Earth's Changing Surface
Lesson 4b: Plate Collisions Build Mountain Ranges

Grade 4	**Length of lesson:** 50 minutes	**Placement of lesson in unit:** 4b 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 evidence can we find to support the idea that mountains form when Earth's crustal plates collide?
Main learning goal: Major mountain ranges on Earth are found at the boundaries of tectonic plates. This evidence supports the idea that mountains are formed when Earth's crustal plates collide. Mountain building occurs very slowly and can't always be felt or seen.		
Science content storyline: Earth's crustal plates move in different directions and sometimes collide or push into each other. Normally these plates move very slowly over time. Colliding tectonic plates cause mountain ranges to form. Earthquakes can also occur where plates collide or slide past each other. When crustal plates beneath continents collide, they can crumple upward to form mountain ranges. Evidence of this is that major mountain ranges on Earth are found at the boundaries of tectonic plates. Mountain building also happens as a result of volcanic eruptions. Hot, slow-moving rock from Earth's interior causes plate collisions and volcanic mountain building.		
Ideal student response to the focus question: Mountain ranges form when two of Earth's crustal plates collide. We found evidence for this on a map of Earth that showed many mountain ranges located at the boundary between two plates. Mostly, plate movement happens too slowly for us to see or feel, but sometimes we can feel earthquakes when two plates collide or slide past each other.		

Preparation

Materials Needed • Student notebooks • Chart paper and markers **Student Handouts and Teacher Masters** • 3.4 Graham-Cracker Collision (Teacher Master) (page 2 from lesson 3b) • 4.1 Map of Plate Boundaries around the World (from lesson 4a) • 4.2 Physical Map of the World (1 for each pair of students and 1 for display) • 4.3 Volcanoes and Earthquakes around the World (1 for each pair of students and 1 for display on a document reader)	**Ahead of Time** • Review Earth's Changing Surface Content Background Document: section 6. • Prepare handout 4.2 (Physical Map of the World) and handout 4.3 (Volcanoes and Earthquakes around the World) for display on a document reader or Smart Board.

Lesson 4b General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
3 min	**Link to previous lesson:** The teacher reviews ideas about plate boundaries and mountain building from the previous lesson.	• The plates of Earth's crust can collide and form mountain ranges.
1 min	**Lesson focus question:** The teacher reviews the focus question from the previous lesson: *What evidence can we find to support the idea that mountains form when Earth's crustal plates collide?*	
5 min	**Setup for activity:** Students examine a topographic (physical) map of the world and prepare to use it in an activity.	• When plates collide, they can form mountain ranges. Evidence of this is the fact that most of Earth's mountains are found at the boundaries where tectonic plates collide.
20 min	**Activity:** Students use a topographic (physical) map of the world to compare locations of collisions at plate boundaries with locations of mountain ranges on Earth's surface. Then students use the physical map and a map of volcanoes and earthquakes to compare locations of collisions at plate boundaries with locations of volcanic and earthquake activity around the world.	• Earth's crustal plates move in different directions, and sometimes they collide or push into each other. Most of Earth's mountains are found where tectonic plates collide. Earthquakes also occur where plates collide.
5 min	**Follow-up to activity:** Students make connections between the graham-cracker collision from lesson 3b and what happens on Earth's surface when crustal plates collide.	• Mountain ranges form when Earth's crustal plates collide. Mountains also form as a result of volcanic eruptions. Hot, slow-moving rock from Earth's interior causes both plate collisions and volcanoes.
15 min	**Synthesize/summarize today's lesson:** Students revisit today's focus question and the Bubble Challenge from lesson 3b. Working with a partner, they revise their ideas about how the movement of Earth's crustal plates is involved in mountain building, earthquakes, and volcanic eruptions on Earth's surface.	• Mountain ranges form when Earth's crustal plates collide. Mountains also form as a result of volcanic eruptions. Hot, slow-moving rock from Earth's interior causes both plate collisions and volcanoes. Earthquakes also occur where plates collide or slide past each other. Evidence from maps of the world show us the relationships between plate movement and mountain building, earthquakes, and volcanoes.
1 min	**Link to next lesson:** The teacher poses a question for students to think about before the next lesson.	

