Earth's Changing Surface
Lesson 2b: Movement of Earth's Plates

Grade 4	**Length of lesson:** 45 minutes	**Placement of lesson in unit:** 2b of 7 two-part lessons on Earth's changing surface
Unit central questions: Why isn't all of Earth's surface flat? What causes the surface to look different in different places?		**Lesson focus question:** What happens to Earth's surface that causes mountains to form?
Main learning goal: Earth's thin outermost layer (crust) is made up of tectonic plates that float or ride on a hot layer of rock moving beneath them. Volcanic activity is one mechanism that builds up Earth's surface in some places.		
Science content storyline: Volcanic eruptions are one way mountains form. In some places on Earth, mountains are built up as magma erupts and then cools into rock. But are other processes involved in mountain building? Earth's outermost layer of cold, rigid rock is very thin and sits on a thick layer of hot, slowly moving rock beneath the surface. Earth's outer layer is made up of interlocking crustal plates—like puzzle pieces—that slowly move across Earth's surface. These crustal plates, called *tectonic plates*, ride or float on the underlying layer of hot, slow-moving rock. How does this plate movement contribute to mountain building? How does it lead to volcanic eruptions?		
Ideal student response to the focus question: One way mountains can form is when volcanoes erupt and lava flows onto the ground and then cools into hard rock. After a volcano erupts many times, the cooling lava builds up the land. Earth's interlocking tectonic plates might also have something to do with mountain building. These plates ride or float on a layer of hot, slowly moving rock inside Earth, and mountains can form when they shift around.		

Preparation

Materials Needed
- Science notebooks
- Chart paper and markers
- Ways Earth's Surface Might Change over Time (chart from lesson 1b)
- For Earth's Moving Mantle demonstration:
  - Glass bread loaf dish (1.5 liter)
  - 2 ceramic coffee cups and a metal spoon
  - 1 Sterno can or 2 small candles
  - Vegetable oil (about 800–1,000 ml, or 28–34 fl oz)
  - 2 tsp (10 ml) thyme
  - 1 box of matches
  - 3 pieces of thin of balsa wood (about 2 mm—or 1/16 in—thick; each 3 x 2 in)

Student Handouts and Teacher Masters
- 2.1 Earth's Moving Mantle Demonstration (Teacher Master)

Ahead of Time
- Review Earth's Changing Surface Content Background Document: sections 4–6.
- Prepare materials for Earth's Moving Mantle demonstration on thermal convection:
  - Follow the instructions and visuals for the demo in handout 2.1.
  - Set the glass loaf dish on 2 overturned ceramic coffee cups.
  - Mix 800–1,000 ml of vegetable oil with about 2 tsp of thyme.
  - Pour mixture into the glass loaf dish and let it sit until the oil is still.
  - Place a Sterno can or 2 small candles underneath the center of the loaf dish.
- View additional diagrams of Earth's composition at http://en.wikipedia.org/wiki/File:Earth-crust-cutaway-english.svg.

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Lesson 2b General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
5 min	**Link to previous lesson:** Review key science ideas from lesson 2a about how the surface of Earth changes.	• Earth's surface changes over time, and we can describe some of those changes.
1 min	**Lesson focus question:** The class revisits the focus question from the previous lesson: *What happens to Earth's surface that causes mountains to form?*	
5 min	**Setup for activity:** Continuing the investigation of science ideas from the previous lesson, the teacher tells students that a thick layer of hot, slowly moving rock inside Earth causes the tectonic plates on Earth's crust to move.	• Earth's thin outer layer of cold, rigid rock is made up of interlocking tectonic plates that float, or ride, on top of an underlying layer of hot, slowly moving rock inside Earth.
10 min	**Activity:** Students observe and discuss a plate-movement demonstration and the layer of hot, slowly moving rock underneath Earth's tectonic plates.	• Earth's thin outer layer of cold, rigid rock is made up of interlocking tectonic plates that float, or ride, on an underlying layer of hot, slowly moving rock inside Earth. This underlying layer moves up, down, and sideways, slowly carrying the crustal plates across Earth's surface.
15 min	**Follow-up to activity:** Students draw and write about how the plate-movement demonstration is similar to what happens with Earth's crust and tectonic plates.	• Earth's thin outer layer of cold, rigid rock is made up of interlocking tectonic plates—like puzzle pieces—that float, or ride, on a thick, underlying layer of hot, slowly moving rock beneath the surface. This underlying layer moves up, down, and sideways, slowly carrying the crustal plates across Earth's surface.
8 min	**Synthesize/summarize today's lesson:** Students summarize the key science ideas from this lesson and the previous lesson that help answer the focus question.	• Volcanic activity is one way mountains are built up. Other processes are involved in mountain building as well. The thin crust of Earth is made up of interlocking tectonic plates that float on an underlying layer of hot, slowly moving rock inside Earth. How does this plate movement contribute to mountain building and volcanic eruptions?
1 min	**Link to next lesson:** The teacher links key science ideas to the next lesson.	

