imagine learning | twig SCIENCE

Earthquake Engineering









Twig Book

GRADE 4
MODULE 4

Name

_____

Earthquake Engineering



GRADE **4**
MODULE **4**

Module Anchor Phenomenon

How can we reduce the damage caused by earthquakes?

Key Investigative Phenomena

- What causes earthquakes?
- How can we measure the energy of a wave?
- What is a tectonic plate?
- Where do most earthquakes happen?
- How can we use patterns to predict earthquake events?
- Can we make earthquake-resistant structures?

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Lesson Types

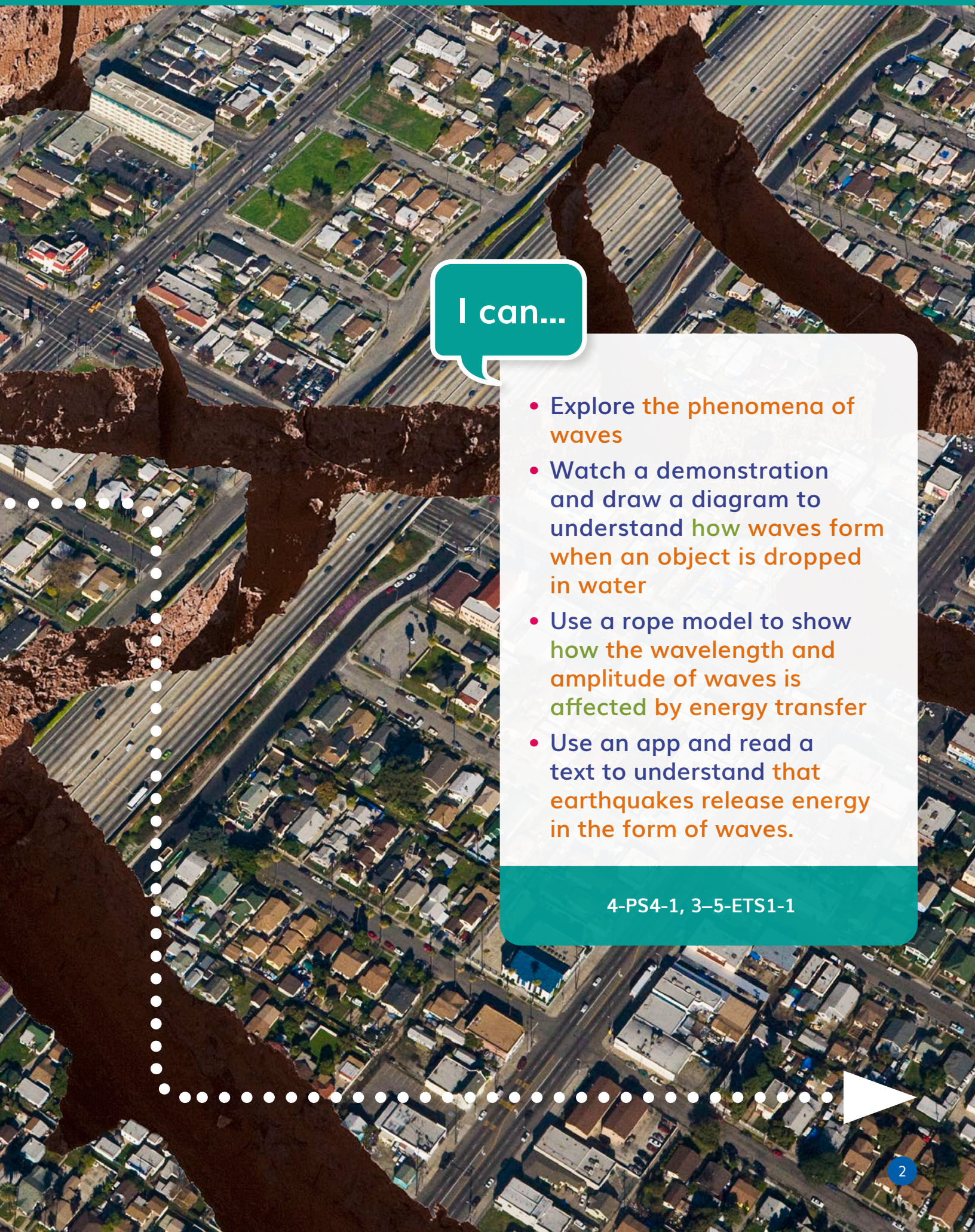
Digital Investigation
Hands-On Investigation
Reading for Evidence
Assessment
Video Investigation



EARTHQUAKE ENGINEERING

Driving Question 1

How are waves involved in earthquakes?



I can...

- Explore the phenomena of waves
- Watch a demonstration and draw a diagram to understand how waves form when an object is dropped in water
- Use a rope model to show how the wavelength and amplitude of waves is affected by energy transfer
- Use an app and read a text to understand that earthquakes release energy in the form of waves.

4-PS4-1, 3–5-ETS1-1

LESSON 1

My House Collapsed!

Hands-On

Develop Models • Create a structure using newspaper and tape.

Criteria

- **Build the tallest structure you can.**

Constraints

- **You only have 10 minutes.**
- **You can only use newspaper and tape.**
- **The structure can't lean against anything.**
- **The structure must stand by itself for at least 3 minutes after the building time is over.**



Reflect

LESSON 1

Fill in the Know and the Wonder columns of the KLEW chart about earthquakes, tsunamis, and volcanoes, and their impact on humans.

Know	Learned	Evidence	Wonder

Word Wall

- natural disaster
- earthquake
- tsunami
- volcano

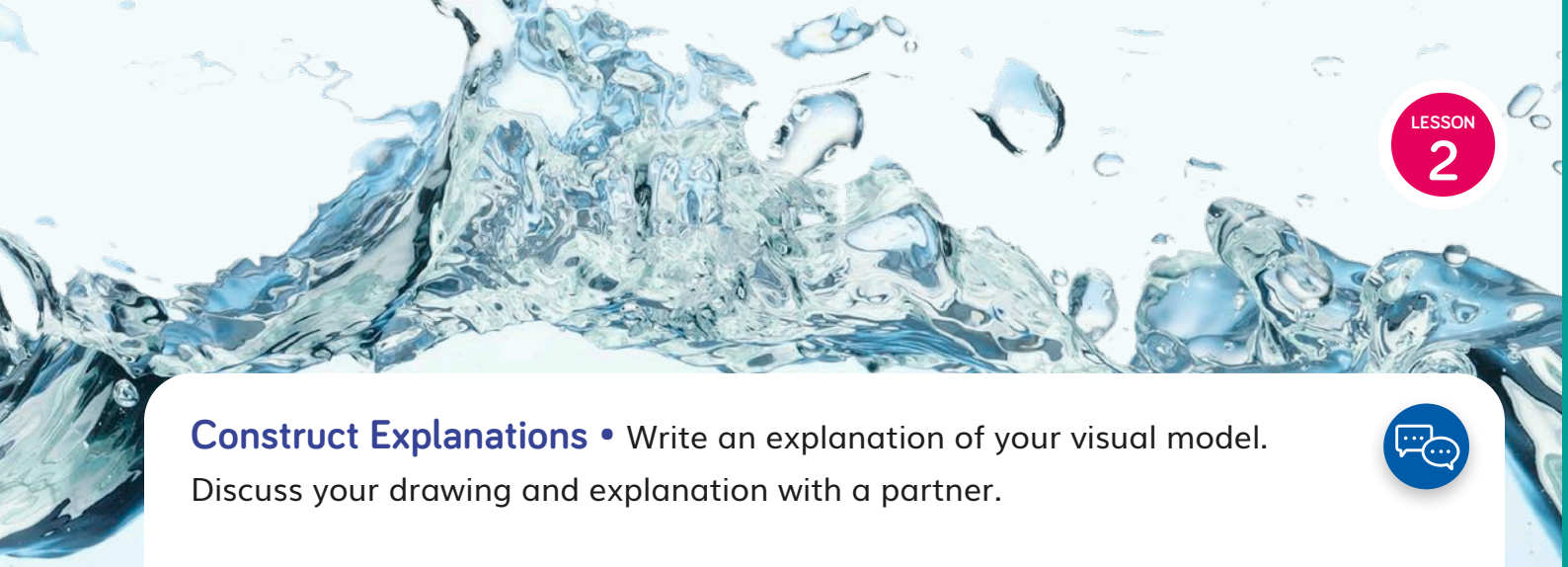
LESSON 2

Making Waves

Hands-On

Make Observations • Describe what you observed when the rock was dropped in water.

Develop Models • Draw a visual model (a diagram of waves in water) to show what happened during the demonstration and the **Raindrops video**.



LESSON 2

Construct Explanations • Write an explanation of your visual model. Discuss your drawing and explanation with a partner.

Word Wall

- energy transfer
- waves
- point of impact

Reflect

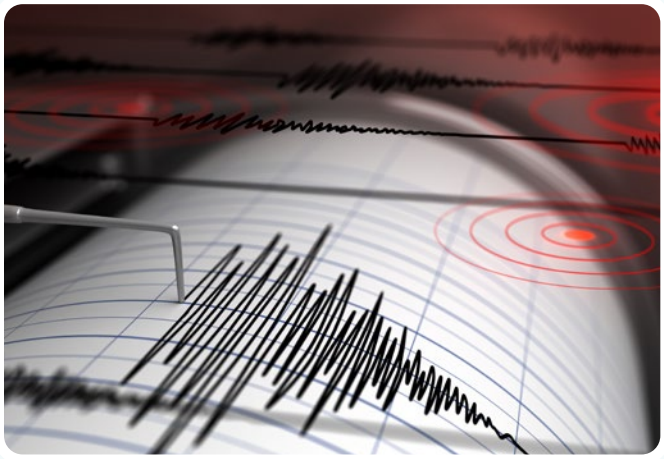
Develop Models • Consider how your understanding of waves has changed and revise your visual model.

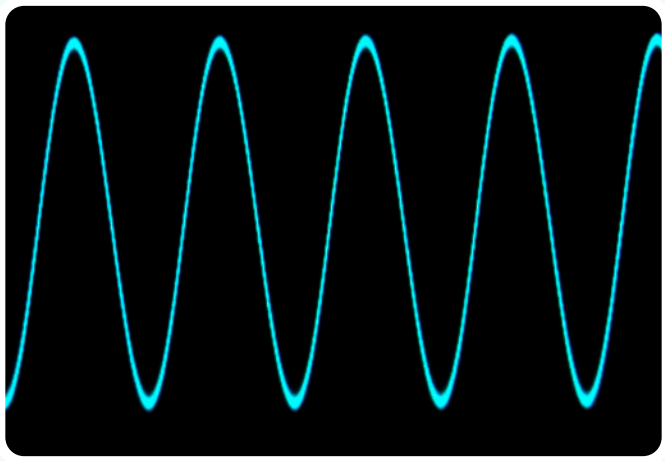
LESSON 3

Learning the Ropes

Hands-On





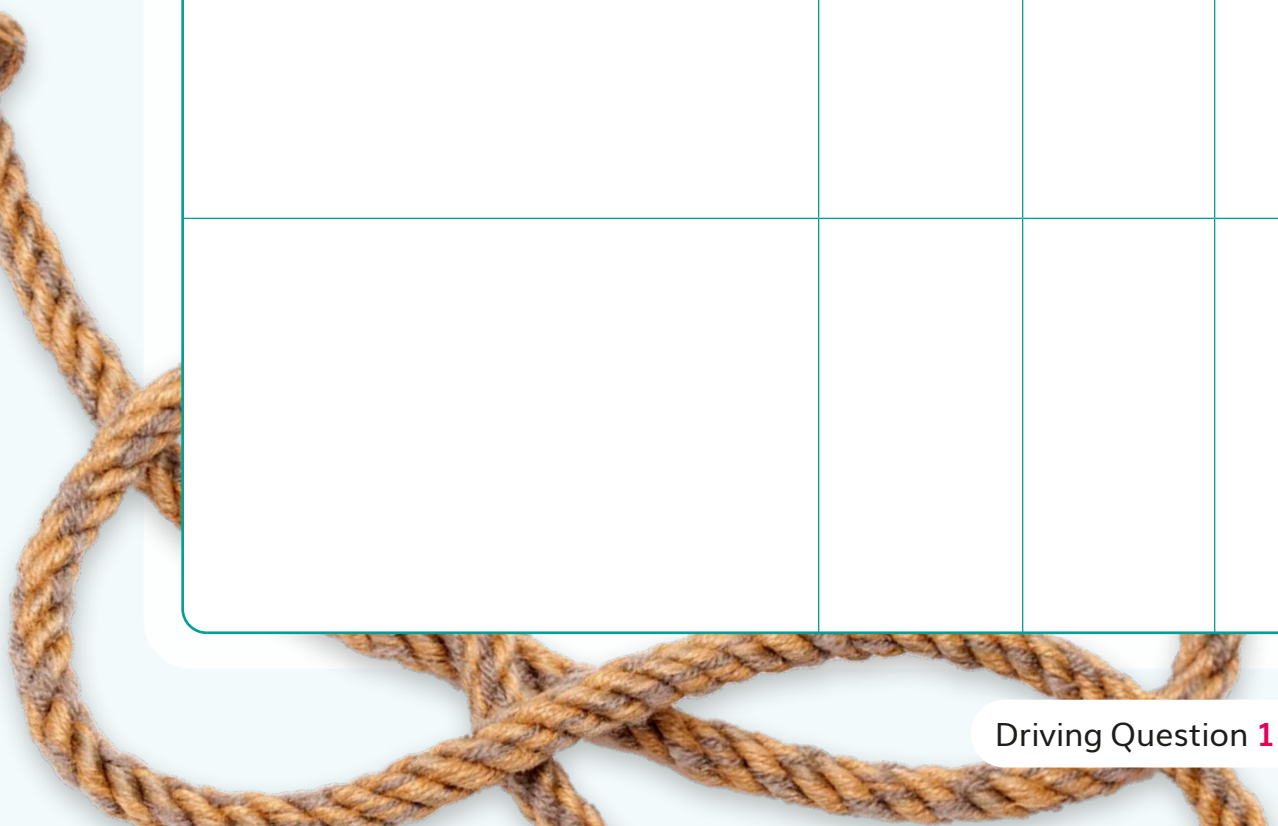




Make Observations • Describe what you observe in the wave images.

Carry Out Investigations • Use a rope to investigate waves.
Measure the approximate height, length, and number of the waves.

Observations	Height	Length	Number of Waves



LESSON 3

Make Observations • Draw pictures of the different wave movements you made, and then:

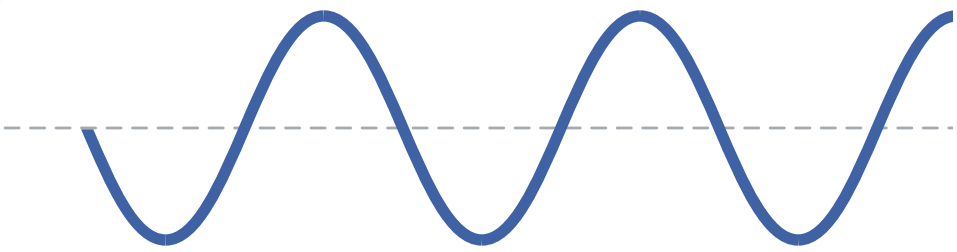
- Write your observations
- Explain what you did to create the wave.

Reflect

Label the amplitude and wavelength on the wave below.

Word Wall

- amplitude
- wavelength



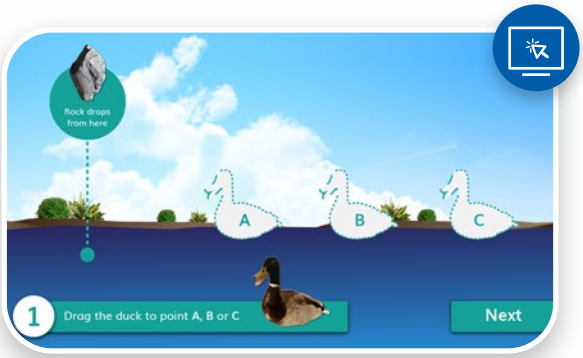
Digital Investigation

Rocks and Ducks

LESSON 4

Carry Out Investigations • Use the **Making Waves interactive** to explore waves. Note the variables for testing:

- Two different rock sizes—small and large
- Three different positions for the duck—A, B, and C



Answer the following questions to guide your exploration.

1. What combination of rock size and duck position causes the duck to move the most?

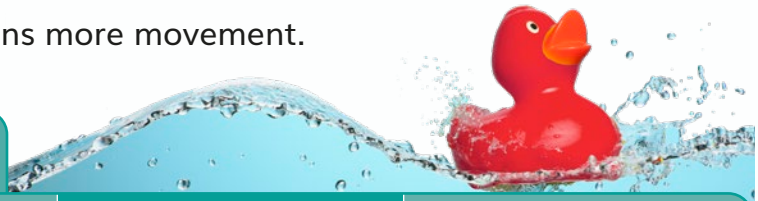
2. What combination of rock size and duck position causes the duck to move the least?

3. Are there different combinations of rock size and duck position that have the same outcome?

LESSON 4

Collect Data • When you have finished using the **Making Waves interactive**, complete the Wave Comparison chart with the amplitude value that shows on screen for each test.

Remember that a higher value means more movement.



Wave Comparison

	Position A	Position B	Position C
Small Rock			
Big Rock			

Write your observations about the amplitude of waves.

Challenge

You explored the **Making Waves interactive** and tested whether the size of the rock and the position of the duck affect the motion of the duck.

In groups, discuss one or two additional questions about waves that you would like to test and investigate. If you tested these questions, what do you think the results would be?



Reflect

LESSON 4

Develop Models • Earthquakes travel through the ground as waves from a point of initial fracture. This is just like where the rock was dropped in the **Making Waves interactive**.

Use what you've learned about waves to:

- Draw a diagram that shows the wave pattern from an earthquake caused by a large fracture
- Draw a diagram that shows the wave pattern from an earthquake caused by a small fracture.