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3 min	**Link to Previous Lesson** **Synopsis:** The teacher reviews ideas about plate boundaries and mountain building from the previous lesson. **Main science idea(s):** • The plates of Earth's crust can collide and form mountain ranges.	Link science ideas to other science ideas.	**Show slide 1.** Today we'll build on what we learned in the previous lesson about Earth's plate boundaries and where mountains might form. **Show slide 2.** Last time we looked at this map of plate boundaries around the world. What did we notice about how Earth's crustal plates move? Think about that for a moment. **NOTE TO TEACHER:** *Display handout 4.1 (Map of Plate Boundaries around the World) on a document reader and ask students to locate their maps from the previous lesson. Direct students to refer to their handouts throughout the following discussion and point out specific locations on the map as they answer the questions on the slide.* **Show slide 3.** So where on the boundary map did we notice Earth's plates moving toward each other and colliding? Where did we notice plates moving side to side or sliding past each other? Where did we notice plates moving apart or away from each other?		

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			What did we decide might happen when two of Earth's crustal plates collide? Today we'll gather more evidence from two new maps. Let's find out whether plate collisions *really* cause mountains to form!	We thought that plate collisions would build mountains.	Tell us more about your ideas.
1 min	**Lesson Focus Question** **Synopsis:** The teacher review the focus question from the previous lesson: *What evidence can we find to support the idea that mountains form when Earth's crustal plates collide?*	Set the purpose with a focus question or goal statement.	**Show slide 4.** Today's focus question is the same question we investigated last time: *What evidence can we find to support the idea that mountains form when Earth's crustal plates collide?* We've gathered some evidence to answer this question, but we need more information to make sure our ideas about plate collisions and mountain are right.		
5 min	**Setup for Activity** **Synopsis:** Students examine a topographic (physical) map of the world and prepare to use it in an activity. **Main science idea(s):** • When plates collide, they can form mountain ranges. Evidence of this is the fact that most of	Make explicit links between science	**NOTE TO TEACHER:** *Distribute handout 4.2 (Physical Map of the World) to each pair of students and direct them to refer to handout 4.1 (Map of Plate Boundaries around the World) from lesson 4a throughout the discussion. Also display a copy of handout 4.2 on a document reader or Smart Board.* **Show slide 5.** So let's see if we can gather more evidence to support the idea that mountain		

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	Earth's mountains are found at the boundaries where tectonic plates collide.	ideas and activities **before** the activity. Select content representations and models matched to the learning goal and engage students in their use.	ranges form when Earth's plates collide. This new map shows where *mountains* are found on Earth. Let's look closely at this map and make sure we understand how to recognize where mountains are located. **NOTE TO TEACHER:** *Point out and discuss the different features of the physical (topographic) map and how to recognize mountains using the elevation scale in the top right-hand corner. Highlight an example or two, and allow time for students to ask questions to make sure they understand how to interpret the map.*		
20 min	**Activity** **Synopsis:** Students use a topographic (physical) map of the world to compare locations of collisions at plate boundaries with locations of mountain ranges on Earth's surface. Then students use the physical map and a map of volcanoes and earthquakes to compare locations of collisions at plate boundaries with locations of volcanic and earthquake activity around the world.	Engage students in analyzing and interpreting data and observations. Make explicit links between science ideas and activities **during** the activity.	**Show slide 6.** **Turn and Talk:** Now I want you work with a partner to compare this physical map of the world with the map of plate boundaries from our last lesson. First, look at where plate collisions occurred on the map of plate boundaries. Then look at the landforms that appear in the same locations on your physical map. Talk about the landforms you observe in these areas on the physical map and decide whether your predictions were correct about what you might see in locations where Earth's plates collide.		

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	Main science idea(s): • Earth's crustal plates move in different directions, and sometimes they collide or push into each other. Most of Earth's mountains are found where tectonic plates collide. Earthquakes also occur where plates collide.		Then complete the sentence on the slide in your science notebooks: *We notice _____ on the physical map where Earth's plates collided on the boundaries map.* **NOTE TO TEACHER:** *Circulate during the pairs work and listen to students' ideas. Are students seeing a pattern on the physical map that shows most mountains are located where tectonic plates collide?* **ELL support:** To make the map comparison easier for ELL students to navigate, hand out sticky notes and have students mark mountain ranges on their plate-boundaries map (handout 4.1). This also gives students something to do while they talk. **Whole-class share-out:** So what landforms did you predict you'd see where Earth's tectonic plates collide? Were your predictions correct? Did you think you'd see mountains? What evidence did the physical map give you to support or challenge your predictions?	Many or most of the mountains on Earth are found where crustal plates are	