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5 min	**Link to Previous Lesson** **Synopsis:** Review key science ideas from lesson 2a about how the surface of Earth changes. **Main science idea(s):** • Earth's surface changes over time, and we can describe some of those changes.	Link science ideas to other science ideas. Engage students in making connections by synthesizing and summarizing key science ideas.	**Show slides 1 and 2.** Last time, we gathered some evidence showing that Earth's surface *does* change over time. Let's review the key science ideas and revise or add to our chart of ideas about the ways Earth's surface changes over time. **NOTE TO TEACHER:** *Keep this discussion brief and encourage students to refer to ideas they've written in their science notebooks. As students share their ideas, revise the chart from lesson 1b (Ways Earth's Surface Might Change over Time) or add any new ideas students contribute. If students don't mention it, you might suggest changing the chart title to "Ways Earth's Surface **Does** Change over Time"—or adding a new section—to reflect the key science ideas they're learning.* Who remembers one key science idea from last time? Yes, volcanic eruptions change the surface of Earth by building mountains. We'll add that idea to our chart.	We learned about volcanoes. When volcanoes erupt, lava flows out of the opening onto the ground and then hardens into rock as it cools. That's how volcanoes build mountains.	How do volcanoes change Earth's surface?

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			Who can share another key science idea from the previous lesson? Those are both important ideas: • Earth's crust is very thin, and • Earth's crust is made up of interlocking tectonic plates that fit together like puzzle pieces. How can we add these ideas to our chart? What do they have to do with changes in Earth's surface? Remember that we ended our last lesson with a wondering: We wonder whether Earth's tectonic plates might be involved in building mountains on Earth's surface. Let's see what we can find out!	Earth has a thin crust, just like an eggshell. The crust is broken into plates that hook together kind of like pieces of a jigsaw puzzle. Well, we didn't know about the plates before. That's a change to Earth's surface, isn't it? I'm not sure, but it might have something to do with building mountains.	
1 min	**Lesson Focus Question** **Synopsis:** The class revisits the focus question from the previous lesson:	Set the purpose with a focus question or goal	**Show slide 3.** Today we'll continue exploring the focus question from last time: *What happens to Earth's surface that causes mountains to form?*		

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	What happens to Earth's surface that causes mountains to form?	statement. Ask questions to elicit student ideas and predictions.	**Show slide 4.** In this lesson, we'll learn more about Earth's tectonic plates and add to our science ideas about ways Earth's surface changes over time. Do you think tectonic plates have anything to do with mountains forming on Earth's surface? Why or why not?		
5 min	**Setup for Activity** **Synopsis:** Continuing the investigation of science ideas from the previous lesson, the teacher tells students that a thick layer of hot, slowly moving rock inside Earth causes the tectonic plates on Earth's crust to move. **Main science idea(s):** • Earth's thin outer layer of cold, rigid rock is made up of interlocking tectonic plates that float, or ride, on top of an underlying layer of hot, slowly moving rock inside Earth.	Make explicit links between science ideas and activities **before** the activity.	**Show slide 5.** So last time you wrote two key science ideas about Earth's crust in your science notebooks: 1. Earth's crust is very thin. 2. Earth's crust is made up of interlocking tectonic plates that fit together like puzzle pieces. Please locate those ideas in your notebooks and prepare to add two more: 3. Earth's tectonic plates move. 4. There is a thick layer of hot, slowly moving rock inside Earth. **Show slide 6.** First, let's explore the idea that Earth's tectonic plates actually move, unlike the pieces of an eggshell. Think about that: There are moving plates underneath the ground we're standing on! How		

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			could that happen? Using your scientific imaginations, see if you can come up with some ideas about how Earth's tectonic plates could be moving underneath the ground we're standing. What could make them move? **NOTE TO TEACHER:** *Jot down students' ideas on chart paper, but don't probe student thinking at this time.* **Show slide 7.** Now let's talk about the idea that a thick layer of hot rock is moving inside Earth. This is another big difference between Earth and a hard-boiled egg. Inside Earth, an extremely hot, thick layer of rock is slowly moving underneath the thin layer of Earth's crust. Scientists think this underlying layer of hot, slow-moving rock actually causes Earth's tectonic plates to move. How could this happen? Try to imagine the broken sections of an eggshell moving. It's hard to do, isn't it? **Show slide 8.**	Maybe erupting volcanoes are so powerful, they make the land move. Earthquakes can maybe move the plates. Maybe gravity makes the land move. Maybe gravity inside Earth is pulling the plates down, and that makes them move.	