Large Fracture Earthquake Waves

Small Fracture Earthquake Waves

Construct Explanations • Explain your diagrams. Why did you draw what you did?

LESSON 5

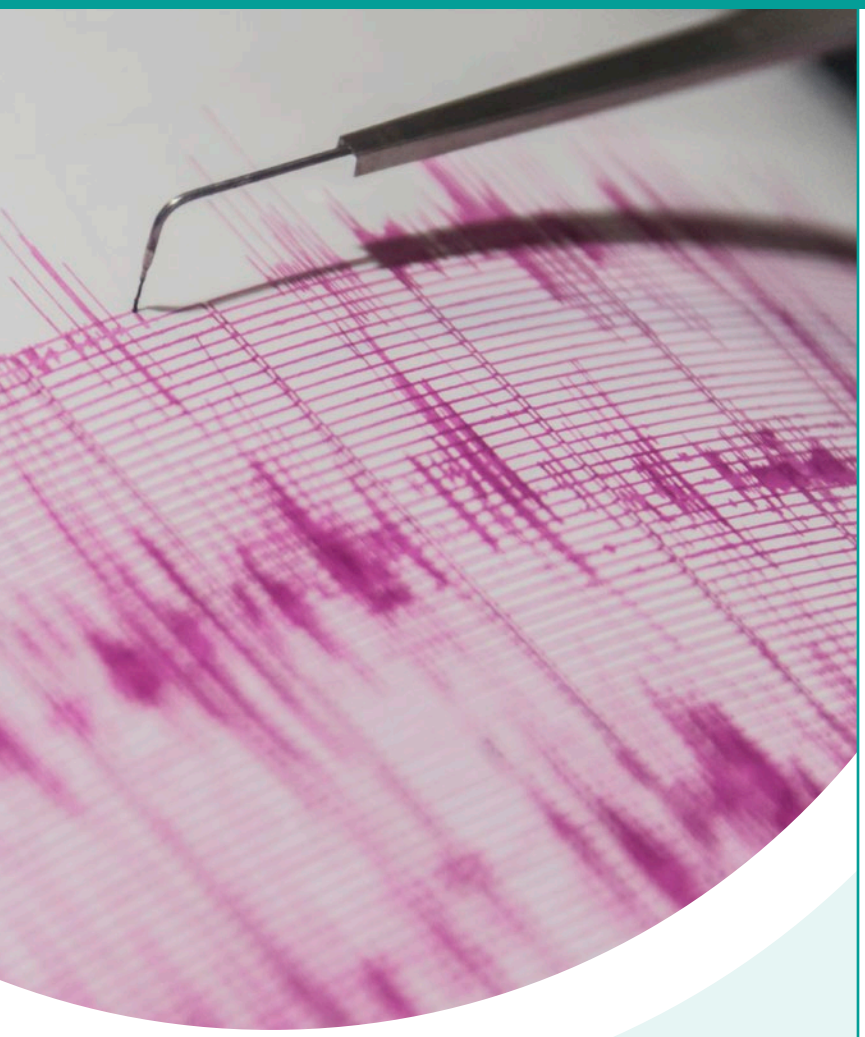
HOW BIG WAS THAT EARTHQUAKE?

Read this article on your own or with a partner. Then fill out the Magnitude Scale chart.

Earthquakes can vary in size. Some are very powerful, while some we can barely feel. To measure earthquakes, scientists use a tool called a **seismometer**. A seismometer detects how much the ground moves during an earthquake, which helps scientists estimate an earthquake's size or **magnitude**, and classify it on a scale.

Earthquakes that measure a 1.0 on the scale are the weakest. People don't realize they're happening because they can't feel them. Even seismometers can struggle to pick up earthquakes with a magnitude of 1.0. From here, each point you go up on the scale increases the amplitude of the earthquake's waves 10 times more than the magnitude below it. So an earthquake that measures 2.0 produces waves with an amplitude 100 times bigger than a 1.0 earthquake. A 2.0 earthquake may make an impact on the surface, causing trees to sway or doors to swing. But it may still be difficult for people to recognize that an earthquake is causing that movement.

Earthquakes that register higher up on the scale are more noticeable to people on the ground. A 3.0 earthquake can cause the light fixtures in a house to sway. If you're on the upper floor of a building, you might feel the earthquake as it happens. At 4.0, an earthquake makes buildings shake lightly as if a big truck is passing by.



An earthquake with a magnitude over 5.0 (or about 10,000 times higher-amplitude seismic waves than a 1.0 earthquake) hit Oklahoma in 2016. It was felt in six surrounding states. In Pawnee, Oklahoma, it caused serious damage to a historic building. "It's still standing," Pawnee Mayor Brad Sewell told CNN, "but some of the outer layers of sandstone fell." At this magnitude, doors can move, glasses and dishes might rattle, and windows can break. Cars may even sway back and forth like rocking chairs.

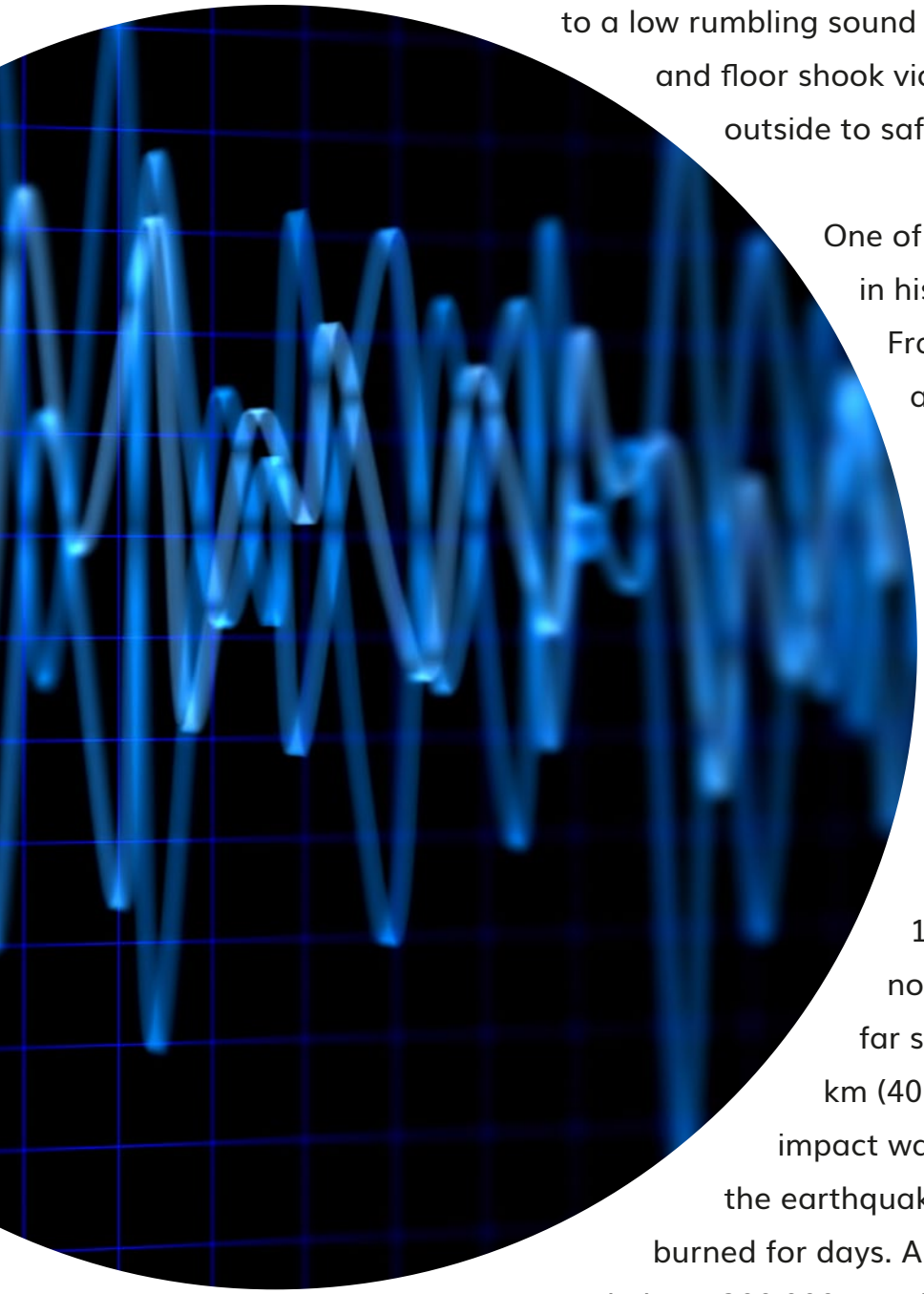
NOTES

Word Wall

- seismic waves

LESSON 5

An even stronger earthquake happened in Italy in 2016. It measured 6.2 in magnitude and killed about 300 people. In this kind of earthquake, objects in a house can fall from shelves and walls can crack. Lewis Sanders IV was more than 48km (30 mi.) from the epicenter of the earthquake. He was still shaken. Sanders later wrote that he woke in the middle of the night to a low rumbling sound and his wife yelling. His walls and floor shook violently. He and his family rushed outside to safety.



One of the most famous earthquakes in history was centered near San Francisco in 1906. On April 18 at 5:12 am, the ground started rumbling. About 25 seconds later, the earthquake started. It lasted between 45 and 60 seconds, and its magnitude was measured at 7.7. At that size, an earthquake is known to knock down weak buildings, shake roads, and cause cracks in the ground. The 1906 earthquake was felt as far north as Southern Oregon and as far south as Los Angeles, about 644 km (400 mi.) away. But the biggest impact was in San Francisco itself, where the earthquake caused a number of fires that burned for days. Almost 3,000 people were killed and about 200,000 people were left homeless. Photos from the aftermath show entire city blocks turned into piles of smoking debris.

At 8.0 and above, an earthquake can do even more damage. These quakes are 10 million times as strong as 1.0 earthquakes. One 8.0 earthquake occurred in China in 2008. Almost 90,000 people were killed. The earthquake wiped out entire towns in the mountainous region of Sichuan, since nearly all the buildings were destroyed.

Believe it or not, there have been even bigger earthquakes than this. Some of them are classified as 9.0 or greater. That's 100 million times higher-amplitude seismic waves than a 1.0 earthquake and it results in near total destruction in the affected area. Usually, these 9.0+ earthquakes occur out at sea, so the greatest destruction comes from tsunamis. But one of these earthquakes hit Alaska in 1964. At 9.2, it was one of the most powerful earthquakes ever recorded. It twisted train tracks, collapsed roads, and wiped out neighborhoods. It also caused a number of tsunamis, including one wave that was measured at over 219 ft. tall.

Earthquakes like the one in Alaska are rare, though. While there are earthquakes happening every day around the world, very few even come close to a 9.0. Most are far less severe, or aren't felt at all.

NOTES

LESSON 5

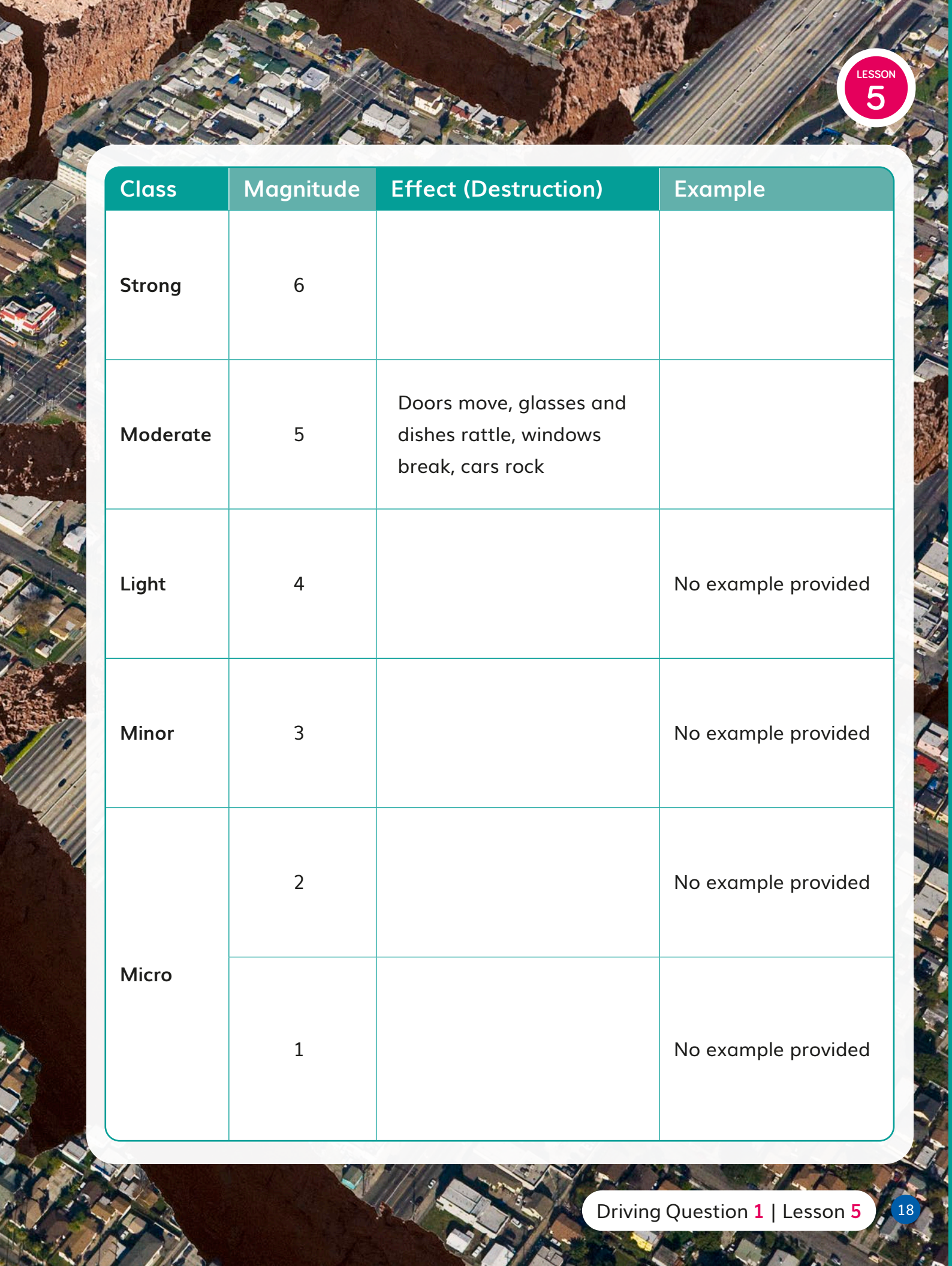
How Big Was That Earthquake?

Reading for Evidence · Hands-On

Collect Data • Use information from "How Big Was That Earthquake?" to fill in the missing sections of this Magnitude Scale chart. Include details for the examples, such as the location, year, and magnitude of the earthquake, where provided in the article.

Magnitude Scale

Class	Magnitude	Effect (Destruction)	Example
Great	10	Results in near total destruction	No example provided
	9	Results in near total destruction	
	8		
Major	7	Ground cracks, roads shake, weak buildings destroyed, others badly damaged	



Class	Magnitude	Effect (Destruction)	Example
Strong	6		
Moderate	5	Doors move, glasses and dishes rattle, windows break, cars rock	
Light	4		No example provided
Minor	3		No example provided
Micro	2		No example provided
	1		No example provided



LESSON 5

Pre-Exploration

True or False • Read the following statements. Put a check mark by each statement that you think is true.

- Earthquakes are rare events. ☐
- Earthquakes often occur near oceans and mountain ranges. ☐
- All earthquakes are caused by erupting volcanoes. ☐
- Some areas on Earth experience more earthquakes than others. ☐
- Small earthquakes happen every day. ☐
- Earthquakes are most deadly when they cause the ground to open up as people, animals, plants, and buildings can fall into openings and disappear. ☐
- Earthquakes are equally likely to happen anywhere on Earth. ☐

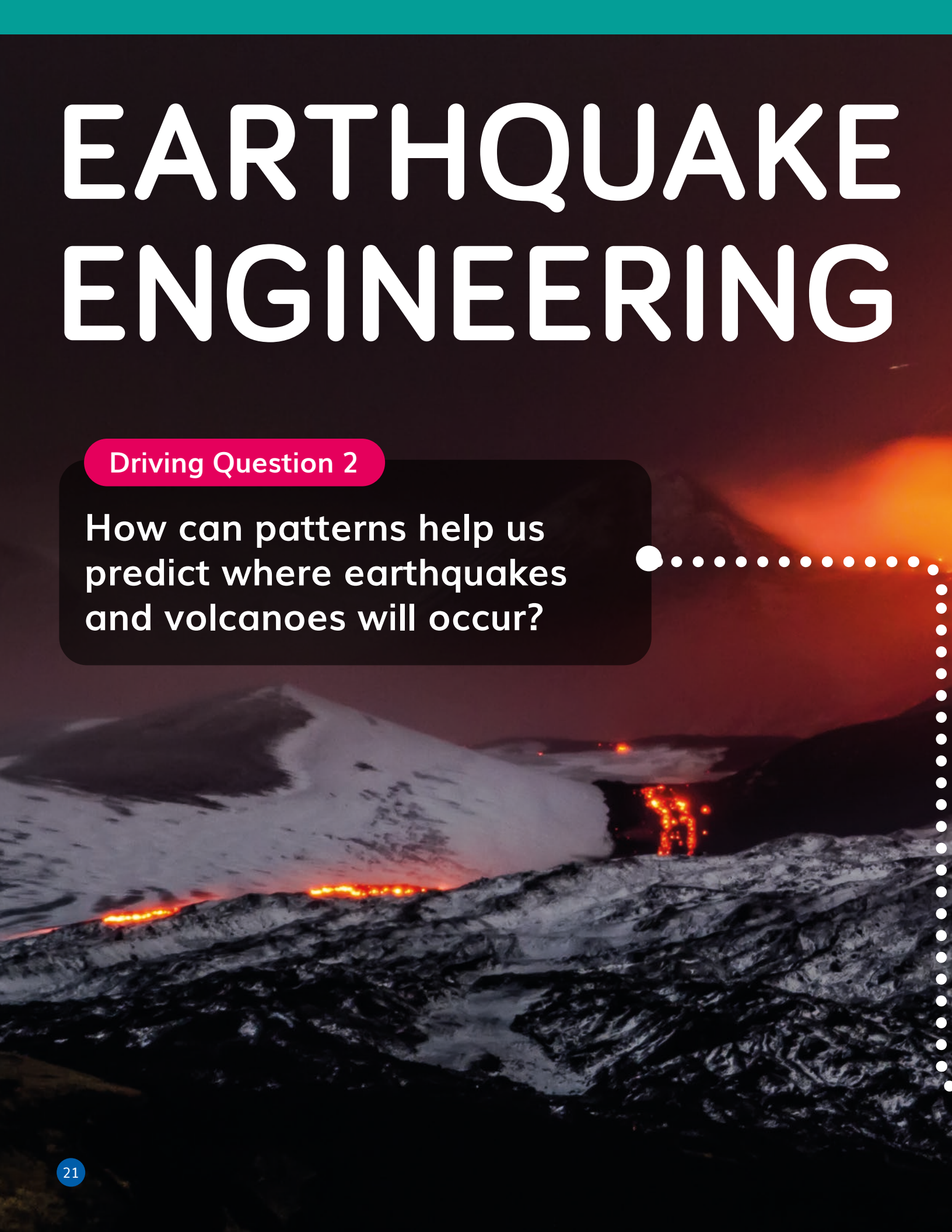
Construct Explanations • Do you think we can see any patterns in when and where earthquakes occur? Give details.