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			Did this map give you any evidence that mountain ranges form when Earth's crustal plates collide?	moving toward each other.	Do others agree or disagree? Any ideas to add?
				Yes. The mountain ranges were right at the edges where plates collide. There weren't any mountain ranges in the middle of plates. *[Inaccurate]*	Can you tell us more about that?
					Do others agree that there are no mountain ranges in the middle of plates?
			Show slide 7.		
		Engage students in communicating in scientific ways.	Do you agree or disagree with the statement on this slide? What's your evidence?		
			So can we say with confidence that mountain ranges form when Earth's plates collide?	I agree because our maps prove it!	
			CONTENT NOTE TO TEACHER: *Students might note some exceptions to mountain ranges forming at the boundaries of tectonic plates (e.g., the Ural Mountains in Asia and the Rocky Mountains in the United States). Be prepared to answer questions about this. The Urals are an ancient plate boundary,*	Yes!	

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		Select content representations and models matched to the learning goal and engage students in their use.	*and the Rockies actually formed as a result of the shallow subduction angle of the Pacific–North American plate boundary that extended the collision far inland.* The physical map provides some evidence that plate collisions are involved in mountain building, but let's look at another map to see if we can gather more evidence. **NOTE TO TEACHER:** *Distribute handout 4.3 (Volcanoes and Earthquakes around the World) to each pair of students. Also display a copy of this handout on a document reader for students to refer to throughout the activity.* **Show slide 8.** This map shows where volcanoes and earthquakes are located on Earth. The black triangles represent volcanoes, and the red triangles represent earthquakes. **Show slide 9.** **Turn and Talk:** Work with your partner to compare these two maps and discuss your observations. What patterns do you notice when you compare the two maps?		

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		Engage students in analyzing and interpreting data and observations.	What do you notice about the locations of volcanoes and earthquakes? Record these patterns in your science notebooks. **NOTE TO TEACHER:** *Students may notice hotspots—places in the middle (interior) of tectonic plates where volcanoes form when the upper mantle pushes through the crust. But the majority of earthquakes and volcanoes are found along plate boundaries.* **Whole-class discussion:** So what patterns did you notice when you compared these two maps? What did you notice about the locations of volcanoes and earthquakes?	All the earthquakes and volcanoes happen at plate boundaries. *[Inaccurate]* There's a plate boundary in California, and there are lots of earthquakes here. But there are volcanoes in the middle of the Pacific Ocean.	Can you say more about what you mean by "all"?

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			Show slide 10. Now that we've gathered more evidence from our three maps, what do you think about plate collisions? Are they involved in building mountains? What's your evidence from the maps?	Earthquakes are located along the edges of crustal plates. They happen when these plates move.	Do you have any ideas about why that happens? Can anyone add to these ideas?
5 min	**Follow-Up to Activity** **Synopsis:** Students make connections between the graham-cracker collision from lesson 3b and what happens on Earth's surface when crustal plates collide. **Main science idea(s):** • Mountain ranges form when Earth's crustal plates collide. Mountains also form as a result of volcanic eruptions. Hot, slow-moving rock from Earth's interior causes	Make explicit links between science ideas and activities **after** the activity. Engage students in analyzing and interpreting data and observations.	**Show slide 11.** **NOTE TO TEACHER:** *Display page 2 of handout 3.4 (Graham-Cracker Collision) on a document reader during this discussion.* How are these graham-cracker "plates" *like* and *not like* the crustal plates on the map of plate boundaries?	The plates of Earth's crust can collide with each other and get bent up just like the graham crackers. The collisions of Earth's plates make	Can anyone add to this idea?