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		Select content representations and models matched to the learning goal and engage students in their use.	I think we need a new model to help us envision how this works. As you observe this new model, I want you to think about how the hot, slow-moving rock inside Earth could make the tectonic plates move. **NOTE TO TEACHER:** *Write this question on the board so that everyone can see it: How can hot, slowly moving rock inside Earth make the tectonic plates move?*		
10 min	**Activity** **Synopsis:** Students observe and discuss a plate-movement demonstration and the layer of hot, slowly moving rock underneath Earth's tectonic plates. **Main science idea(s):** • Earth's thin outer layer of cold, rigid rock is made up of interlocking tectonic plates that float, or ride, on an underlying layer of hot, slowly moving rock inside Earth. This underlying layer moves up, down, and sideways, slowly carrying the crustal plates across Earth's surface.	Make explicit links between science ideas and activities **during** the activity. Engage students in analyzing and interpreting data and observations.	**NOTE TO TEACHER:** *Carefully follow the step-by-step instructions on the teacher master (handout 2.1, Earth's Moving Mantle Demonstration). Caution students to maintain a safe distance from the heat source.* **Show slide 9.** First, let's look at our model. What do you think the pieces of wood represent? So the wood represents the different plates of Earth's crust. It's important to understand that tectonic plates aren't the same thing as continents. We'll investigate more about that tomorrow. What do you think this vegetable oil represents? **NOTE TO TEACHER:** *Make sure students understand that even though the vegetable oil is a liquid, in the real world, the layer of hot rock below Earth's crust is not liquid. The*	Continents! Earth's plates! Lava! The hot, slow-moving rocks inside Earth.	

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			vegetable oil illustrates convection well but could introduce a misconception that Earth is filled with liquid rock. What do you think the heat source represents? What do you observe about this system? For example, what do you notice about the plates and the hot, slow-moving rock? Now I'm going to add some heat to the system. **NOTE TO TEACHER:** *It will take a few minutes for the oil to start moving visibly. While you're waiting, elicit student predictions.* Do you think the heat will cause any changes to the plates? If so, what do you think will change? **Show slide 10.**	The Sun! The heat deep inside Earth. *[Students may offer various observations, but the key observation they should make is that nothing is moving in the system.]* Yes, I think the heat will make the liquid boil, and bubbles will rise to the surface. Yes, it'll probably push the plates up.	Will that change the tectonic plates on Earth's surface?
		Ask questions to elicit student ideas and predictions.			

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			NOTE TO TEACHER: *Once motion is detected in the system, have students describe the pattern of movement. You might want to have a few students observe the dish from above to note how the plates are moving, and from the side to see how the hot rock is moving. To encourage careful observations, you might ask the following questions.* What patterns of movement do you notice in the system as it heats up? Remember that the vegetable oil represents the hot, slow-moving rock inside Earth. Where do you observe upward flow in the oil? **ELL support:** Introduce the term *flow* before asking students about it, or use a different word and then link it to this key term. You might ask students to show patterns of flow with their hands and then describe these patterns. Is there also sideways flow within the hot, slowly moving rock? What about downward flow? What's happening to the plates? **NOTE TO TEACHER:** *It isn't important that students observe the two convection cells (the upper mantle and the whole mantle) shown in the teacher master for this demonstration. The key is understanding that heat is making the hot, slowly moving rock move upward,*	In the center, right above the heat source. Yes, toward the top. After the rock [or oil] goes sideways, it goes [or flows] down. The plates move when the hot rock underneath them moves.	

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			sideways, and downward, and that these motions are making the tectonic plates move.		
15 min	**Follow-Up to Activity** **Synopsis:** Students draw and write about how the plate-movement demonstration is similar to what happens with Earth's crust and tectonic plates. **Main science idea(s):** • Earth's thin outer layer of cold, rigid rock is made up of interlocking tectonic plates—like puzzle pieces—that float, or ride, on a thick, underlying layer of hot, slowly moving rock beneath the surface. This underlying layer moves up, down, and sideways, slowly carrying the crustal plates across Earth's surface.	Make explicit links between science ideas and activities **after** the activity.	**Show slide 11.** Now I'd like you to compare what you observed in the demonstration to what happens with Earth's crustal plates. You'll work independently on this task as you follow the steps on the slide: 1. In your science notebooks, draw a picture of what you observed when you looked at the baking dish from the side. 2. Make sure to label your picture. 3. Then write a description telling how this model is like what happens to Earth's crust. Make sure to use complete sentences! **ELL support:** Allow ELL students to talk about their observations with a partner before they write their descriptions. Make your instructions more explicit. For example, "Think about what we observed in the demonstration. Then describe what you think happens to Earth's crust." **Individual work time (10 min).** **NOTE TO TEACHER:** *Circulate around the room as students work on this task. Ask questions to probe and challenge student thinking: What does this represent? Can you say more than "it moves"? What moves? How does it move?*		