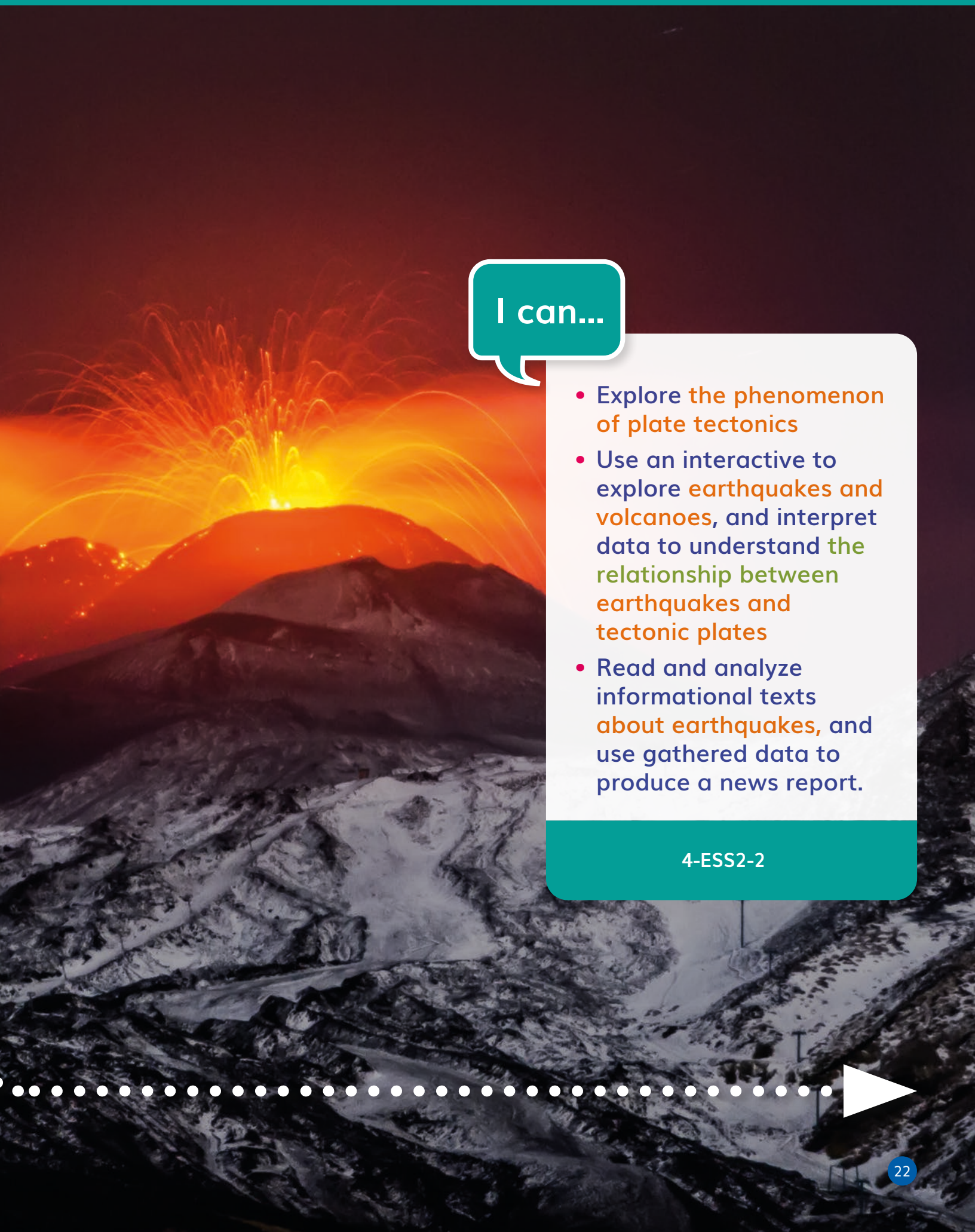

LESSON
5

EARTHQUAKE ENGINEERING

Driving Question 2

How can patterns help us predict where earthquakes and volcanoes will occur?





I can...

- Explore the phenomenon of plate tectonics
- Use an interactive to explore earthquakes and volcanoes, and interpret data to understand the relationship between earthquakes and tectonic plates
- Read and analyze informational texts about earthquakes, and use gathered data to produce a news report.

4-ESS2-2

LESSON 1

Explore the World

Digital Investigation

Make Observations •

Look at the **Earth Explorer interactive.**



- Open up different views and make observations of patterns in earthquakes, volcanoes, and mountain ranges. Discuss the patterns you find.
- Describe the patterns you see and give examples from the data. Find as many patterns as you can.

Patterns	Examples

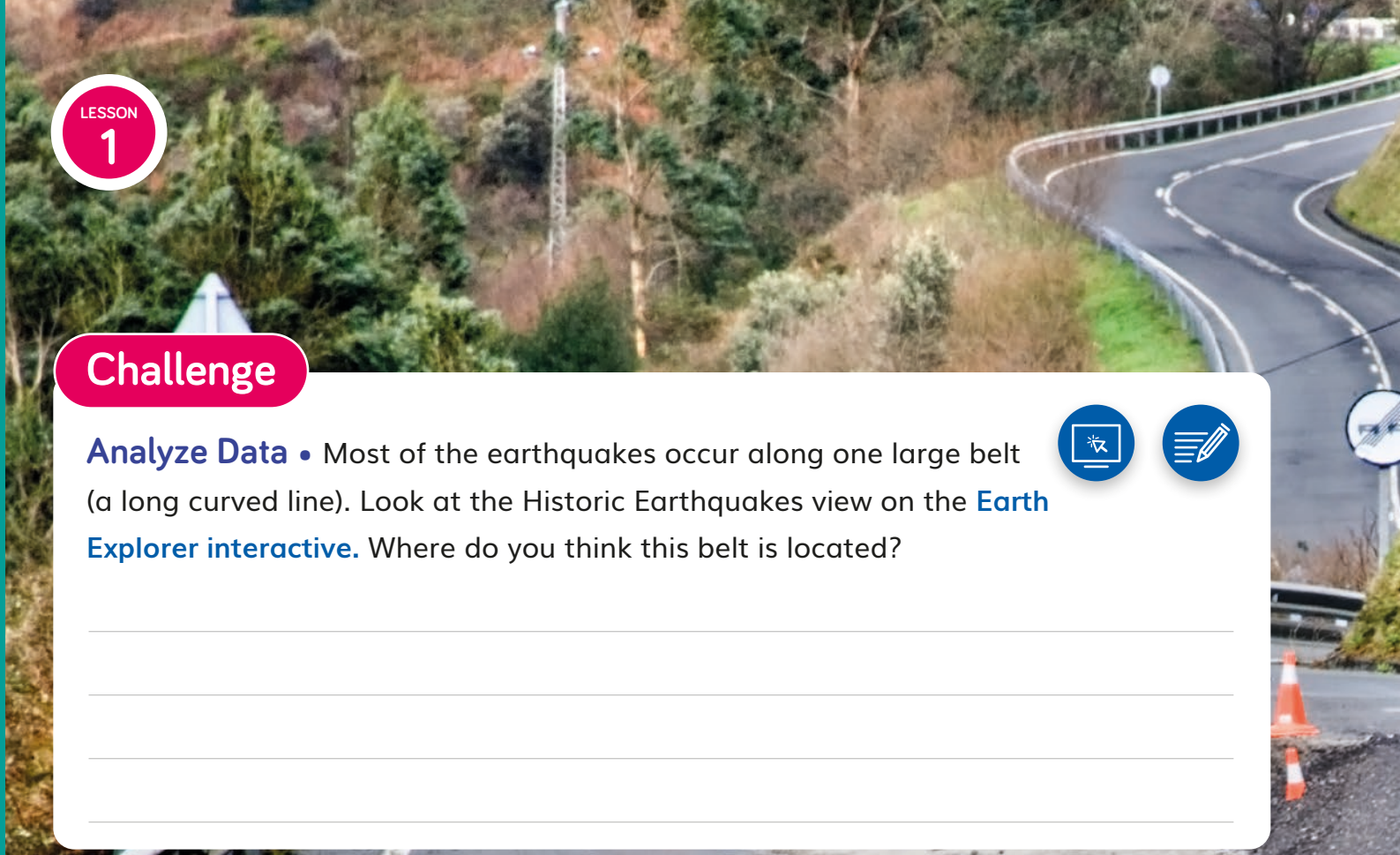
LESSON 1

Patterns	Examples

Analyze Data • Write about one pattern that you think is interesting.



1. Describe the pattern.
2. Give data that shows the pattern.
3. Explain why you think it's interesting.
4. Write any questions that you have about the pattern.



LESSON 1

Challenge

Analyze Data • Most of the earthquakes occur along one large belt (a long curved line). Look at the Historic Earthquakes view on the **Earth Explorer interactive.** Where do you think this belt is located?

Word Wall

- ocean
- Pacific Ocean
- Atlantic Ocean
- Ring of Fire
- elevation
- mountain range
- belt
- pattern
- tectonic plates

Reflect

Draw Conclusions • How might knowing where earthquakes happen help us answer the Module Anchor Phenomenon, **"How can we reduce the damage caused by earthquakes?"**

Digital Investigation

An Earthquake is Born

LESSON 2

Make Claims • What causes earthquakes?

Make Observations • Select the Tectonic plates view on the **Earth Explorer interactive**. Write down what you observe about tectonic plates.

Select the Tectonic plates and Historic Earthquakes views on the **Earth Explorer interactive**. Write down what connections you observe between them.

Word Wall

- fault
- fault line

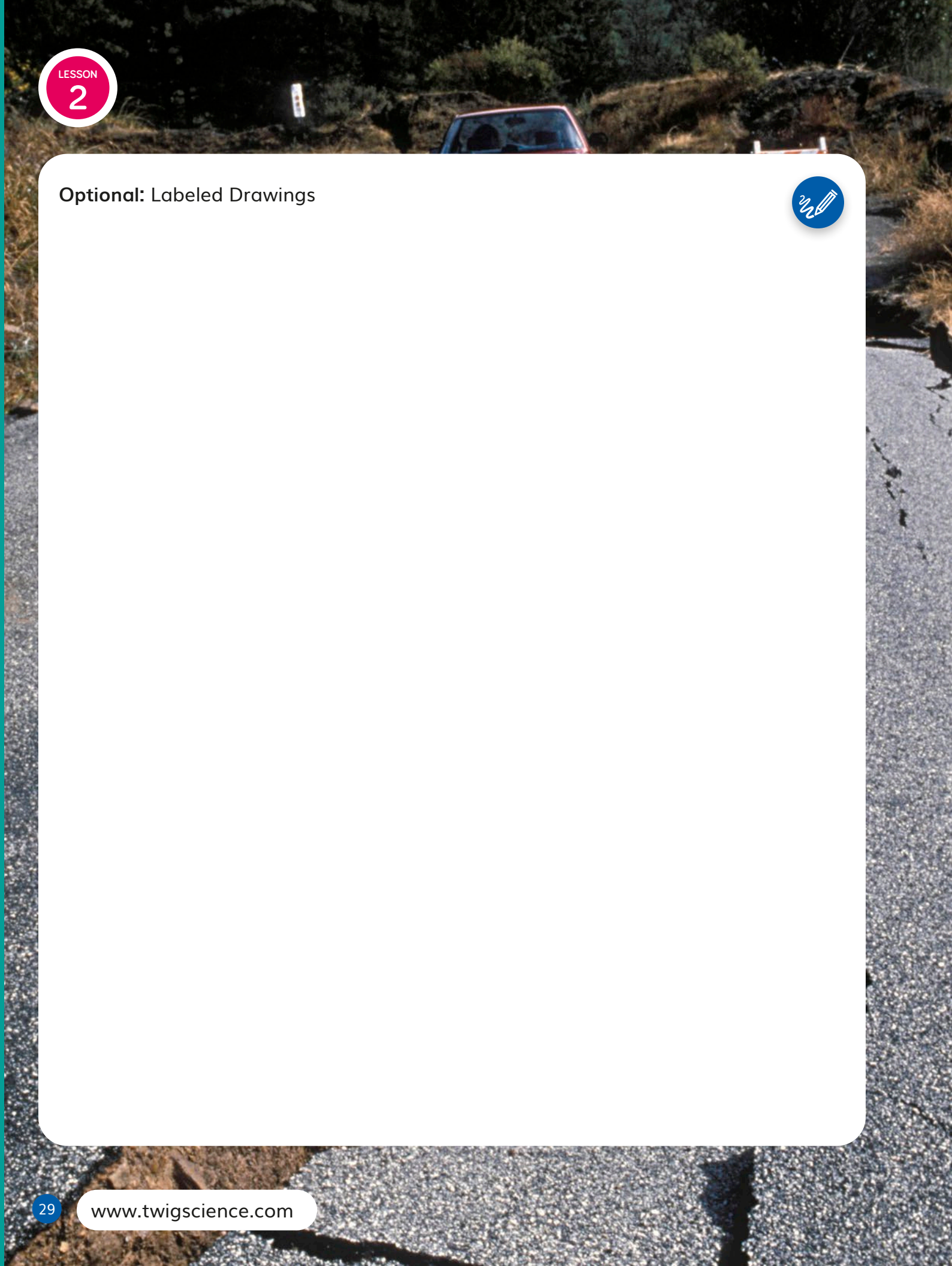
LESSON 2

Argue from Evidence • Based on what you discovered in the **Earth Explorer interactive** and the **Why Earthquakes Happen video**, revise your claim about what causes earthquakes. Include evidence from both the video and the interactive.

Reflect

Earthquake Patterns Graphic Organizer

Claim	
Earthquakes are caused by	
Evidence	**Reasoning**
On the map, I observed	I know that
Some examples are	
Other evidence includes	



LESSON 2

Optional: Labeled Drawings

Digital Investigation

Little Earthquake, Where Are You?

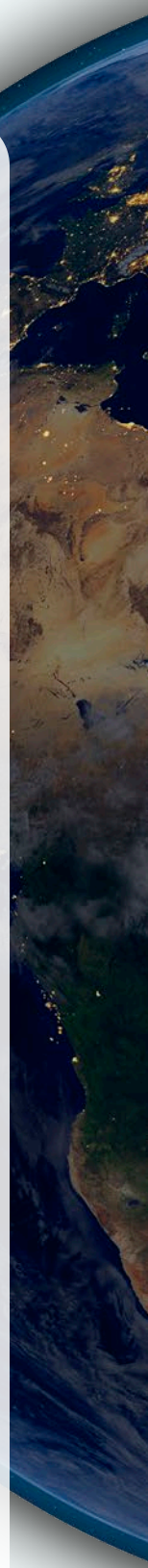
LESSON 3

Obtain Information • Using the **Where On Earth Are You? video** and what you discussed in class, write definitions of the following terms.

Latitude:

Longitude:

LESSON 3



Obtain Information • Answer the following questions using the **Earth Explorer interactive.**

1. How is magnitude shown for each earthquake?

2. Do the locations of yesterday's earthquakes follow the patterns you saw in the previous lesson? Why or why not?

3. Does anything about the locations of the earthquakes surprise you?

4. What area had the most earthquakes based on the data you entered?

LESSON 3

Make Observations •

Take notes while your classmates share their observations.

Reflect

Argue from Evidence • Based on the patterns you have noticed, what parts of the world have both the greatest frequency **and** highest magnitude of earthquakes? Explain your thinking.

Word Wall

- latitude
- longitude

LESSON 4



CALIFORNIA EARTHQUAKES

Read the text carefully. Remember to:

- **Circle key words**
- **Underline confusing words or sentences**
- **Write the strategy you tried when you didn't understand (such as visualize, summarize, or context clues)**
- **Add drawings or notes to remember important facts and ideas.**

The Earth can shake, rattle, and roll. If you live in California, you've heard about earthquakes. Maybe you've even felt an earthquake. California experiences more than 10,000 earthquakes each year, according to the United States Geological Survey. But most of these are too small for humans to feel. Only two or three reach magnitude 5.5, the point where they cause damage to buildings.

As scientists have learned more about earthquakes, the way that they record earthquake magnitude has changed. The Richter scale was developed in the 1930s to compare the sizes of earthquakes in Southern California. In the 1970s, the moment magnitude scale was introduced to describe the energy released by an earthquake.

While most earthquakes are barely noticeable to us, some have done great damage. Here are the stories of some of the most powerful and well-known earthquakes in California history.



