

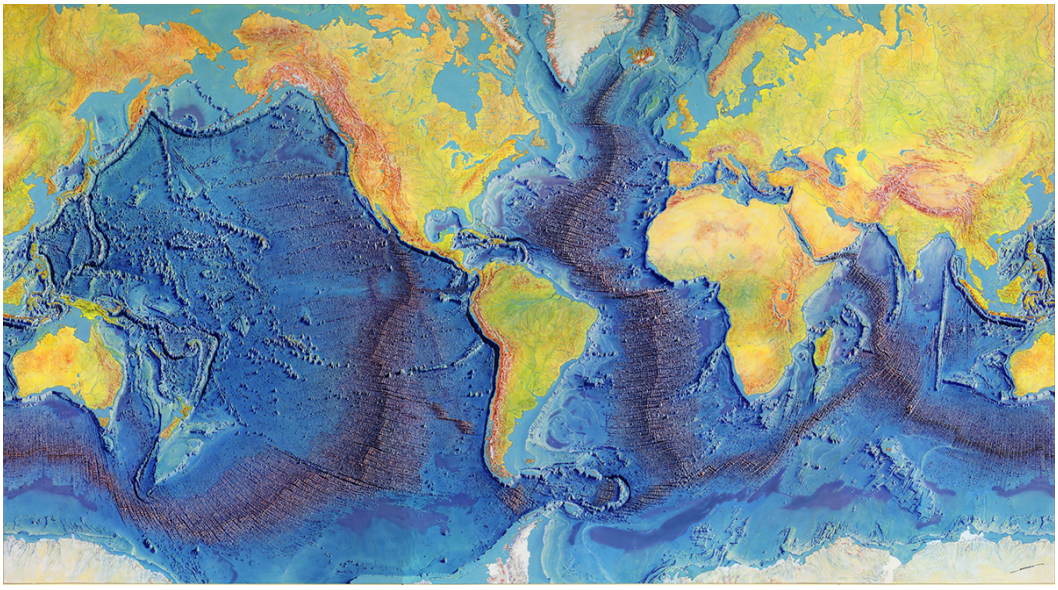
Fate of the Plates

How does convection of the mantle explain the wide range of surface ages and features across Earth's surface?

Infiniscope

What Students Do

Students will investigate plate margins, explore surface features and model plate boundaries as they traverse the globe with Orby, an interplanetary explorer who is fascinated by Earth's unique surface.



Instructional Objective	Learning Outcomes	Standards
Explain the phenomena of plate movement, its driving force, and the patterns of surface features that provide evidence for this movement.	**Use a model to simulate plate boundary (system) interactions and surface features related to plate interactions.** **Use geologic surface features and smaller scale observations to predict the cause / effect relationship and model the relationship for plate boundaries interactions on Earth.**	**Science and Engineering Practices** • Constructing Explanations and Designing Solutions • Developing and Using Models **Disciplinary Core Ideas** • ESS2.A. Earth Materials and Systems • ESS2.B. Plate Tectonics and Large-Scale System Interactions • ESS1.C. The History of Planet Earth **Crosscutting Concepts** • Patterns • Systems and System Models • Cause and Effect

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Lesson Specs

Grade Range

Elementary	Middle School	**High School**	College +

NGSS Content Areas

Life Sciences	**Earth and Space Sciences**	Physical Sciences

Devices

PC, Mac, Chromebook	iPad, Android Tablet	iPhone, Android Phone

Browsers

Chrome	Edge	**Firefox**	Safari

Time

Prep Time	~10 min	**Lesson Time**	~60 min

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Skills

Prior Skills	• Use models • Construct explanations of phenomena	**Skill Building**	• Observe patterns • Cite patterns as evidence to help explain phenomena • Use models to simulate the phenomena of plate tectonics • Use models to generate data to support explanations of phenomena

Required Materials

☐ Computer or laptop	*1 per student*
☐ Access to Ethernet or wifi	

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5E



Coming Soon!

Density

Convection

Continental Drift

Earth's Interior

Pretest - Coming Soon!

Fate of the Plates

Coming Soon!

Assessment - Coming Soon!

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Misconceptions

Below are a list of misconceptions that students commonly hold about plates, plate boundaries, and the concept of plate tectonics. Beneath each misconception is information for the instructor on how that misconception was addressed in the learning experience.

Misconception Alert

Misconception #1

Boundaries only occur where continents meet ocean basins.

➨ To address this misconception, the simulation models at least one plate boundary where one or both plates have oceanic crust. It also discusses the difference between active and passive margins.

Misconception #2

Earth's interior is molten magma.