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	both plate collisions and volcanoes.	Ask questions to elicit student ideas and predictions.	Mountain ranges can form when Earth's crustal plates crash into each other. Do you think these mountains always become volcanoes?	mountain ranges. But do Earth's plates get soggy at the edges like the graham crackers? Plates that collide don't always have lava. They just crash into each other. But plates move because of the hot, slow-moving rock underneath them. That's kind of like volcanoes. Mountains that form when plates collide are just crumpled rock like the graham crackers. They don't erupt like volcanoes or have hot lava that turns into layers of rock that builds mountains when it cools.	Does anyone agree, disagree, or have something to add?
			So when Earth's plates collide, sometimes they form volcanoes, and sometimes they		

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			just crumple up like the graham crackers and form mountain ranges. **Show slide 12.** When plate collisions build up Earth's surface, this is called this *uplift*. Forces inside Earth are *lifting up* the crust. Volcanoes and mountains formed by uplift happen in different ways, but in both cases, the hot, slow-moving rock from Earth's interior is involved. **NOTE TO TEACHER:** *A graphic showing uplift might be helpful here. This could be displayed on a classroom wall for students to refer to. To grasp the concept, students could simulate uplift individually or in pairs. It may also be useful to help students understand how the noun* uplift *relates to the action verb* lift up*. Nominalization (verbs changing to nouns) happens a lot in science. To support students in understanding the process better, you may want to change terms like* plate movement *or* plate collisions *into action verbs.* **Show slide 13.** Now let's review some important science ideas about earthquakes and volcanoes: • Earthquakes happen along fault lines when tectonic plates collide or		
		Summarize key science ideas. Link science ideas to other science ideas.			
		Highlight key science ideas and focus question throughout.			

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			slide past each other. • Most earthquakes and volcanoes occur at plate boundaries, but sometimes they happen in the middle or interior of a plate. Volcanoes that happen at interior locations are called *hotspots*. • Fault lines are cracks in Earth's crust that occur at plate margins and in the middle (interior) of plates. • All plate boundaries are faults, but not all faults are plate boundaries.		
15 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** Students revisit today's focus question and the Bubble Challenge from lesson 3b. Working with a partner, they revise their ideas about how the movement of Earth's crustal plates is involved in mountain building, earthquakes, and volcanic eruptions on Earth's surface. **Main science idea(s):** • Mountain ranges form when Earth's crustal plates collide. Mountains also form as a result of volcanic eruptions. Hot,	Highlight key science ideas and focus question throughout.	**Show slide 14.** Today we compared three different maps of the world and gathered a lot more evidence about the relationship between mountain formation and the movement of Earth's tectonic plates. Let's revisit our focus question, *What evidence can we find to support the idea that mountains form when Earth's crustal plates collide?* Based on everything you've learned from our map investigations, how would you answer this question now? What evidence from the three maps supports the idea that mountains form when Earth's plates collide? **NOTE TO TEACHER:** *If time allows, encourage students to write one or two*	Most of the mountain ranges on Earth are located where plates come together.	What's your

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	slow-moving rock from Earth's interior causes both plate collisions and volcanoes. Earthquakes also occur where plates collide or slide past each other. Evidence from maps of the world show us the relationships between plate movement and mountain building, earthquakes, and volcanoes.	Engage students in making connections by synthesizing and summarizing key science ideas.	*sentences in their science notebooks about the evidence they have to support the key science idea that mountains form when Earth's plates collide. If time is running short, just have them share their answers to the focus question in a class discussion, but make sure students support their ideas with evidence from the three maps.* **Show slides 15 and 16.** *Embedded Assessment Task* Before we end today's lesson, let's return to our Bubble Challenge from lesson 3b. Working with a partner, I'd like you to revise your bubble maps showing what happens when tectonic plates collide, move apart, or slide past each other. Where would you find mountains, volcanoes, and earthquakes? What's your evidence? **Pairs work on their bubble maps.** **Whole-class share-out:** Let's share our ideas. How did you revise your bubble maps? Where would you expect to find mountains, volcanoes, and earthquakes?		evidence from the maps?

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			What's your evidence? **NOTE TO TEACHER:** *If possible, display some of the bubble maps using a document reader or Smart Board. Students should have strong evidence to support their thinking about what happens when plates collide, move apart, and move side to side. Encourage them to provide evidence from the three maps. Students' understandings might not be complete, but they should understand more at the end of this lesson than they did at the end of lesson 3b.*		
1 min	**Link to Next Lesson** **Synopsis:** The teacher poses a question for students to think about before the next lesson.	Link science ideas to other science ideas.	**Show slide 17.** Here's an interesting question I want you to think about before our next lesson: *If plate collisions form mountains and cause them to grow taller, can mountains eventually grow so tall that they reach outer space?*		