San Francisco: April 18, 1906

While not the biggest, this magnitude 7.8 earthquake is perhaps the best known of all of California's earthquakes. The "Great Quake" of 1906 struck early in the morning. Its epicenter was near San Francisco. Yet tremors caused by the movement of the San Andreas Fault were felt from Southern Oregon to Southern California, and inland to central Nevada. More than 80% of the city was damaged. This damage was caused by the movement of the fault, followed by fires that raged afterward. Some estimates placed the number of deaths from the earthquake and fires at around 700, but now we think the number is at least 3,000. To this day, the 1906 San Francisco earthquake remains one of the worst natural disasters in US history.

NOTES

LESSON 4

Loma Prieta: October 17, 1989

The Loma Prieta earthquake took place on October 17, 1989, at 5:04 pm. It is known as the World Series Quake. The Oakland Athletics and the San Francisco Giants had both made it to the World Series. Just before the game started, the pregame show was interrupted by tremors—the live television feed went black. The 6.9 magnitude earthquake, centered near Loma Prieta Peak in the Santa Cruz Mountains, collapsed portions of the interstate. It also caused severe destruction to parts of San Francisco, 113 km (70 mi.) away—San Francisco's Marina district was badly damaged. Monterey Bay, Santa Cruz, Watsonville, and Los Gatos were also affected. More than 60 deaths were reported in total. The property damage was so severe that the Loma Prieta earthquake was recorded as the most expensive natural disaster to ever occur in the United States at the time.

Northridge: January 17, 1994

On January 17, 1994, at 4:31 am, a 6.7 magnitude earthquake struck a heavily populated area of Los Angeles. The Northridge Quake is named after the community near its epicenter. Tremors were felt as far away as Las Vegas, Nevada, and Baja California. The earthquake was caused by a sudden break in a previously unknown fault. It lasted only eight seconds, but in that short time, buildings, shopping centers, and parking garages were badly damaged. Portions of major freeways collapsed, and every building on the Cal State Northridge campus was damaged. When it was over, the earthquake had caused extensive property damage—the most costly in US history. Since the earthquake occurred very early in the morning on Martin Luther King Jr. Day, many people were still in bed. This may have reduced the number of deaths. Nonetheless, 57 people died and thousands of people were injured.



San Francisco (North Bay Area): August 24, 2014

Measuring 6.0 on the magnitude scale, the 2014 South Napa earthquake was the largest to strike the San Francisco Bay Area since Loma Prieta in 1989. It started at 3:20 am, when a part of the West Napa Fault opened. The tremors were felt as far away as the Nevada border. The earthquake caused substantial damage to many older, historical buildings, making them unsafe and uninhabitable. The streets were covered in rubble and broken glass. Major fires broke out, and firefighters struggled to put them out quickly because the earthquake had damaged the water mains. Farther away from the city center, newer buildings escaped most of the damage.

NOTES

LESSON 4

However, many homes were left without electricity because of the damage caused to power lines. Although it was large, the South Napa earthquake only caused 200 injuries and one death. This was significantly lower than the number of casualties caused by Loma Prieta.

California Earthquake Map

The locations of some of the most destructive earthquakes in California history give scientists and engineers information about where earthquake-resistant buildings are most needed.



Glossary

aftershock	a smaller earthquake that follows the largest shock of an earthquake
earthquake	the sudden movement of the Earth along a fault and the shaking and release of energy caused by that movement
epicenter	the point on or under the Earth's surface, directly above the focus, where the earthquake began
fault	a weak area or break along the edges of the plates of the Earth's crust
magnitude	a number used to describe the size and strength of an earthquake
natural disaster	a sudden and terrible event that is caused by something in nature, such as an earthquake, hurricane, or tornado
tremor	a word used to describe a small earthquake or the shaking movement caused by an earthquake

California Shakin'

LESSON 4

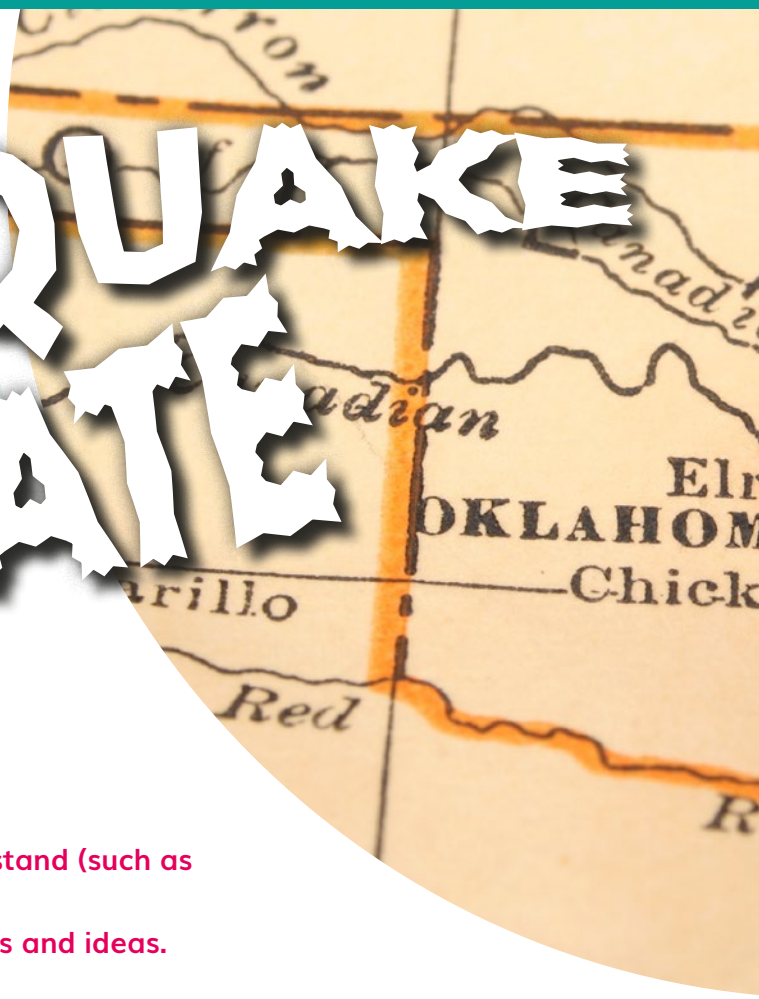
Close Read • Complete this chart using information from the article.

California Earthquakes Graphic Organizer

Earthquake	Magnitude	Areas Affected	Property Damage	Deaths
San Francisco April 18, 1906				
Loma Prieta October 17, 1989				
Northridge January 17, 1994				
North Bay Area August 24, 2014				

LESSON 5

EARTHQUAKE STATE



Read the text carefully. Remember to:

- **Circle key words**
- **Underline confusing words or sentences**
- **Write the strategy you tried when you didn't understand (such as visualize, summarize, or context clues)**
- **Add drawings or notes to remember important facts and ideas.**

Why has the number of earthquakes in Oklahoma skyrocketed in recent years?

From "The Earthquake State: Why Has the Number of Earthquakes in Oklahoma Skyrocketed in Recent Years?" by Joe Bubar. Published in SCHOLASTIC NEWS/WEEKLY READER, Edition 5/6, January 30, 2017. Copyright © 2017 by Scholastic Inc. Used by permission.

Just before 7:45 p.m. on November 6 last year, 11-year-old Caden Kennedy was about to practice the trumpet in his home in Cushing, Oklahoma. Suddenly, he was interrupted by a loud noise.

"It sounded like a big rumble," the fifth-grader says. The next thing Caden knew, the floor started to shake. The lights went out, and pictures fell off the walls. Caden knew what was happening: it was an earthquake! He and his family quickly fled from their home.

"When we got outside, everyone was panicking, like, 'What do we do?'" says Caden.



Fortunately, nobody was killed in that earthquake, and only a few people suffered slight injuries. But several buildings were damaged, and schools were closed the next day so officials could check that they were safe. Caden and his family had to stay with a friend in another town for five days while they waited for their home to be inspected. Luckily, it had only minor damage, like cracks in the walls.

NOTES

LESSON 5

LESSON 5



For Caden and many Oklahomans, earthquakes have become an all-too-common occurrence. Scientists measure the strength of an earthquake by its magnitude. An earthquake with a magnitude of 3 or higher is strong enough for most people to feel. In 2016, Oklahoma had more than 600 earthquakes with a magnitude of 3 or greater. The one that struck Cushing on November 6 was a magnitude 5. The strongest earthquakes measure 9 or higher, but they are very rare.

Oklahoma wasn't always earthquake country. For decades, the state averaged fewer than two earthquakes with a magnitude of 3 or greater each year. But in the past few years, that number has increased rapidly. What's causing all these earthquakes?

Human-made earthquakes

For as long as scientists have been recording earthquakes, Alaska has had the most of any state, followed by California. These states are located near the edges of tectonic plates. These plates are enormous, slow-moving slabs of the Earth's crust that float on top of hot, solid rock. Most earthquakes occur when plates slide past each other, push together, or

pull apart from each other.

But Oklahoma isn't near the edges of major plates. Scientists say the increase in earthquakes there likely has to do with drilling for oil and natural gas. In the past decade, Oklahoma's production of oil and natural gas has skyrocketed. Companies drill deep underground for oil and gas, which is often mixed with water and chemicals. Once the liquid is extracted from the ground, the water must be separated from the oil and gas. The problem is, this water isn't safe to use. "It's very salty water and also has some bad chemicals in it, so you can't dispose of it very easily," says scientist Jeremy Boak. He's the director of the Oklahoma Geological Survey, the group that studies earthquakes in the state.

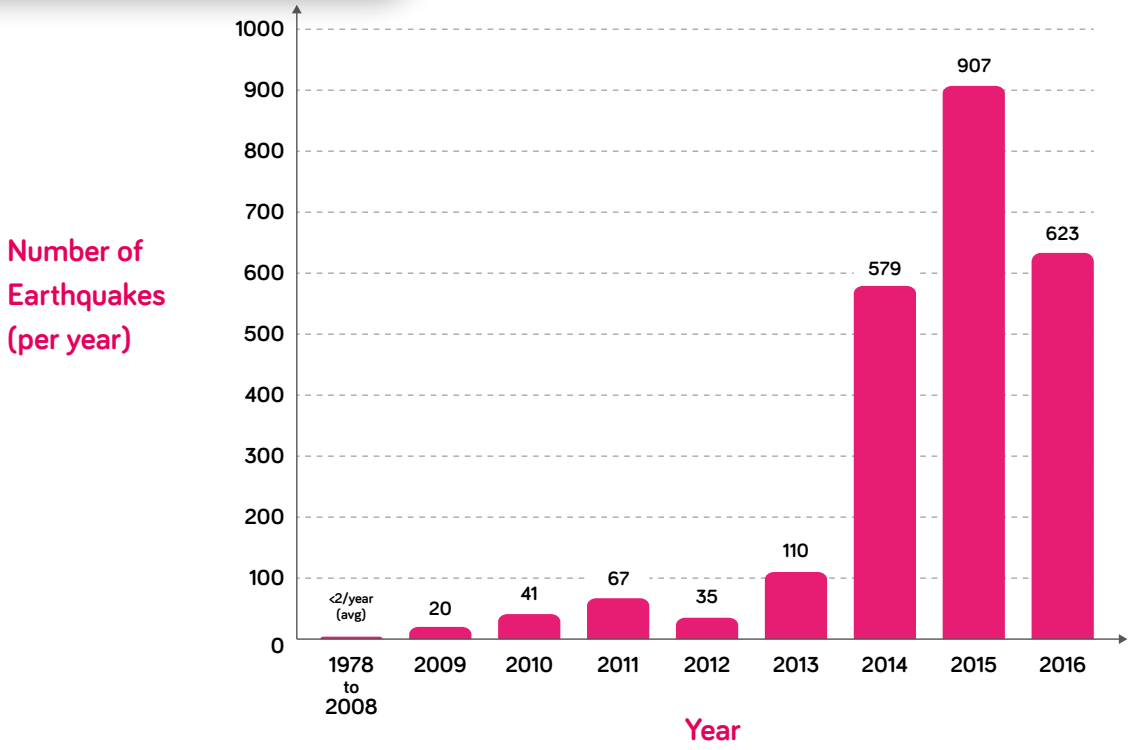
To get rid of that water, oil and gas companies dig deep wells to pump it back into the earth. Scientists say that's probably causing the earthquakes (see the Oklahoma Earthquakes Magnitude graph below).

NOTES

LESSON 5

LESSON 5

Oklahoma Earthquakes—Magnitude 3.0 and Greater



A shaky future?

None of Oklahoma's quakes have been deadly, but many people in the state are worried. The Oklahoma Corporation Commission oversees the state's oil and gas drilling. Last May, it answered concerns about an increase in earthquakes by placing new limits on the amount of wastewater that companies can pump into the ground. So far, that change seems to be helping. In 2016, the number of earthquakes dropped from a record high of 907 in 2015.

Meanwhile, many Oklahomans are getting used to living with earthquakes. Lisa Favalora, Caden's teacher at Cushing Middle School, remembers feeling her first one.

"I thought, 'Oh my goodness, is that an earthquake?,'" she says. "Now we're like, 'Oh well, there was another one.'"

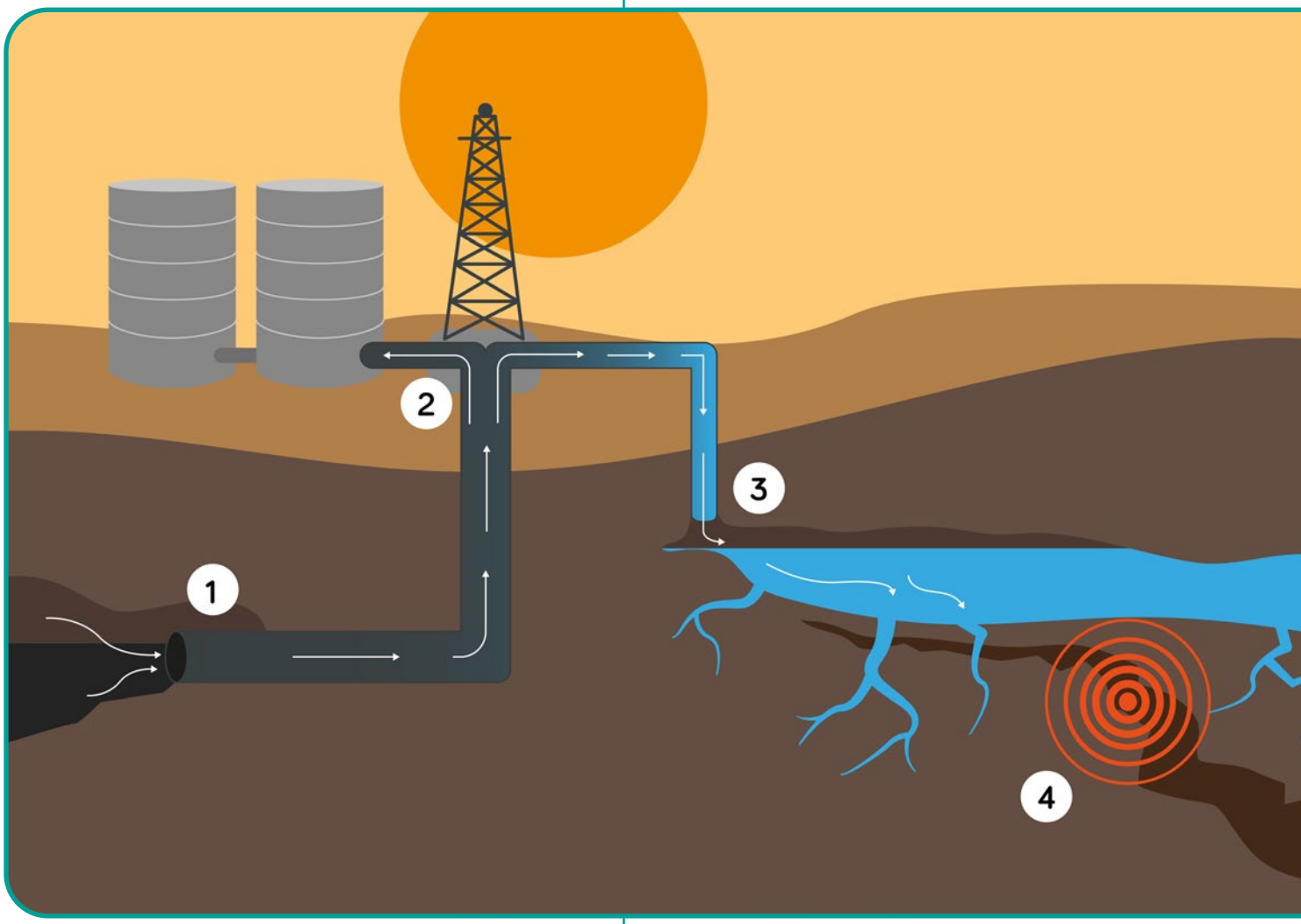
LESSON 5

NOTES

Words to Know:

extract: remove or pull out

dispose of: get rid of; throw away



LESSON 5

Earthquakes in Oklahoma

Reading for Evidence

Summarize • For a paper aimed at your peers, write a news report about the increase in earthquakes in Oklahoma and what might be causing it. Remember that this report is an informational text, so you must include facts to back up what you say.