➨ To address this misconception, the simulation does not use "hot" colors, like red and orange, for the interior, but instead uses green, reflecting current scientific consensus of the color of the mantle. Also, the simulation does not show interior material erupting onto the surface; magma looks distinct from the mantle.

Misconception #3

Plates float on the ocean.

➨ To address this misconception, the simulation has a cross section that clearly shows there isn't water under the plates.

Misconception #4

Only continents move, not oceans.

➨ To address this misconception, the simulation clearly shows that there are tectonic plates

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under both the continents and the oceans, and it the movement of these tectonic plates that cause both continents and oceans to move.

Misconception #5

Events like earthquakes and volcanoes cause plates to move.

➨ To address this misconception, the simulation shows that convection occurs in the mantle, causing the plates to move. The learning experience also talks about this mechanism for plate motion, and further shows that volcanoes and earthquakes are the result of plate motion, not the cause of it.

Misconception #6

Tectonic plates are not in contact with each other, or are separated by oceans.

➨ To address this misconception, the simulation shows the tectonic plates touching each other, with no gap or ocean between them.

Misconception #7

Magma forms from melting plates or comes from beneath the subducting plate.

➨ To address this misconception, the simulation shows that magma is generated above the subducting plate at a subduction zone.

Misconception #8

At subduction zones, volcanoes are not directly related to melting above the subducting plate.

➨ To address this misconception, the simulation only shows volcanoes forming over a subducting plate at a subduction zone.

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Vocabulary

Below is a list of vocabulary words, found in this learning experience, and their definitions. The definitions are provided here for the instructor to use as they prepare students for the experience.

continental plate	a large piece of Earth's lithosphere, made of granitic (granite) rocks
convection	the transfer of energy through the cycling of matter where warm, less dense material rises and cool, more dense material sinks
convection cell	a circular pattern of moving material caused by differences in density
convergent	two plate margins come together
divergent	two plate margins move apart
lithosphere	the rigid outer layer of Earth, made up of the crust and uppermost mantle
mantle	the layer of Earth's interior between the crust and the outer core
mid-ocean ridge	a long underwater mountain chain composed of volcanic rock; a divergent margin
mountains	an area where Earth's surface is dramatically higher than the surrounding surface
oceanic plate	a large piece of Earth's lithosphere, made of basaltic (basalt) rocks
plate margin	the edge of a tectonic plate, which is in contact with another tectonic plate; as known as a plate boundary
ridge push	the force that causes a tectonic plate to move away from a mid-ocean ridge

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rift valley	a long, low area between higher land/mountains; volcanoes are found along the floor; a divergent margin
seismic	relating to earthquakes; vibrations of the crust
slab pull	the force that pulls a plate towards a subduction zone; caused by the weight of the subducting plate
subduction	the process of one tectonic plate being pulled beneath another tectonic plate into the mantle
tectonic plate	a large piece of Earth's lithosphere
transform	to slide past each other
trench	a long, narrow depression on the seafloor; the deepest spots on Earth
volcano	an opening vent where lava erupts from a magma chamber

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Next Generation Science Standards

Core Question

How and why is Earth constantly changing?

NGSS Core Question: ESS2: Earth Systems

Component Question

How do Earth's major systems interact?

NGSS ESS2.A: Earth Materials and Systems

Why do the continents move, and what causes earthquakes and volcanoes?

NGSS ESS2.B: Plate Tectonics and Large-Scale System Interactions

Performance Expectations

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. [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] [*Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.*]

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HS-ESS2-3.
Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. [Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.]

NGSS Objectives

Objective	NGSS SEP	NGSS DCI	NGSS CCC
Instructional Objective **Explain the phenomena of plate movement, its driving force, and the patterns of surface features that provide evidence for this movement.**	**Constructing Explanations and Designing Solutions** Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.	**ESS2.A.** 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 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) (HS-ESS2-1) Plate tectonics can be viewed as the surface expression of mantle	**Patterns** Observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting explanations of phenomena.

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		convection. (HS-ESS2-3) **ESS1.C.** 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) Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6)	
Learning Outcome 1 **Use a model to simulate plate boundary (system) interactions and surface features related to plate interactions.**	**Developing and Using Models** Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.	**ESS2.B.** 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) (HS-ESS2-1) Plate tectonics can be viewed as the surface	**Systems and System Models** They can use models (e.g., physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales.

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		expression of mantle convection. (HS-ESS2-3)	
Learning Outcome 2 **Use geologic surface features and smaller scale observations to predict the cause / effect relationship and model the relationship for plate boundaries interactions on Earth.**	**Developing and Using Models** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**ESS2.B.** 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) (HS-ESS2-1) Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3)	**Cause and Effect** Suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems.

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