Lesson 2.4
Which Way Is Up?
Lesson Overview

Students visualize an experiment in which they imagine people all over the planet standing and dropping rocks at the same time in order to stimulate their initial ideas about gravity. To introduce the Investigation Question: *If Earth is spinning, which way is up?*, students make predictions about what will happen when these imagined people drop the rocks in their respective locations. Next, students watch a video of students from many different countries who drop rocks and then revisit their initial thinking. Students use the sense-making strategy of visualizing as they read *Which Way Is Up?*—a book that introduces the idea that Earth pulls us (and other objects) toward its center due to the force of gravity, which affects our perceptions of *up* and *down*. After reading with a partner, students discuss their ideas about the actual direction of up and down and why it is so. This lesson introduces students to the force of gravity as the determining factor in working out which way is down, and by association, which way is up.

**Anchor Phenomenon:** Different sections of an ancient artifact show what the sky looked like from one location and depict different stars.

**Investigative Phenomenon:** When people in different locations on Earth drop rocks, the rocks always fall to the ground.

**Students learn:**

- Earth pulls objects, including people, down toward the ground with the force of gravity.
- Because of gravity, people all over Earth experience the same perception of *up* and *down*, even though Earth is a sphere and spins.
- One way to visualize while reading is to use the text and diagrams to make a movie in your mind.
- Basic laws of nature are the same everywhere in the universe.
Partner Reading

Using the strategy of visualizing, students read *Which Way Is Up?* as they continue to reflect on up, down, and spinning around.

Instructional Guide

1. **Introduce *Which Way Is Up?*** Remind students of the new Investigation Question. Call attention to the title of the book, and point out that the book should help students answer this question.

2. **Designate partners and distribute copies of the book and sticky notes.** Distribute one book to each pair and three sticky notes to each student. If necessary, review the procedures for reading with a partner.

3. **Hold up a copy of *How Big Is Big? How Far Is Far?!*** Remind students that the strategy of visualizing for this book meant that they connected measurements in the book to things that were familiar, which helped in understanding very large sizes and distances.

   - Point to page 4 in *How Big Is Big? How Far Is Far?!* and remind students that visualizing how big a car is helped in understanding how big a beluga is.

4. **Introduce a new approach to visualizing for understanding.** Hold up a copy of *Which Way Is Up?*

   We have been thinking about the spinning Earth, and the book we will read today will help us figure out which way is up if our planet is moving. But a book can’t show Earth spinning; a book can’t show anything actually moving. That’s why visualizing can help us with this book. This time, when you visualize, you can use the text and the diagrams to make a movie in your mind that will help you think about the way something moves.

5. **Model visualizing on pages 4–5.** Ask students to follow along as you read.

   - Read page 4 aloud. Continue reading on page 5, and pause after the second sentence.
     
     **Say:** I am making a movie in my mind of me running outside, and I’m trying to imagine what could be pulling on me.
6. Students practice visualizing with a diagram and with text. Have students skip to page 11.

- Ask students to look at the diagram of Earth and the arrow and visualize what movement this diagram is trying to show.
  Say: *What did you visualize?* [This diagram shows Earth spinning.]

- Discuss classroom experiences that helped students visualize.
  Say: *How did you know what a spinning Earth looks like?* [I connected my experience with the Mount Nose Model and visualized Earth spinning in the direction of the arrow.]

- Visualize with text.
  Say: *Readers also use the text to help them make movies in their minds. Keep the movie of the spinning Earth in your mind. As I read, pay attention to how the movie in your mind changes, based on what I read.*

- Read aloud the first sentence on page 11.
  Say: *How did the movie in your mind change?* [Earth stopped spinning.] Point out that Earth doesn’t actually ever stop spinning, but imagining it being still helps you think more about gravity.

7. Remind students to mark pages. Remind students to use their three sticky notes to mark places in the text where they used the strategy of visualizing.

8. Students read with partners. Students should read from the beginning of the book. Explain that as they read, students should think about their ideas from earlier in the lesson about what would happen if people all over Earth dropped rocks. Circulate and support students as necessary.