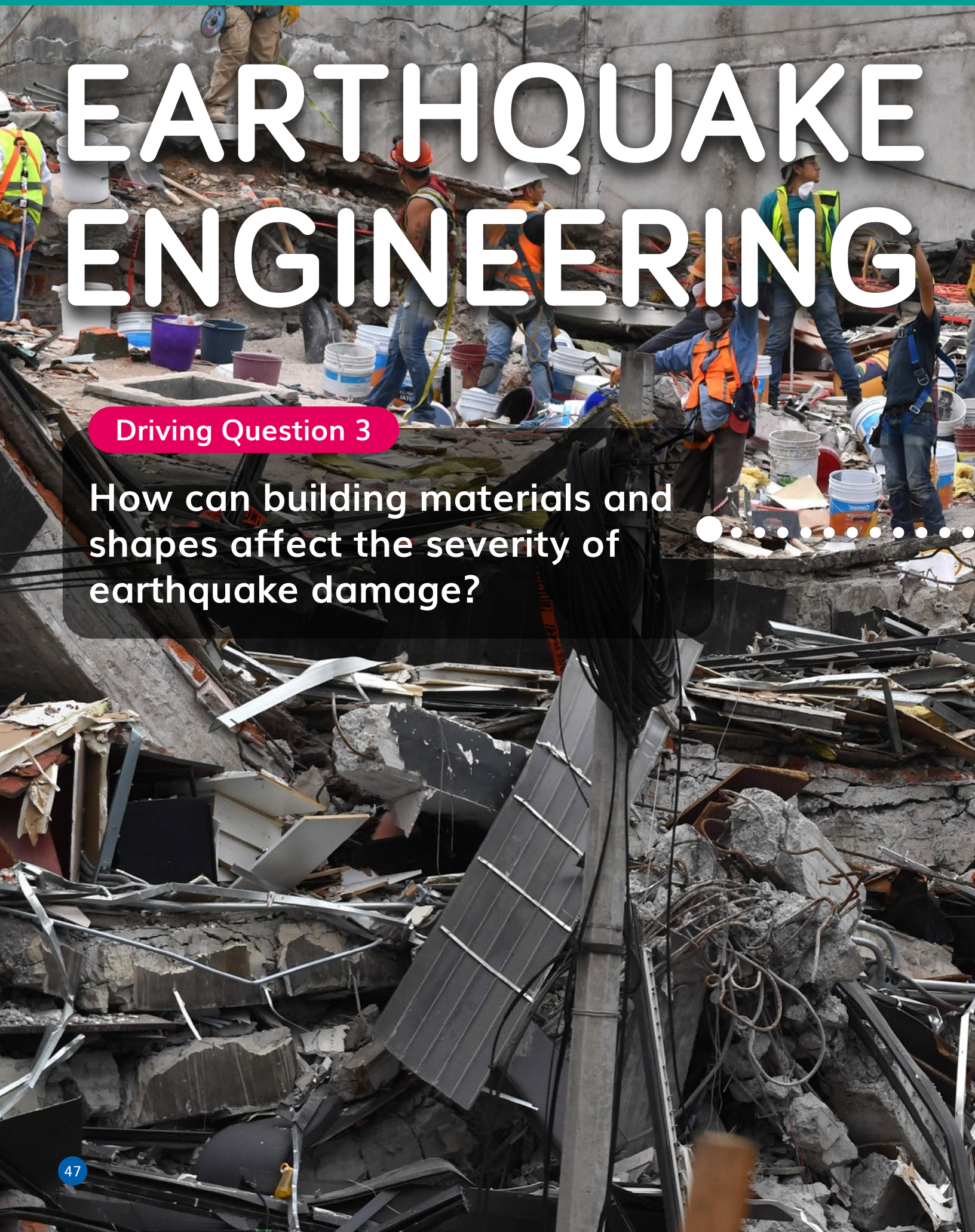
As you write your report, be sure to:

- Explain what has been happening
- Explain why it happened
- Describe the effects on people and the environment
- Describe how people feel about what happened
- Make a concluding statement.

Change in Yearly Earthquake Rate in Oklahoma



LESSON 5



EARTHQUAKE ENGINEERING

Driving Question 3

How can building materials and shapes affect the severity of earthquake damage?



I can...

- Explore the phenomena of loads and forces
- Build different model buildings and test their stability by applying different forces and loads
- Watch a video and read informational texts to compare and contrast the effects of earthquakes in different locations.

3–5-ETS1-1, 3–5-ETS1-2, 3–5-ETS1-3

LESSON 1

Overloaded

Hands-On

Make Predictions • Which structure do you predict will be the most stable? Circle your response.

TRIANGLE RECTANGLE SQUARE

Develop Models • With your team, build three structures of the following two-dimensional shapes: a triangle, a rectangle, and a square.

Criteria

- Build three two-dimensional structures:
  - A triangle
  - A rectangle
  - A square

Constraints

- You can only use marshmallows and spaghetti to build your structure.

You will have **15 minutes** to build and test your structures.

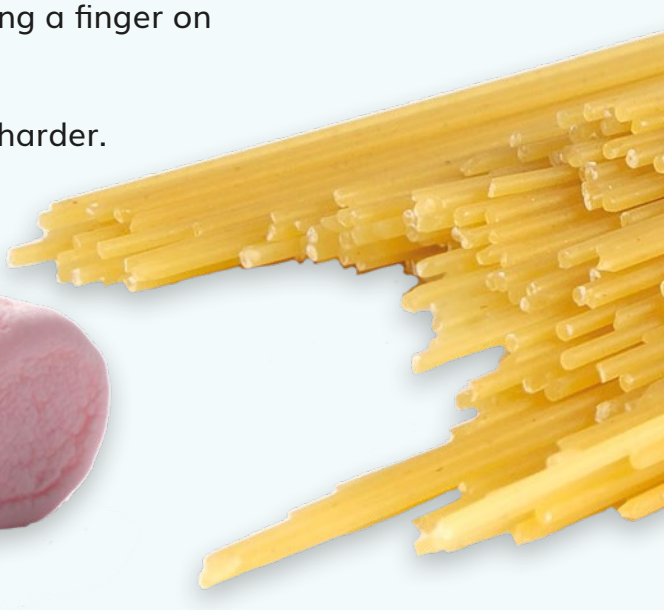
Use Models • Conduct the following four tests on each structure, and describe what happens in the graphic organizer.

- **Test 1:** Try to stand the structure up on its own.
- **Test 2:** Apply force to the side of the structure with a finger or by blowing on it.
- **Test 3:** Apply force to the top of the structure by placing a finger on the middle of the top and pressing down gently.
- **Test 4:** Apply more force to the top by pressing down harder.

Word Wall

- dead load
- live load
- horizontal load





Test	Triangle	Rectangle	Square
1			
2			
3			
4			

Make Observations • Answer the following questions.

1. Which structure stands up on its own?

2. Which structure continues to stand when you apply a horizontal load?

3. Which structure continues to stand when you apply a force to the top?

Challenge Build structures of three-dimensional shapes, such as pyramids, cubes, or prisms, and perform similar tests.

LESSON 1

Pre-Exploration

Evaluate Information • Two students had a discussion about earthquake safety. They disagreed about which buildings are safest during an earthquake. Read their ideas below.

Student 1: The newest buildings are the best at standing up during an earthquake.
Student 2: The heaviest buildings are the best at standing up during an earthquake.

Is one of the students correct? Which student do you agree with more? Explain your reasoning.





Materials and Forces

LESSON 2

	Compression	Tension	Torsion	Bending
Graham Cracker	Prediction	Prediction	Prediction	Prediction
	Result	Result	Result	Result
Mini Marshmallow	Prediction	Prediction	Prediction	Prediction
	Result	Result	Result	Result
Spaghetti	Prediction	Prediction	Prediction	Prediction
	Result	Result	Result	Result

Pipe Cleaner

Prediction	Prediction	Prediction	Prediction
Result	**Result**	**Result**	**Result**

Reflect

Make Predictions • Watch the **Wood video** and predict how wood would react to these forces.

Compression:

Tension:

Torsion:

Bending:

Word Wall

- compression (squeezing)
- tension (stretching)
- torsion (twisting)
- bending

Straw, Brick, or Wood, Mr. Wolf?

LESSON 3

Hands-On

Criteria

- Build a structure that will be strong enough to support a live load of one bag of sand.
- The structure must be at least 30 cm tall.

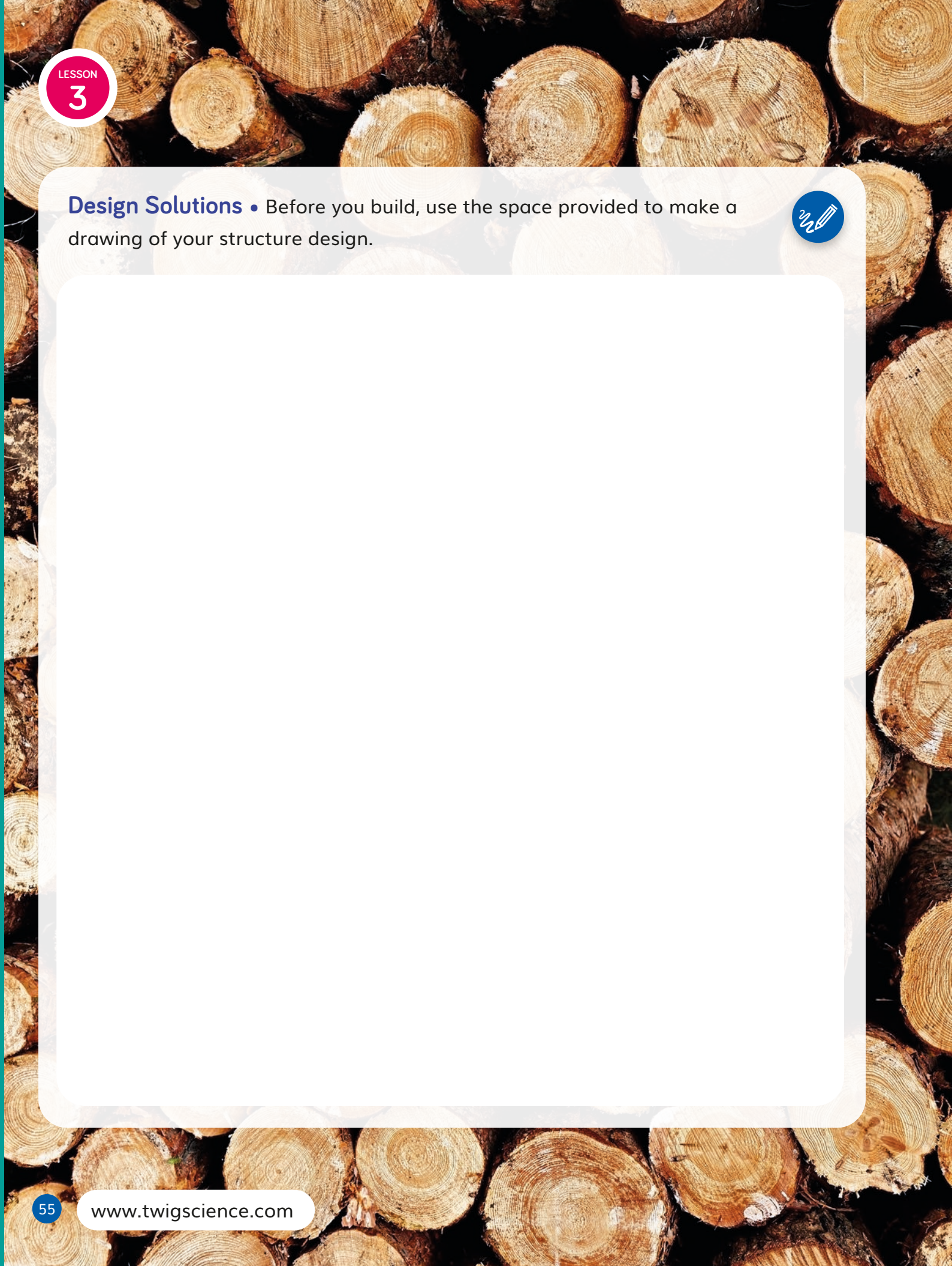
Constraints

- You can only use your two given materials.
- You will have 15 minutes to build and test your structure.

Design Solutions • Follow these steps to build and test your structure.

1. **Plan:** Decide on a design for your structure with your partner. Make a drawing of your design. Apply what you have learned about shapes and loads to your design. Remember that the structure needs to be at least 30 cm tall and able to support the weight of one bag of sand.
2. **Build:** Use your design to build the structure with the two materials provided.
3. **Test:** Place the bag of sand on the structure.
4. **Write:** After discussing with your partner, write down one **advantage** and one **disadvantage** of each material.





LESSON 3

Design Solutions • Before you build, use the space provided to make a drawing of your structure design.

Make Predictions • Predict what will happen when you place the live load on top of your structure. When the teacher tells you to, test the structure and record what happens.

Prediction:

Result:

Make Observations • What two materials did you use to build your structure?

Summarize • Discuss the advantages and disadvantages of these materials with your partner. Write one advantage and one disadvantage of each material.

Make Observations • When the teacher tells you to, walk around the classroom and look at other students' structures.



Discuss the advantages and disadvantages of the other materials that you see with your partner, and note your observations.

Take notes during the class discussion.

Challenge

Design Solutions • If time allows, design and build two structures and write a comparison of the advantages and disadvantages of each.

Reflect

Self-Assess • How effectively did you work today? Explain why you think you worked at the level you did.

LESSON 4

THE 1989 SAN FRANCISCO EARTHQUAKE



Read the two articles below. Underline, highlight, or annotate any passages that answer the focus questions.

The 1989 World Series was a big one...but not because of baseball. The Series was between the San Francisco Giants and the Oakland Athletics, and the Athletics had won the first two games. But in Game 3, things got a little crazy. Held in San Francisco, the game was filmed live for television. Just before the game started, the ground started to shake. As viewers around the country tuned in, announcer Al Michaels said, "I'll tell you what, we're having an earth..." But no one watching the game on TV heard the rest—the live feed went black.

The earthquake struck at 5:04 pm, only 26 minutes before Game 3 was supposed to start. The epicenter of the earthquake was near Mt. Loma Prieta in the Santa Cruz Mountains—that's 90 km (56 mi.) south of San Francisco. The shaking lasted only 20 seconds, but the earthquake was big. It had a magnitude of 6.9, the biggest in the area in over 80 years.

Matt Kettmann, a 12-year-old baseball fan, was at the game with his dad. Years later, he wrote about the earthquake. The



windows in the stadium shook, and the ground swayed and rolled. Then the power went out. Fans outside the stadium heard about the earthquake on their radios—they probably felt it too.

The earthquake caused a lot of destruction. In West Oakland, close to the game, the Cypress Street Viaduct collapsed. It was a two-deck road, and the top deck fell onto the bottom one. Two sections of the San Francisco-Oakland Bay

NOTES

LESSON 4

Bridge collapsed. Over 900 homes were destroyed, and over 18,000 homes were damaged. Even though there were building codes, they weren't good enough. Government officials studied the damage to these homes and updated the building codes to make buildings even safer. After the earthquake, the damage totaled $10 billion. In all, 63 people were killed.



US Government scientists described the earthquake as a wake-up call. They saw how different types of rock responded to the shaking. They learned that buildings constructed on soft ground needed to be built differently. They also started a mapping project around San Francisco—they wanted to identify areas in need of extra protection. They wanted to prepare the city so it could handle future earthquakes better.

After the earthquake, baseball officials talked about canceling the rest of the World



Series. But the Major League Baseball Commissioner at the time, Fay Vincent, wanted to keep going: "It's important to move on." Just 10 days after the earthquake, the Giants and Athletics finished Game 3. Before the game, firemen, police officers, and paramedics were asked to throw the first pitch on the field. The fans joined together and sang the song "San Francisco."

The Athletics won Games 3 and 4, winning the whole World Series. The celebration wasn't huge, though. In an interview years later, Athletics pitcher Dave Stewart said "it would have been the improper thing to do."

NOTES

LESSON 4

Devastation in Haiti



In the late afternoon on January 12, 2010, a huge earthquake shook Haiti. Haiti is a small country south of Florida, in the Caribbean Sea. It's also one of the poorest countries in the Western Hemisphere. The earthquake's epicenter was just 24 km (15 mi.) southwest of Port-au-Prince, the capital city of Haiti.

In 2010, around 3 million people lived in the Port-au-Prince area. Sebastien Delatour, a 14-year-old, was one of them. On the day of the earthquake, Sebastien was at home with his family. Suddenly, he felt the ground shake. His sister fell in the shower, bumping her head. His mom ran outside, terrified. But Sebastien felt lucky. Just over a week later, he spoke to UNICEF, an international charity. Sebastien told them, "I'm fortunate, I guess, for having a house and water."

The 2010 earthquake in Haiti was really big. Scientists know this thanks to a seismometer—that's an instrument that measures earthquakes. It detects how much the ground moves during an earthquake. The earthquake in Haiti measured a magnitude of 7.0. The seismic wave amplitude was 1,000 times stronger than most of the small earthquakes scientists detect every year.

According to the United Nations (UN), more than 220,000 people were killed. Parts of Port-au-Prince were completely demolished. Shortly after it happened,



officials estimated it had caused about $14 billion in damage. Almost 1.5 million people lost their homes. Schools collapsed, bridges and roads were ruined, and hospitals were destroyed. Before the earthquake, there were no building codes in Haiti. Many buildings had been poorly constructed. It was very hard to reach people and help them because of all the damage. After the earthquake, people struggled to get shelter, food, and medical care. Many people had to camp out in tents. Many left the city on foot.

Four years after the devastating earthquake, these problems had not gotten much better. Ban Ki-moon, Secretary-General of the UN, traveled to Haiti in 2014: "145,000 people continue to live in makeshift camps," he said. "We must intensify our efforts to help Haiti build a more stable and prosperous future[.]"