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		Engage students in communicating in scientific ways.	**Show slide 12.** **Whole-class share-out (5 min):** Now let's have a few of you share what you wrote. As you're listening to your classmates' ideas, think about whether you agree or disagree, have something to add, or have any questions about the model or the ideas your classmates share. **MISCONCEPTION NOTE TO TEACHER:** *During the discussion, students may compare the heat source in the demonstration (the Sterno can or candles) to the Sun. Make sure to correct this misconception. You might say something like this: "Several of you talked about the Sterno can/candles being like the Sun. But actually, the heat source for the underlying layer of rock comes from deep within the center of Earth, not from the Sun."*		
8 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** Students summarize the key science ideas from this lesson and the previous lesson that help answer the focus question. **Main science idea(s):** • Volcanic activity is one way mountains are built up. Other processes are involved in mountain building as well. The thin crust of Earth is	Highlight key science ideas and focus question throughout. Engage students in	**Show slide 13.** Today we continued investigating our focus question from last time: *What happens to Earth's surface that causes mountains to form?* Over the past two lessons, we've gathered some important information about Earth's surface in three different activities. Let's review those activities and see if the science ideas we learned about can help us answer our focus question. ***Embedded Assessment Task*** In the first activity from last time, we looked at		

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	made up of interlocking tectonic plates that float on an underlying layer of hot, slowly moving rock inside Earth. How does this plate movement contribute to mountain building and volcanic eruptions?	making connections by synthesizing and summarizing key science ideas. Ask questions to elicit student ideas and predictions.	pictures of volcanoes. Did we learn anything from that activity about how mountains are built? So volcanic eruptions slowly build up mountains over time, and that changes Earth's surface. This also answers our first unit central question, *Why isn't all of Earth's surface flat?* In our second activity, we looked at a hard-boiled egg and a cracked eggshell. Did this activity help us learn anything about how mountains are built? What did we learn about Earth's crust from the eggshell model of Earth? In our third activity, we observed a demonstration that used heated vegetable oil representing hot, slow-moving rock inside Earth and pieces of wood representing tectonic plates on Earth's crust. What did we learn about Earth's crust from this activity?	Yes. Lava flows out of a volcano when it erupts and then turns into rock when it cools. After a lot of eruptions, the rock piles up and makes the mountain taller. No, because eggshells don't have mountains. That Earth's crust is thin. The crust is cracked into plates. That Earth moves inside. That a layer of hot rock is moving around	

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				slowly inside Earth. The rock moves up and down and sideways. It makes the plates move. Sideways, like they're floating.	Tell us more about how the hot rock moves. Does that have anything to do with changing Earth's surface? Do the plates also move up, down, and sideways?
			So we learned that Earth's plates are moving because a layer of hot, slow-moving rock beneath the surface is carrying them. **Show slide 14.** Do you think the movement of Earth's tectonic plates has anything to do with building mountains? Why or why not? What do you think?	We didn't say anything about that. The wood pieces moved away from each other, so that's kind of making an ocean or a valley between them, not a mountain. So I don't think the plates	I know. But what do you think? Do you have any evidence from our demonstration?

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			I'd like you to write one or two sentences in your science notebooks that describe whether you think plate movement causes mountains to form. Use these sentence starters: • *Yes, I think plate movement causes mountains to form because _____.* • *No, I don't think plate movement causes mountains to form because _____.*	make mountains. Maybe when the oil *[the hot, slow-moving rock]* gets hot enough, it will bubble up and make mountains.	
1 min	**Link to Next Lesson** **Synopsis:** The teacher links key science ideas to the next lesson.	Summarize key science ideas. Link science ideas to other science ideas.	**Show slide 15.** So far we've discovered that volcanic eruptions can build mountains, and that Earth's thin crust is divided into tectonic plates that fit together like pieces of a jigsaw puzzle. We've also learned that a thick layer of hot, slowly moving rock inside Earth causes these plates to move. **Show slide 16.** Now we have some new wonderings: Are Earth's moving plates involved somehow in building mountains? If so, how? That's what we'll investigate next time!		