9. Pairs discuss their use of the visualizing strategy. Have students share one place where they used the strategy of visualizing, using their sticky notes as a guide.

10. On-the-Fly Assessment: Visualizing Motion. As partners share, circulate to listen to how students are discussing their use of the sense-making strategy of visualizing. For suggestions on what to listen for and how to maximize learning by all students, press the hummingbird icon and select ON-THE-FLY ASSESSMENT.
Embedded Formative Assessment

On-the-Fly Assessment 6: Visualizing Motion

Look for: At this point in the unit, students have had several opportunities to visualize ideas from their reading, as well as from their investigations. In this activity, students are encouraged to visualize by making a movie in their minds in order to better understand how Earth’s movement affects which way is up. Students then discuss in pairs one way they visualized as they read. As students discuss, take note of whether or not students describe visualizations that involve motion.

Now what? If students are having trouble using the text and diagrams to visualize Earth’s motion, provide some additional modeling. Refer students to the diagrams on pages 18–19. Read the text aloud, stopping after the first paragraph on page 19. Think aloud as you visualize Earth spinning. You may want to use an inflatable globe and actually spin it to help students “see” what you are visualizing. Depending on the needs of your students, you may provide this additional modeling individually, in a small group, or with the whole class.

Teacher Support

Background

About the Book: Which Way Is Up?
Which Way Is Up? with its clear text and simple illustrations helps students explore the meaning of the directions up and down in various locations on our spinning, spherical planet. The book introduces the force of gravity, which causes Earth to pull everything toward its center. Various examples show that this pull is inescapable and always in the downward direction, up is the opposite, and gravity is measured by an object’s weight. This book delivers essential content and supports students in understanding a key idea that is difficult to observe firsthand: what people on Earth see in the sky when they look up changes, and we do not all see the same thing at the same time. However, gravity is the constant force that helps people determine which way is up.

Background

Science Note: Force, Mass, and Kilograms
On Earth, weight is the force of gravity on an object exerted by Earth. If you were standing on the Moon or another planet, your weight would be the force exerted by whatever object you were standing on, and it would be different from your weight on Earth. Weight is different in different places. Mass, on the other hand, is a property of an object, and it does not change in different places. An object’s mass is the same no matter how strong the gravitational pull of Earth or the Moon or another planet. The kilogram is a unit of mass, not weight. Since kilograms are used in everyday-life only on Earth, it is common to think of a kilogram as measure of weight. Many scales for weighing, even scientific ones, are marked in kilograms. In Which Way Is Up?, the weights of several objects are described in both pounds and kilograms, even though the kilogram is a unit of mass, not force.
Instructional Suggestion

Going Further: Visualizing Dropping Rocks through Earth
Students may benefit by further discussing the thought experiment presented on pages 16–17 of Which Way is Up? You may want to draw the diagram on page 17 on the board so students can point to and share their ideas about what they think would happen if someone dropped a rock into a tunnel that went through Earth. As students engage with the diagram, notice whether they are thinking of down as toward the center of Earth in the diagram or toward the floor of the classroom. Question them and help them clarify their ideas. This thought experiment has never been done in real life, so you can concentrate on how they apply ideas, rather than a right answer.

Background

Literacy Note: Visualizing
In this lesson, students are introduced to a new purpose for visualizing: understanding motion. You will model making a movie in your mind based on text and then provide a guided opportunity for students to make their own movies in their minds, using both a diagram and text. Since books cannot convey motion, the strategy of visualizing by creating a movie in your mind is particularly useful for comprehension.
Reflecting on the Reading

Students reflect on the reading by discussing the whys of up and down.

Instructional Guide

1. Pairs discuss up and down. Ask partners to discuss new ideas about up and down from Which Way is Up?

2. Discuss students’ ideas.

   • Based on what you read, what new ideas do you have about which way is up, and which way is down? Are up and down always the same? [Accept all responses.]

   Depending on how you think about it, up and down might seem like they are in different directions for people in different locations on Earth.

3. Project pages 14–15 in Which Way Is Up? Acknowledge that there can be different ways of thinking about up and down.

   • Focus students on page 14 and discuss down.