NOTES

LESSON 4

LESSON 4

Earthquakes Around the World

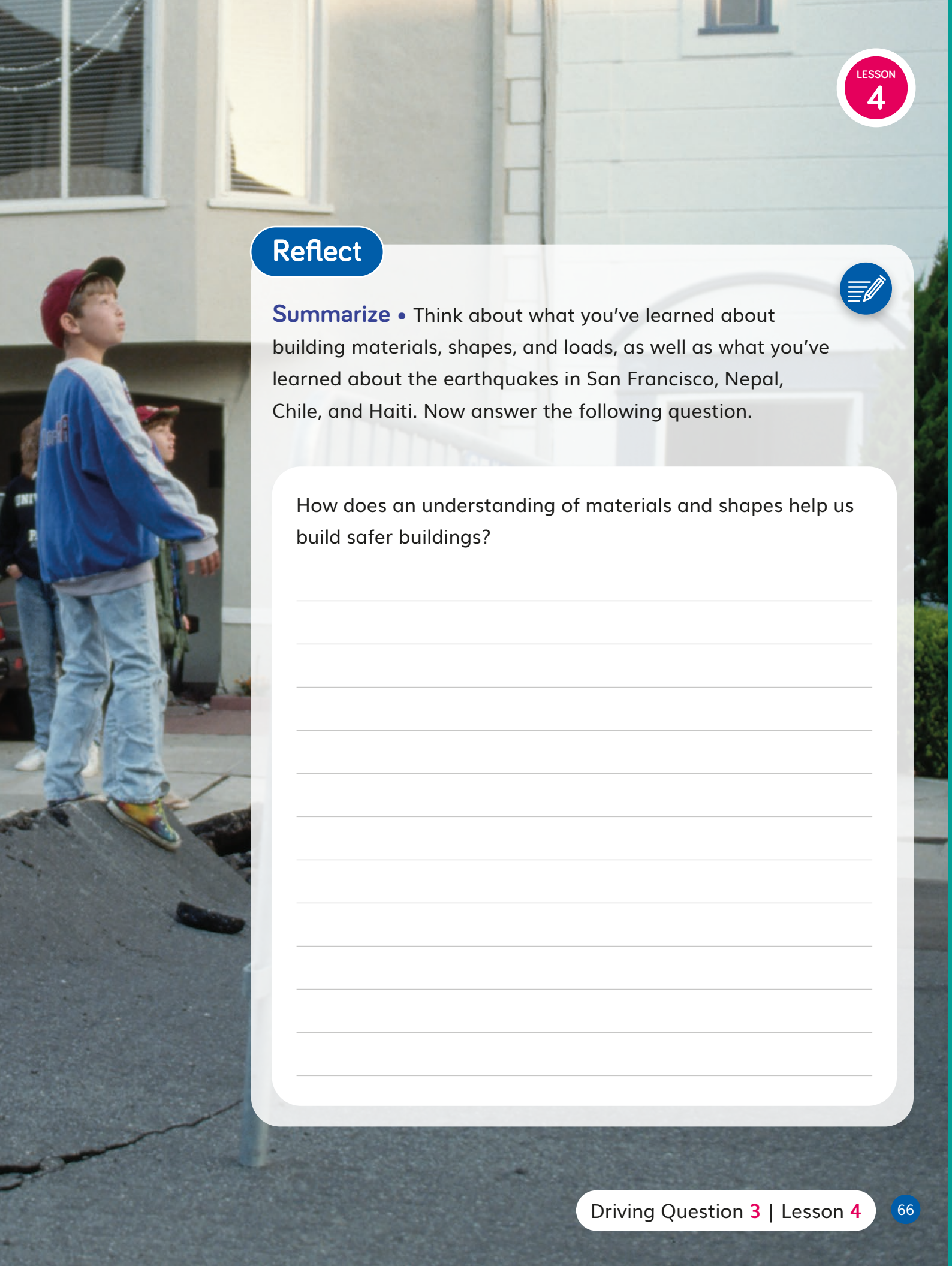
· Video Investigation · · Reading for Evidence ·

Challenge

Evaluate Information • Answer the questions.

1. What might account for the differences between the effects of the two earthquakes?

2. What other information would help you compare the earthquakes?



LESSON 4

Reflect

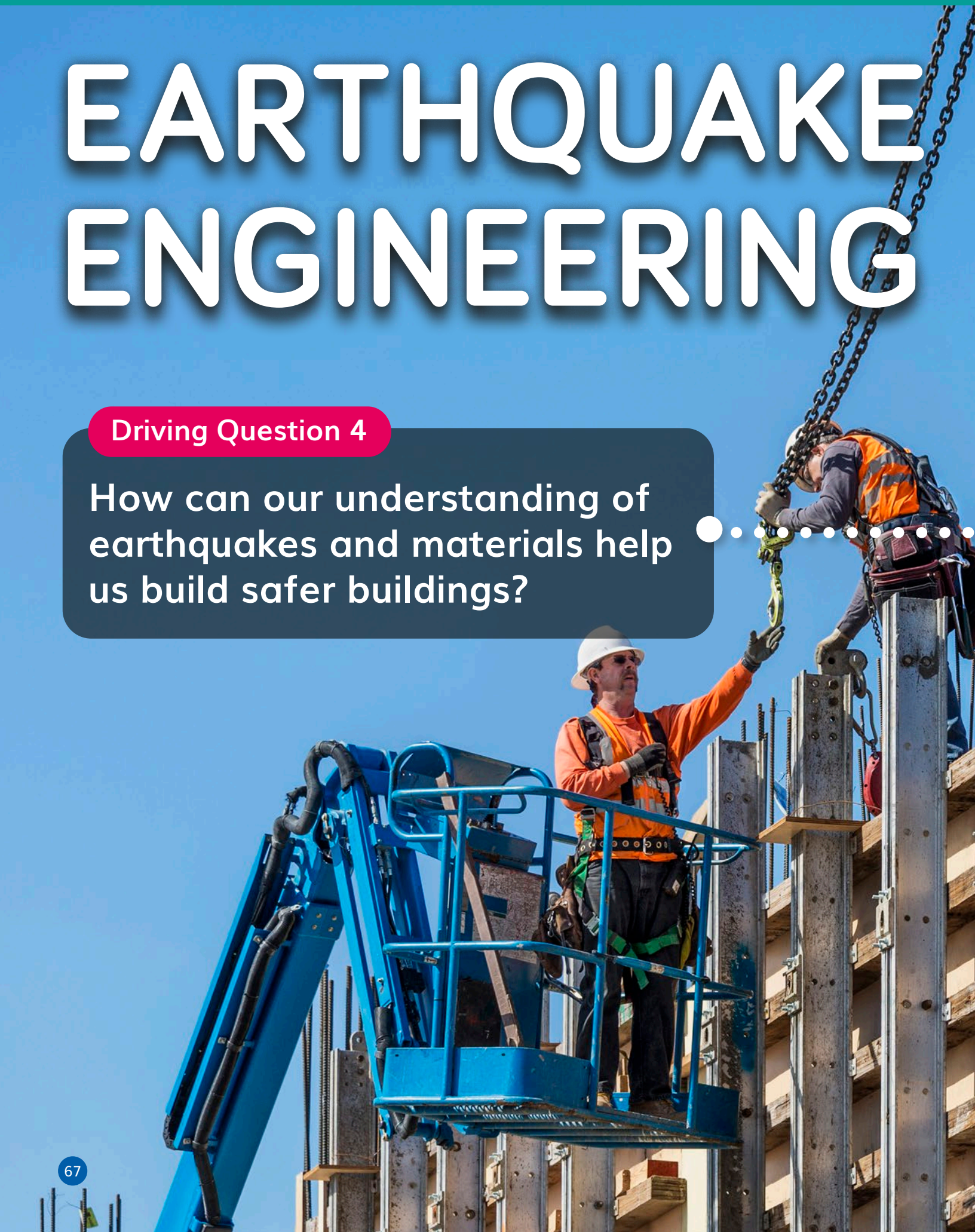
Summarize • Think about what you've learned about building materials, shapes, and loads, as well as what you've learned about the earthquakes in San Francisco, Nepal, Chile, and Haiti. Now answer the following question.

How does an understanding of materials and shapes help us build safer buildings?

EARTHQUAKE ENGINEERING

Driving Question 4

How can our understanding of earthquakes and materials help us build safer buildings?





I can...

- Work in a team to plan and build an earthquake-resistant structure, and test it using an earthquake simulator.

4-ESS3-2, 3–5-ETS1-1,
3–5-ETS1-2, 3–5-ETS1-3

LESSON 1

Back to the Drawing Board

Hands-On

Improve Designs • Think about what you've learned so far about shapes, materials, and loads.

List three things that you want to include in your design that will make it more stable.

1.

2.

3.

List three things that you should not include in your design because they would make it less stable.

1.

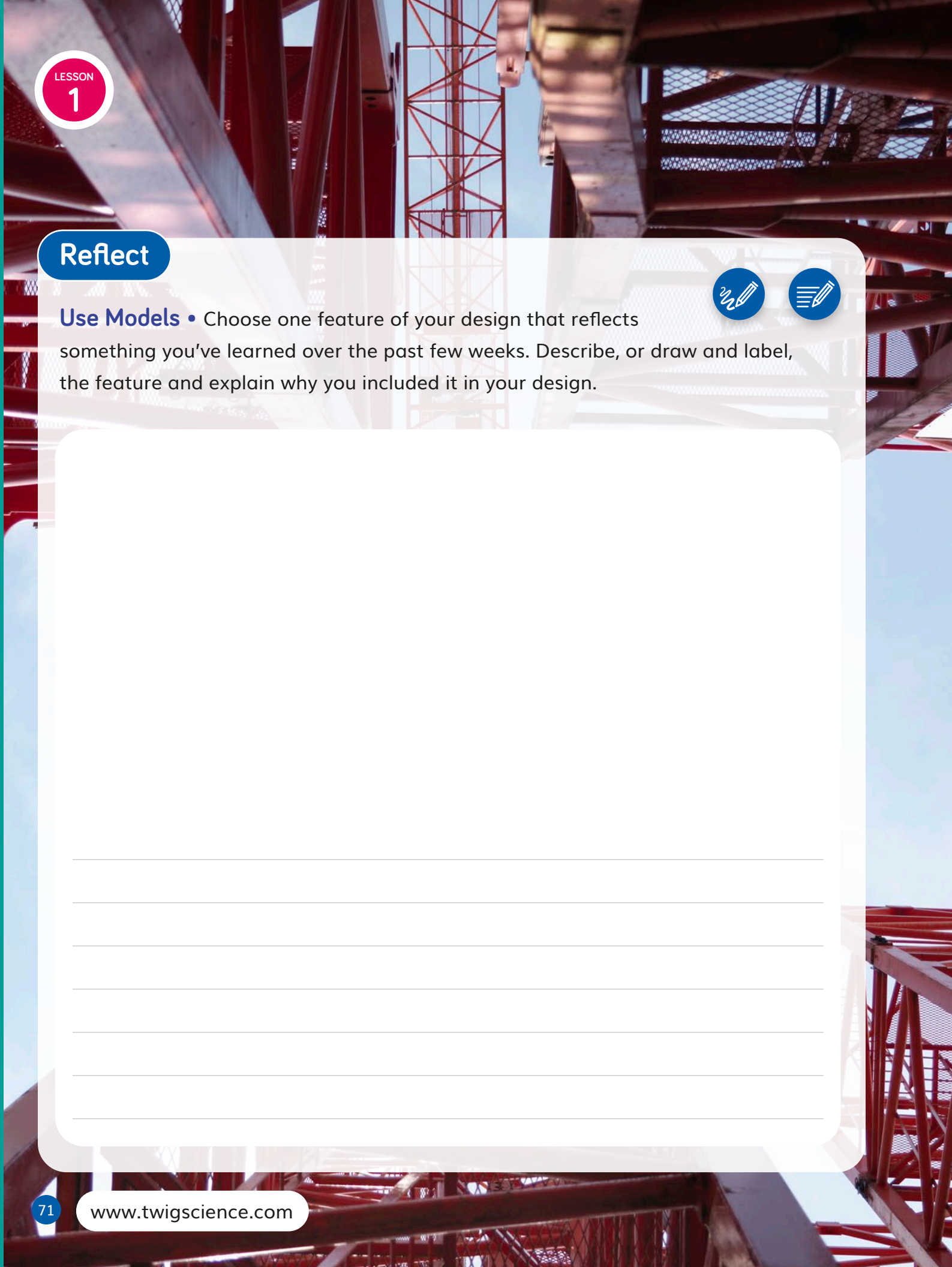
2.

3.



LESSON 1

Design Solutions • Design your earthquake-resistant structure. Make sure you consider the constraints and the criteria. Record your plans.



LESSON 1

Reflect

Use Models • Choose one feature of your design that reflects something you've learned over the past few weeks. Describe, or draw and label, the feature and explain why you included it in your design.

Hands-On

Let's Build It!

LESSON 2

Design Solutions • In your team, build your structure while keeping in mind the following Criteria and Constraints, as well as the recommended building process.

Criteria

- Build a structure that will not collapse when placed on the shake table for 15 seconds.
- The structure must be at least 30 cm tall.
- The structure must have at least two stories.
- The structure must be able to carry a live load of at least one bag of sand and will be tested with additional sandbags.

Constraints

- The structure will need to be carried to the shake table for testing.
- The total cost of materials used must be under the budget.
- You have one lesson to design your structure and one to build it.

Building Process Checklist

- ☐ Build according to your design.
- ☐ Check your building against the Constraints.
- ☐ Perform small tests to see whether the structure will sustain a live load and the stress of shaking.
- ☐ Fix any flaws that you find.
- ☐ When you are finished building your structure, measure and record the height and number of stories.

Record the height of your structure and the number of stories.

Height of structure (in cm): _____ Number of stories: _____



LESSON 2

Reflect

Describe one way that your team worked well together today.

Rumble and Shake! It's an Earthquake!

Test Solutions • Test the structure you designed and built by following these steps.

1. Put on your safety goggles.
2. Set up your video and have your stopwatch ready.
3. Test that your structure can survive an earthquake by shaking it with the earthquake simulator for 15 seconds.
4. If your structure does not collapse, place a sand bag on the structure and shake for 15 seconds. Record how long your structure remained standing for. Repeat by adding additional bags, one at a time, until the structure collapses.
5. Stop the video.
6. Fill in the time chart.
7. Add your team's results to the class Test Chart.

Time Chart

Sand Bags (Live Load)	Time
0	
1	
2	
3	
4	
5	

Make Observations • As you observe the tests, take notes on what happens to each structure.



LESSON 3



Family Outreach

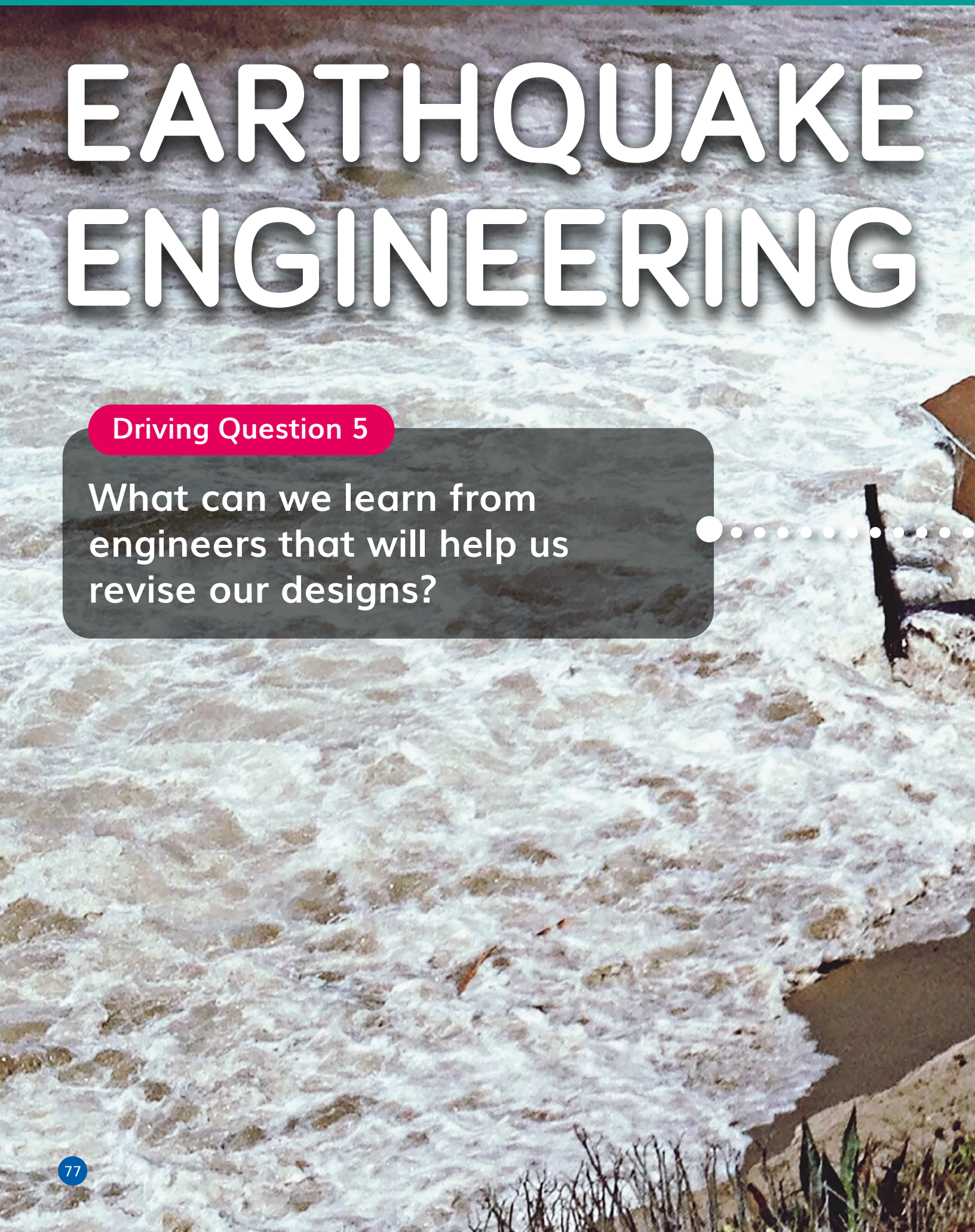
Take home the **Family Outreach 1 handout** and show your family the results of your test. Tell them about:

- What you were doing
- What you've discovered so far.

EARTHQUAKE ENGINEERING

Driving Question 5

What can we learn from engineers that will help us revise our designs?





I can...

- Further explore the phenomena of natural hazards
- Identify earthquake hazards
- Read texts and watch a video to learn how engineers solve problems and make their buildings safer.

4-ESS3-2

LESSON 1

Better Safe Than Sorry

Challenge

Make Observations • Complete the table below. In the Hazard column, list every item that you circled on your classroom pictures. Fill in the other two columns based on your discussion with your partner.

Hazard	Why It's Dangerous	How to Make It Safe



LESSON 1

Reflect

Find potential earthquake hazards at home and think of ways to make these hazards safer.

