confidence and motivation with reading/speaking • Create **movement** to go with the word. Movement can be a motivating factor and kinesthetic tool for conceptualizing the rhythm and flow of fluent reading while triggering brain function for optimal learning • **Performance Level Descriptors** - this document provides teachers with a description of what output they can expect from students based on earned NYSESLAT levels in the modality of speaking. Scroll for grades 9-12	**Reading** • **Supplementary Text** to reinforce concepts. If necessary, use lower Lexile levels to ensure comprehension. • **Visual Aids** - Pictures or models to support vocabulary words/ concepts • Video to review introduce a topic - use **closed captioning** so students can read along and listen to content • **4 Square / Frayer models** to help students gain a deeper understanding of vocabulary. • **Highlighting** important text to assist students in answering questions after the reading. • **Chunking**-Break reading of text into chunks or paragraphs • **Vocabulary Morphology**- segmenting words into affixes (prefixes/suffixes) and roots/base words. Understanding that words connected by meaning/origin can be connected by spelling can be critical to expanding a student's vocabulary. • **Performance Level Descriptors**- this document provides teachers with a description of what output they can expect from students based on earned NYSESLAT levels in the modality of reading. Scroll for grades 9-12.	**Writing** • **Sentence Frames** - to begin a sentence- such as *Biodiversity is…* or *An example of competition is….* • **Cloze passages** with word banks • **Word banks** • **Graphic Organizers** to help break down the writing process and organize thoughts • **Standards-based sentence stems** • **Performance Level Descriptors**- this document provides teachers with a description of what output they can expect from students based on earned NYSESLAT levels in the modality of writing. Scroll for grades 9-12.	**Instructional Accommodations (depending on the student's needs)** • **Extended time** for tests in class, projects and assignments • **Directions read.** Broken down as necessary • **Model** how to complete the activity in the lesson • **Oral simplification** of directions or questions • **Translated version** of test when available. Student may have both version English and native language version • Use of **approved bilingual glossaries** from NYS in each subject
Special Education Modifications **Special Education students must have**	**Instructional** • **Pre-teach** vocabulary • Use **picture vocabulary** • Scaffold **Depth of Knowledge** questions • Provide copy of notes/**notes in "cloze"** form • Use of **Think, Pair, and Share** strategy to help process information • **Scaffold** written assignments with the use of **graphic organizers** • Allow for **multiple ways to respond** (verbal, written, response board) • Provide **model of performance task**		**Technology:** • **Audio** reading of text • **Text to type** functions • **Videos** to clarify/visualize Living Environment concepts • **Record class lecture/discussions** and make accessible to student • **Nearpod**- interactive presentations of notes • **Playposit** - show a video clip about the topic and add your own questions for them to answer as they watch • Allow students to type answers in chat on **Teams**		**In Class Assessments** • Provide **review packet or review sheet** of concepts covered on the test • Practice similar questions prior to the test • Provide **multiple options** for projects • Give a **timeline** of when things are due and remind them of the process often.

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accommodations as per Individual Educational Plan (IEP)	● **Modify informational text** to fit the needs of the students ● Provide a digital or paper i**nteractive notebook** ● Present complex **tasks in multiple ways** Provide **mnemonic strategies** for Living Environment concepts	**Other:** ● Arrange seating for maximum engagement and minimum distraction ● Accessible lab space (counter level)	● **Use of timer** in class ● Break all complex tasks into chunks
BPS Science K-12 Schoology Folder: 9-12 Resources Earth Science Resources Curriculum Materials	**SUTW Strategies** ● Informal Outline ● Color-Coding – Informative/Explanatory Text ● Two-column notes ● I-V-F Topic Sentence progressing to Four Step Summary Paragraph ● CUPS – Capitalization, Usage, Punctuation, Spelling ● Transitions		
Culturally and Linguistically Responsive Teaching (CLRT) in the Science Classroom	Materials, resources, and/or discussions address diverse cultural backgrounds and real-world applications ● Artifacts (posters, charts, etc.) in the science classroom are representative of the cultures of the student population ● All students are given an opportunity to engage in science discourse ● Teacher demonstrates high expectations for all students CLRT resources which align to Science content are denoted with a *		