Hazard	Why It's Dangerous	How to Make It Safer

LESSON 2

Civil Engineering

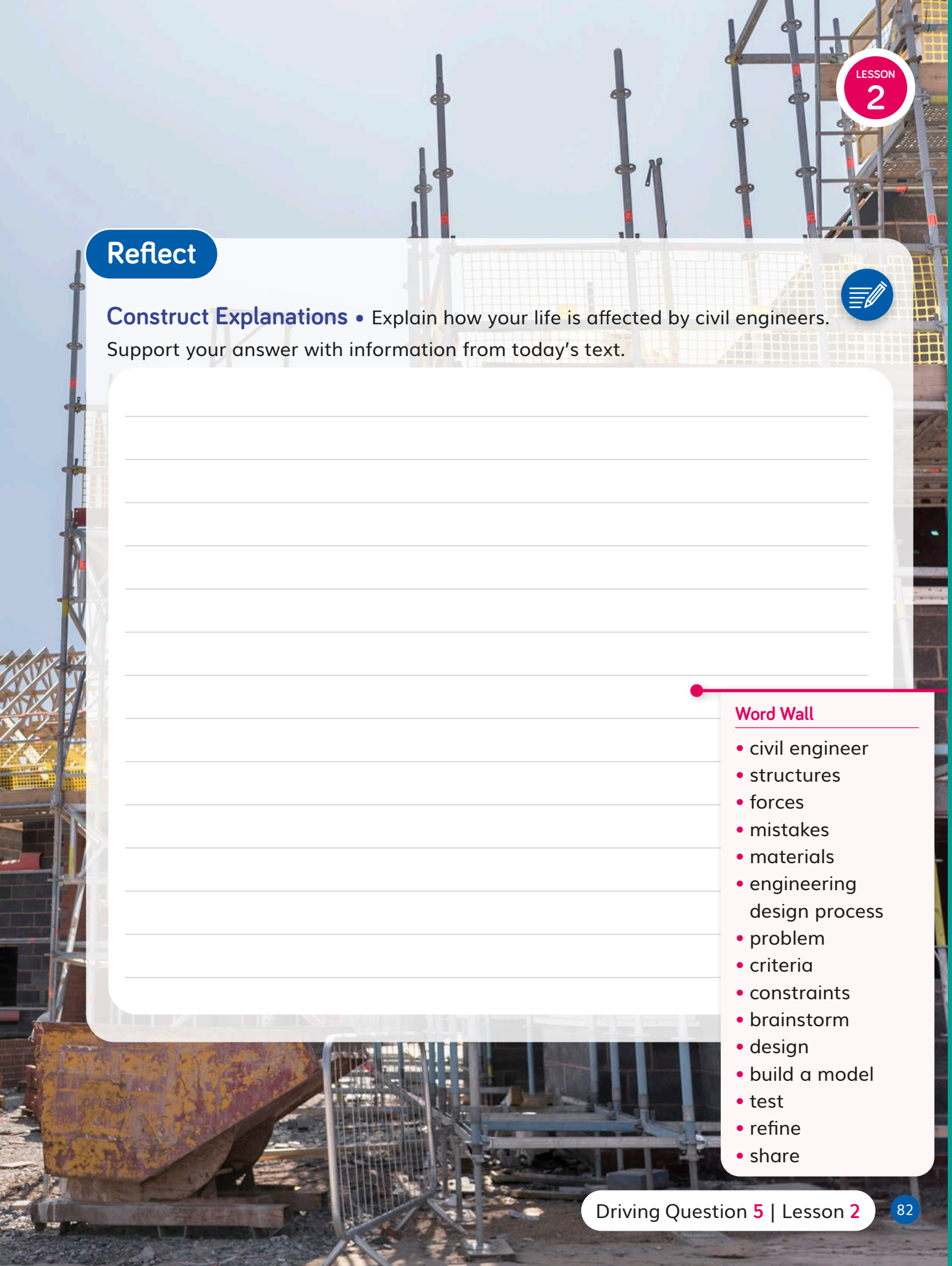
· Reading for Evidence ·

Close Read • As you listen to the reading you should:

- Write down key ideas for each key word listed
- Note any questions you have about what you hear.

Key Word	Key Idea
civil engineer	
materials	
engineering design process	
prototype	

Questions



LESSON 2

Reflect

Construct Explanations • Explain how your life is affected by civil engineers. Support your answer with information from today's text.

Word Wall

- civil engineer
- structures
- forces
- mistakes
- materials
- engineering design process
- problem
- criteria
- constraints
- brainstorm
- design
- build a model
- test
- refine
- share

LESSON 3

Made in Japan

EARTHQUAKE PROOF HOMES



By Michael Abrams, Reprinted Courtesy
The American Society of Mechanical Engineers

Read "Made in Japan: Earthquake-Proof Homes."

As you read, do the following:

- **Circle key words**
- **Underline confusing words or sentences**
- **Add drawings or notes to remember important facts and ideas.**

Read the text again with a partner:

Annotate evidence that proves the solution was successful, and evidence that suggests the solution may not have solved the problem.

Earthquakes don't kill people. People's houses in the midst of earthquakes kill people. Look at the statistics—or the photographs—and you'll know that the vast majority of fatalities from earthquakes large or small come from buildings, or parts of buildings, falling on people.

What better way to avoid tragedy then, but by tossing a house in the air when an earthquake comes?

That's the general idea behind the levitating house developed by a Japanese company. The product of inventor Shoichi Sakamoto, the house sits, during more stable times, on a deflated air bag. When sensors feel a tremor, they switch on a compressor within a second. The compressor pumps air into an airbag, inflating it within a few more seconds, and ultimately lifting the entire house a good three centimeters off its supposedly earthquake-proof concrete foundation.



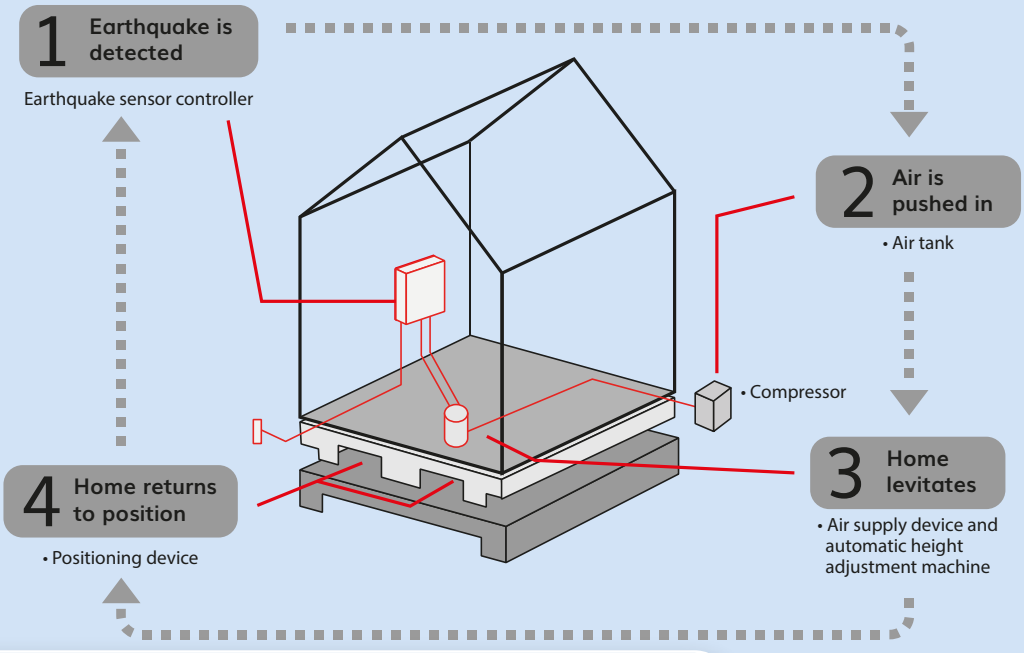
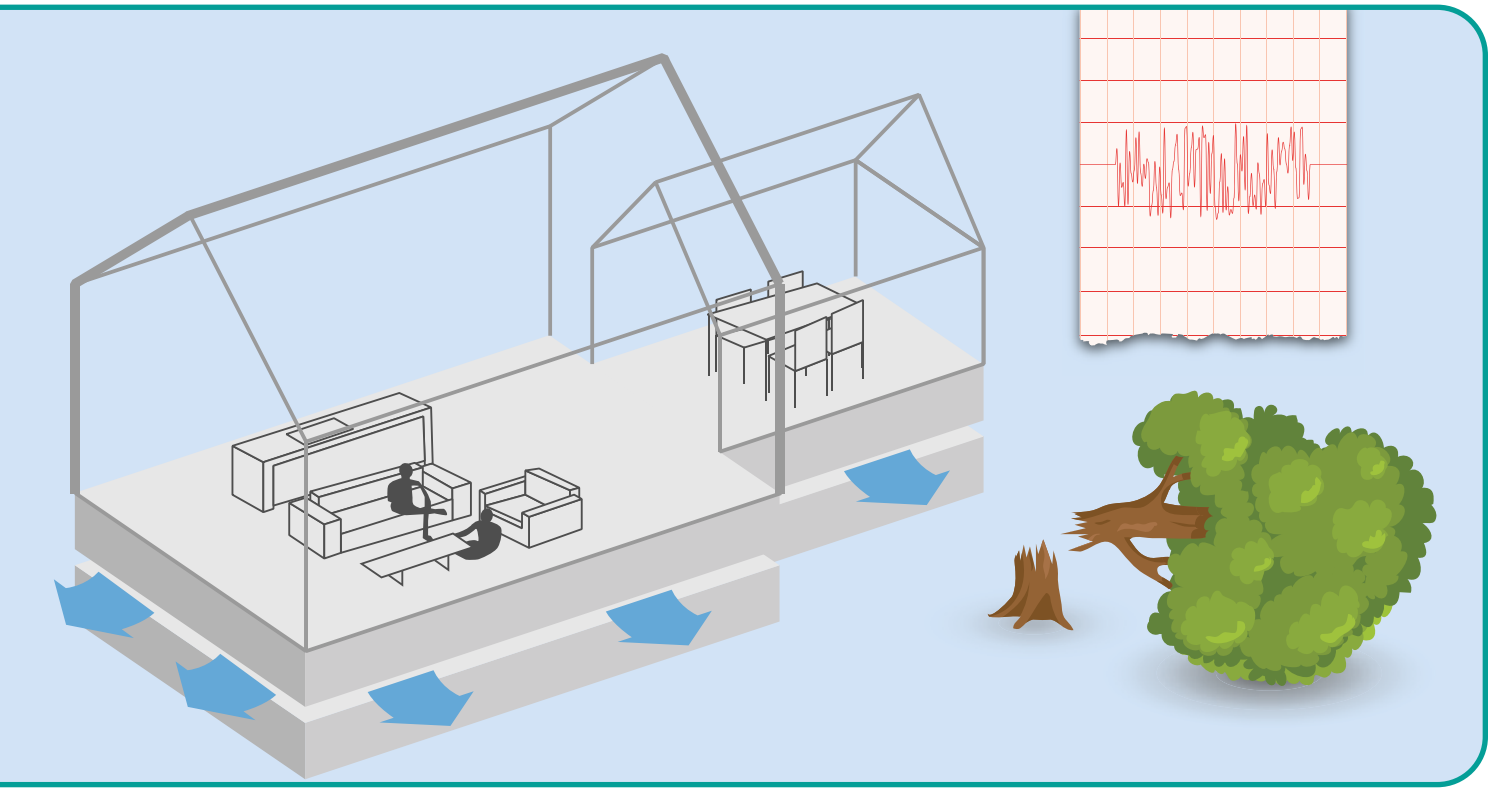


Diagram of how a house would levitate in an earthquake

There the structure will hover, its inhabitants able to casually go about their business, for the duration of the quake. Then the airbag deflates and the house gently settles back down.

The company built such a house on a "shake table" and equipped it with a few inhabitants, some furniture, and a couple of glasses of juice. When the mock tremors hit, in front of a rapt, hardhat-outfitted audience, the denizens hardly noticed, and

not a drop of juice was spilled. The system will be added to new, otherwise typically built homes of an appropriate weight, and can be retrofitted to existing structures as well.



Minimizing damage

"It would take care of a smaller earthquake, I would think," says Deke Smith, Executive Director of the Building Seismic Safety Council and the buildingSMART alliance, part of the National Institute of Building Sciences, Washington, DC. "It would dampen some of the motions certainly. I think it would be more of a comfort thing than a minimizing damage thing. But I don't know that if you invested in it that you will have eliminated any problems with earthquakes for your structure."



The company's shake test dealt only with side-to-side motion and most earthquakes are not limited to a two-dimensional plane. Three centimeters of levitation will only protect a house from earthquakes that don't rise higher than three centimeters. Never mind the question of what would happen to a floating house hit by a tall wave of a quake. It would likely slip right off its foundation. Or, conceivably, a strong tornado might more easily carry the structure off to Oz.

Word Wall

- hazard
- safety
- revise

NOTES

LESSON 3

LESSON 3

Improving design



Another problem is that the first tremors that would activate the system may very well be the biggest, most destructive tremors of the earthquake. The airbag, were it able to inflate, might be pushing up against the rubble of an already damaged house. "Each earthquake has its own signature," says Smith. "Some might have a big jolt in the beginning, some in the end, some in the middle."

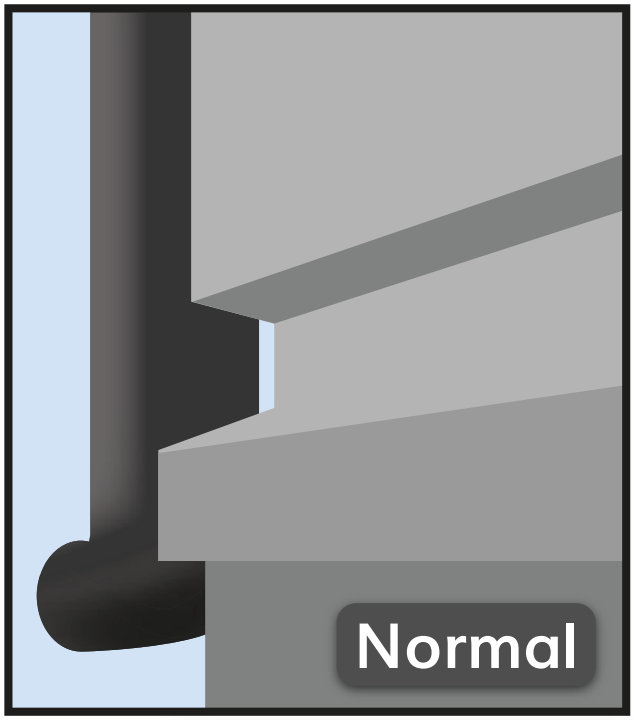
However, even if the system is only good for that rare, lateral shaking earthquake which never moves the earth higher than three centimeters, and saves its biggest jolts for its finale, 88 Japanese homes are soon to be retrofit with the airbag and its assemblage. That's 88 experiments that will provide some data after the next quake. At approximately three million Yen a pop (over $37,000), it's also a sizable chunk of change.

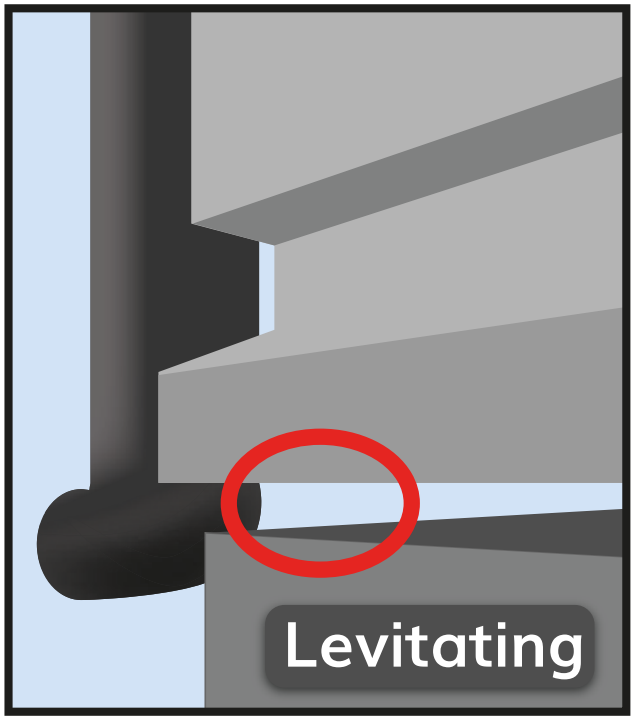
"Going out and building some of them is good," says Smith. "That's how we keep improving. It may be an idea that will spur somebody else's thoughts in some other direction. It may be a viable piece to a larger solution someday."



LESSON 3

NOTES





Structure levitates 1–3 cm

LESSON 3

Think Outside the Box

Why do engineers need to know about different materials and the forces they must withstand in an earthquake?

Challenge

Design Solutions • You have just read about an unusual design for earthquake safety. Now it's your turn! Design your own earthquake-proof home. Label your drawing to help the viewer understand how it works. You can create anything, so use your imagination!

Reflect

Evaluate Information • Would you use Shoichi Sakamoto's airbag system in your own home? Explain why or why not.

A Bright Idea

LESSON 4

Improve Designs • List aspects of your last design that you need to improve upon and explain the changes you will make in your next design.

Aspects to Improve	Changes in Next Design

LESSON 4

Communicate Information • Write a paragraph about what failure means for a scientist or an engineer.

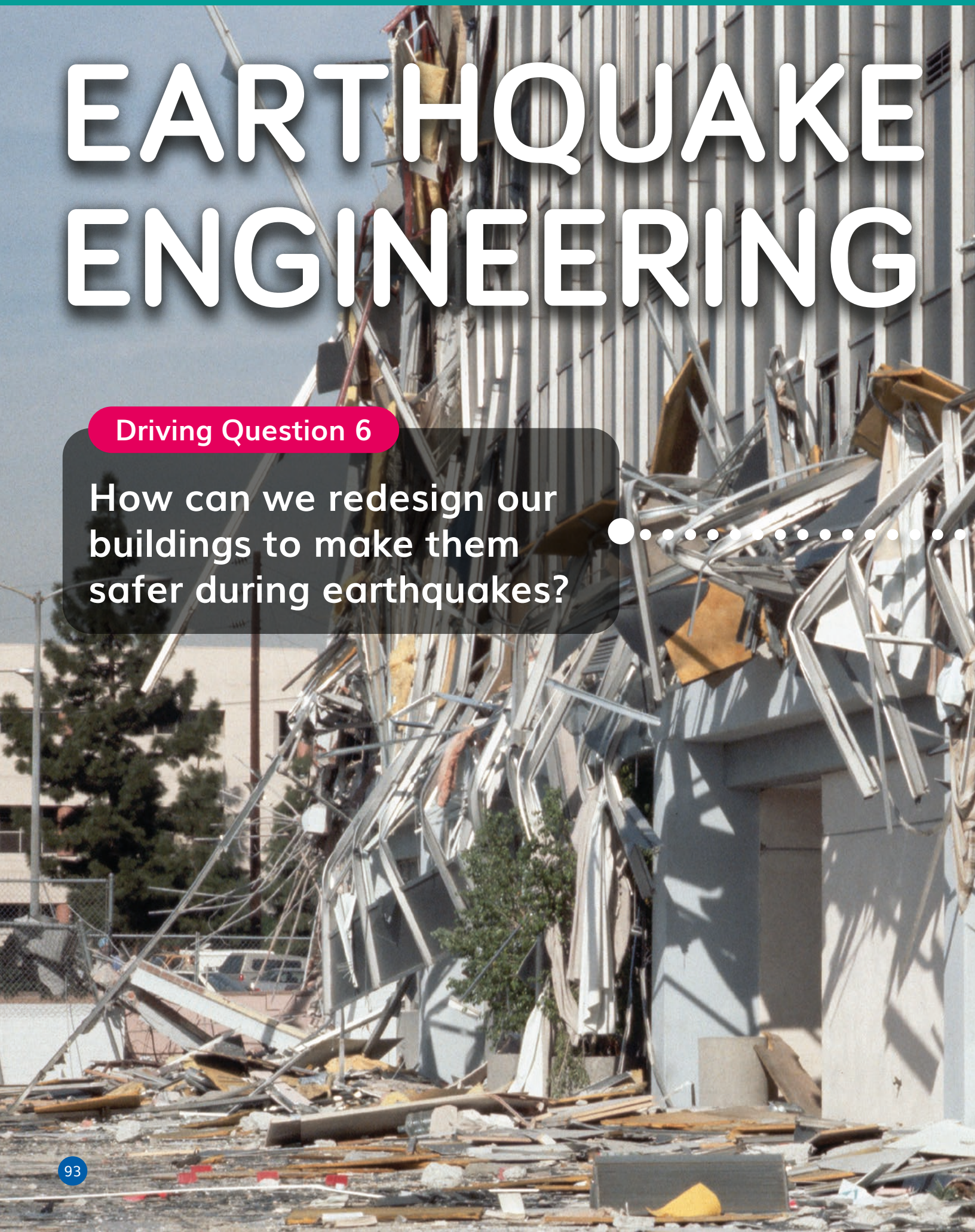




LESSON 4

Reflect

Write a newspaper headline about what will change in your building design project.



EARTHQUAKE ENGINEERING

Driving Question 6

How can we redesign our buildings to make them safer during earthquakes?



I can...

- Use what I have learned in previous lessons to build a new and improved earthquake-proof model
- Present my model and use what I have learned about earthquakes and engineering to explain my design.

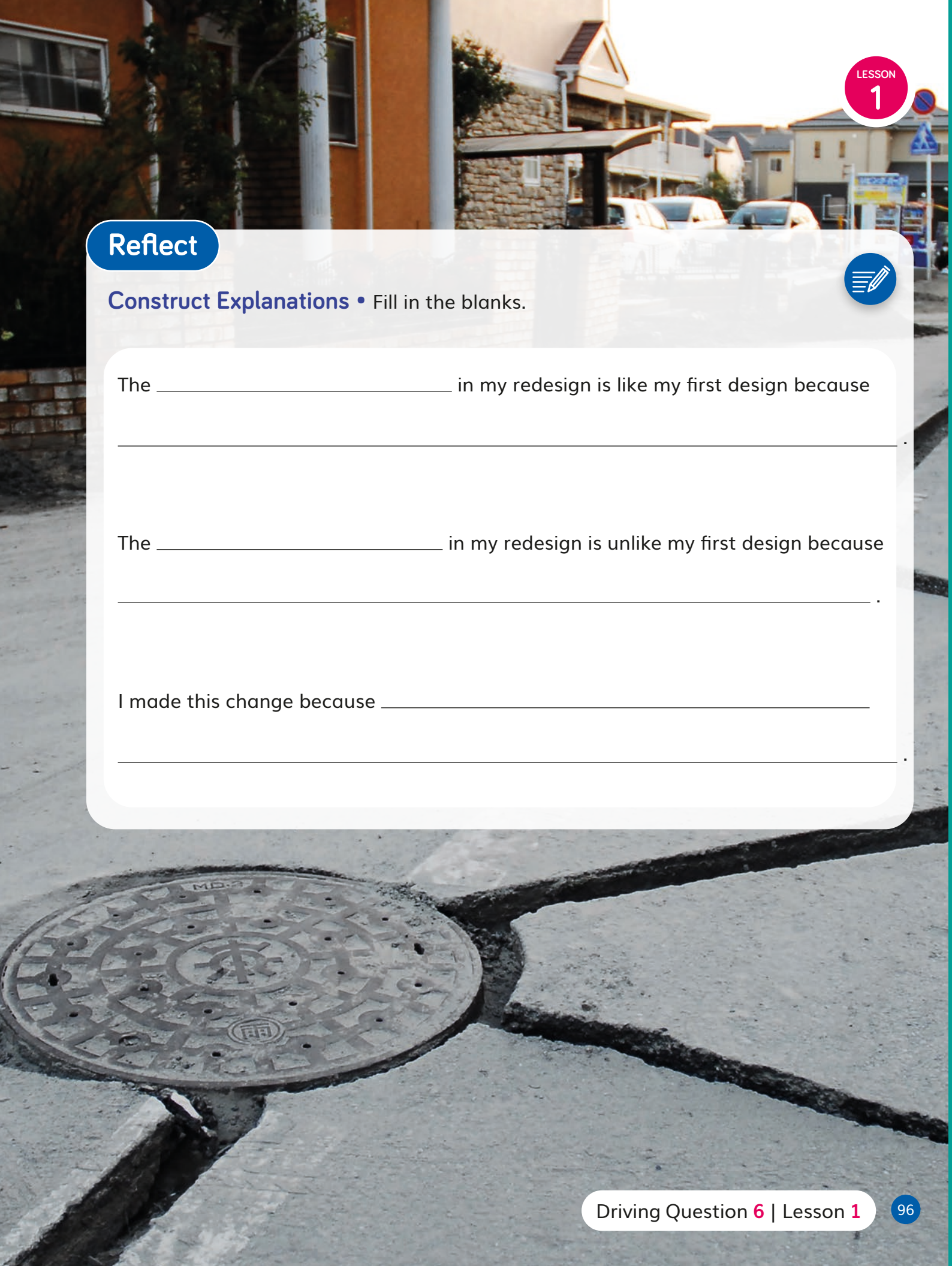
4-ESS3-2, 3–5-ETS1-1, 3–5-ETS1-2, 3–5-ETS1-3

LESSON 1

Final Little Changes

Hands-On

Improve Designs • Look over the table you filled out on page 90. Think about everything you've learned, discovered, and discussed about engineering for earthquake safety. With your team, revise your last design for a structure that meets all the Criteria and Constraints. Draw your new design and label changes made.



LESSON 1

Reflect

Construct Explanations • Fill in the blanks.

The _____ in my redesign is like my first design because

_____ .

The _____ in my redesign is unlike my first design because

_____ .

I made this change because _____

_____ .

LESSON 2

Built to Last

Hands-On

How many stories is your structure?

How tall is your structure (in cm)?



Reflect

Name your building. The name should describe the structure in some way.

Why is this name a good description of your building?

Rumble, Tumble, Crumble!

LESSON 3

Test Solutions • Test the structure you designed and built by following these steps.

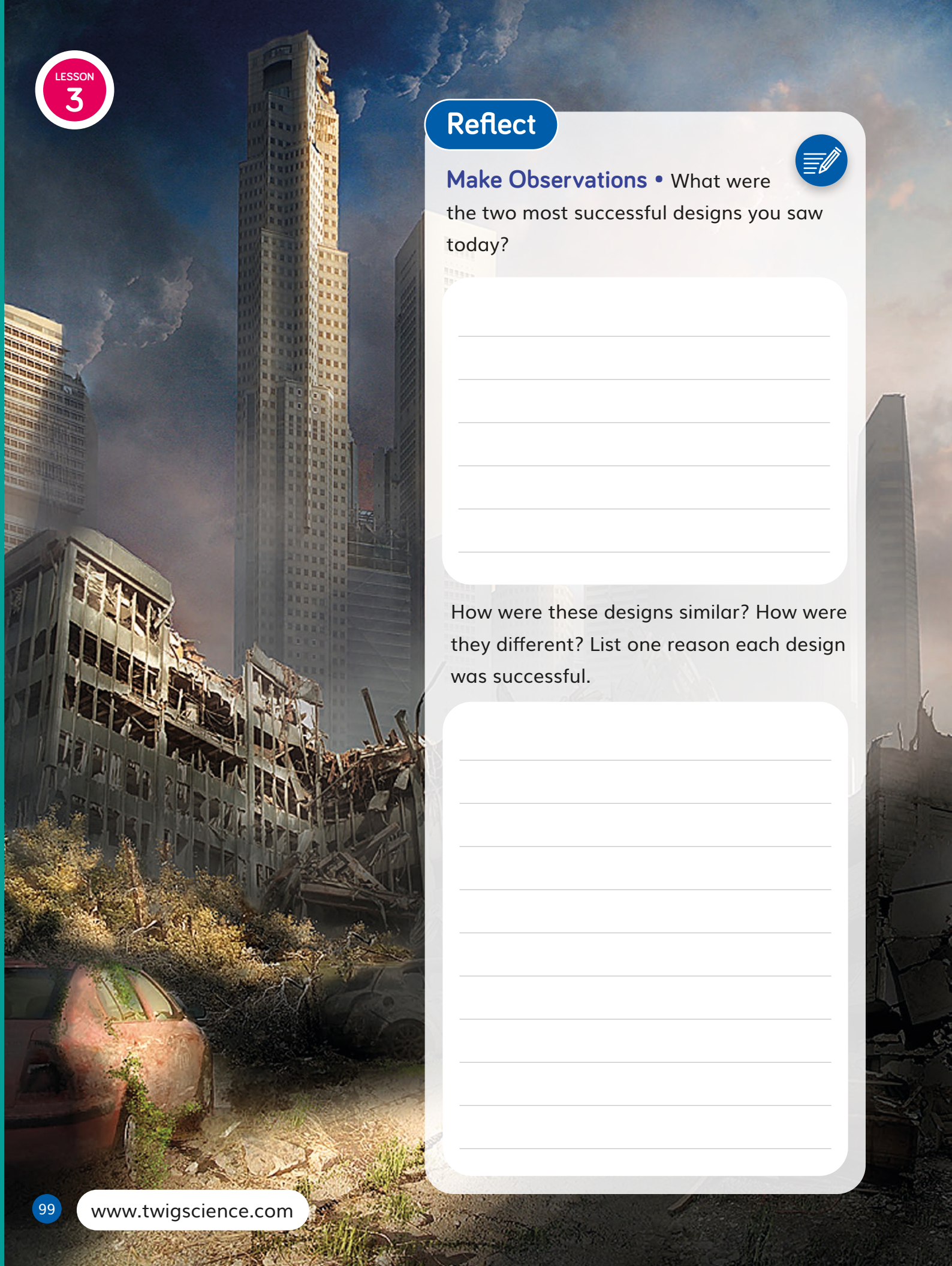
1. Put on your safety goggles.
2. Make sure the video is ready to record and have your stopwatch ready.
3. Test that your structure can survive an earthquake by shaking it with the earthquake simulator for 15 seconds.
4. If your structure does not collapse, place a sand bag on the structure and shake for 15 seconds. Record your result. Repeat by adding additional bags, one at a time, until the structure collapses.
5. Wait for the teacher to stop the video.

Live Load	Time
0	
1	
2	
3	
4	
5	

Take notes about what you observe as the other teams test their structures.

Word Wall

- fair test
- data
- budget



LESSON 3

Reflect

Make Observations • What were the two most successful designs you saw today?

How were these designs similar? How were they different? List one reason each design was successful.

Preparing Our Presentation

LESSON 4

Hands-On

Poster Guidelines

Design and Data

- Include your original designs (this can be in your Twig Book) and photos of your final structure.
- Show the data you collected (the structure measurements and test results) for each structure.
- Make sure your poster is organized with a title and headings.

Analysis

- Describe your structure's main features and how they make it earthquake-resistant.
- Compare the test results of your first and second structures.
- Explain what you could still improve and why.

Reflection

- Explain how your design changed as you learned from your failures or challenges.
- Can you answer the Module Anchor Phenomenon: How can we reduce the damage caused by earthquakes?

Challenge

Add a section on your poster about where you might build a full-scale version of your structure, and why. Include a description of the site, a drawing or map, and a written explanation.

LESSON 5

Presenting Our Work

3-D Performance Task

Ask Questions • Write two questions you might ask other teams about their presentations.

1

2

Challenge

Summarize • Which structure do you think was the most successful? The most creative? The most improved? Why?



LESSON 5

CHAPTER 1

Shake, Rattle, and Roll

by Alice Boynton

Note-Taking Chart

Key Ideas	Key Words and Pictures

Questions

Summary



Read Across Texts

_____ and _____ are different texts about the same topic.

The author of _____ included details such as _____.

This helped make the topic more meaningful to me because _____.

The author of _____ included details like _____.

This helped make the topic more meaningful to me because _____.

I think the most useful text on the topic was _____ because _____.

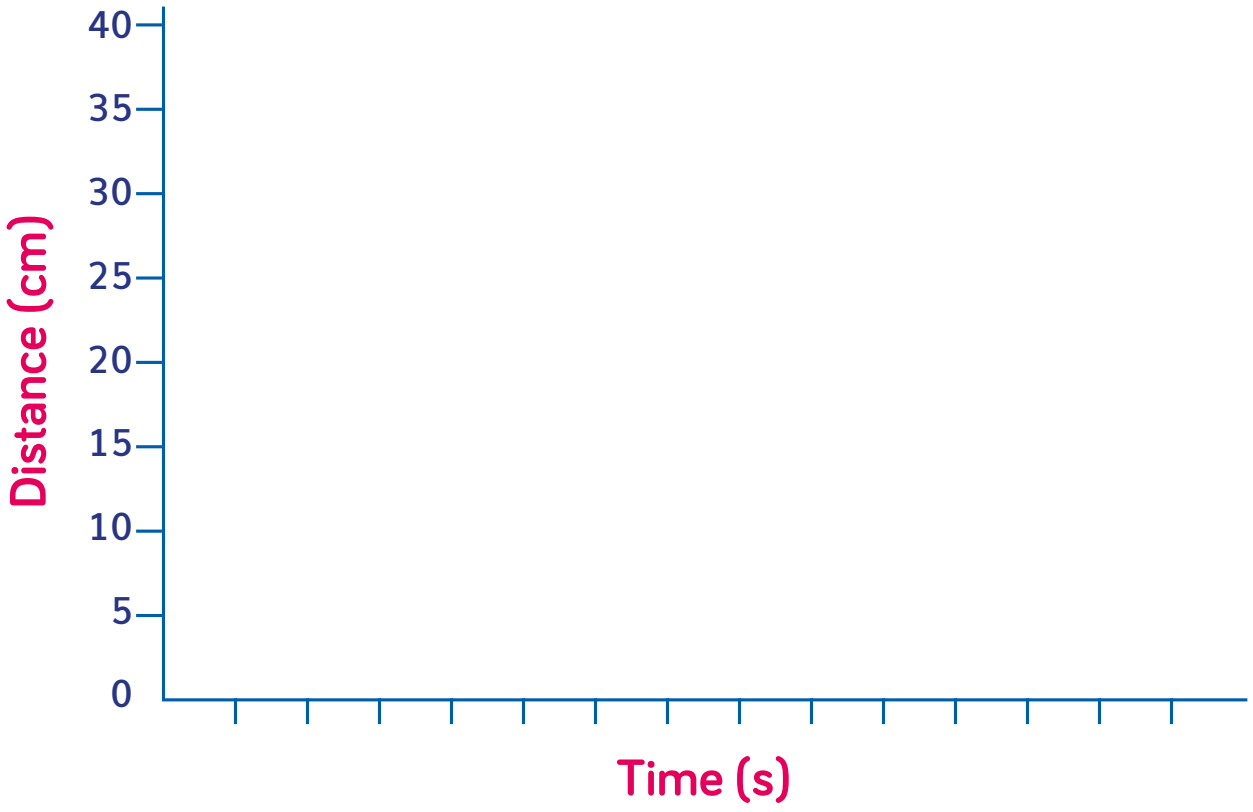
CHAPTER 2

Shake, Rattle, and Roll

by Alice Boynton



Distance vs Time



CHAPTER 3

Shake, Rattle, and Roll

by Alice Boynton



Compare/Contrast

Scientists in California and Japan are testing new ideas to make buildings earthquake-proof. In California, _____ _____ . This building _____ _____ _____ .

In Japan, _____ _____ . This building _____ _____ .

The buildings in California and Japan are similar in many ways. They are similar because _____ _____ .

But in some ways, the buildings in California and Japan are **different.** They are different because _____ _____ .

So, the buildings in California and Japan have **similarities** and **differences.**

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