   If you visualize two people on opposite sides of Earth pointing down, both of those people are pointing down toward Earth, so that’s the same. But they aren’t pointing in the same direction, so that is different.

   • Focus students on page 15 and discuss up.

   If you visualize two people on opposite sides of Earth pointing up, both of those people are pointing away from Earth, so that’s the same. But one of them is pointing toward the sun, and the other is pointing away from the sun, so that is different.

4. Post the vocabulary card for gravity on the classroom wall. Connect the definition of gravity to up and down.

   Gravity means the pull between Earth and other objects, and it acts even without touching. Because of gravity, this desk is pulled down to the floor, because of gravity, this pencil is pulled to the desk. Earth pulls all objects down toward Earth with the force of gravity.
If we think about the force of gravity, **down** is always the same for everyone anywhere on Earth—down is toward the ground. And, since **up** is the opposite of **down**, that means **up** is always away from the ground, anywhere on Earth.

5. **Explain that there is gravity on the Moon and on other planets too.**

If you visualize an astronaut in space, you might picture them floating around with no gravity to pull them down. However, other objects in the universe, like the Moon and other planets, also have gravity just like Earth.

In that case, it is the Moon or the other planet that pulls on objects without touching them. So if you picture an astronaut on the Moon, for them, instead of down and up being toward and away from Earth, down is toward the Moon and up is away from the Moon.

So, the law of gravity applies not just to Earth, but to other planets in the universe too.

6. **Remind students of the Investigation Question written on the board:** "If Earth is spinning, which way is up?"

We’ve begun to understand which way is up. In the next lesson, we’ll continue thinking about which way is up for people in different places, at different times.

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**Teacher Support**

**Background**

**Science Note: Gravity of Objects Other Than Earth**

In this unit, we define and discuss gravity with respect to Earth: Earth pulls us and other objects down toward Earth’s center. In reality, all objects with mass exert some gravitational force on other objects with mass. In the case of Earth, its mass is so much larger than our own that we only notice the force of gravity due to Earth. If we were on the surface of another planet or moon, such as Mars or Titan, a moon of Saturn, it would be that body, rather than Earth, that would be exerting its gravitational force on us. Gas giant planets and stars have even greater gravitational pull, due to their greater size, and they pull objects in toward their centers, even though they have no solid surface to stand on.

**Rationale**

**Pedagogical Goals: Understanding the Nature of Science**

One goal set forth by the Next Generation Science Standards (NGSS) is for students to understand the nature of science as a discipline and how scientific knowledge develops over time. The NGSS call out eight understandings about the nature of science that are woven throughout the Amplify Science curriculum. This unit gives students an opportunity to experience the understanding that Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Specifically, this activity, in which the students connect the ideas of up and down in different places around the world to the force of gravity, illustrates the idea that the basic laws of nature are the same everywhere in the universe.
Partner Reading

Using the strategy of visualizing, students read *Which Way Is Up?* as they continue to reflect on up, down, and spinning around.

Instructional Guide

1. **Introduce Which Way Is Up?** Remind students of the new Investigation Question. Call attention to the title of the book, and point out that the book should help students answer this question.

2. **Designate partners and distribute copies of the book and sticky notes.** Distribute one book to each pair and three sticky notes to each student. If necessary, review the procedures for reading with a partner.

3. **Hold up a copy of How Big Is Big? How Far Is Far?** Remind students that the strategy of visualizing for this book meant that they connected measurements in the book to things that were familiar, which helped in understanding very large sizes and distances.
   - Point to page 4 in *How Big Is Big? How Far Is Far?* and remind students that visualizing how big a car is helped in understanding how big a beluga is.

4. **Introduce a new approach to visualizing for understanding.** Hold up a copy of *Which Way Is Up?*

   - *Hemos estado pensando en la Tierra que gira, y el libro que leeremos hoy nos ayudará a averiguar hacia dónde es arriba si nuestro planeta se está moviendo. Pero un libro no puede mostrar a la Tierra girando; un libro no puede mostrar nada moviéndose realmente. Por eso visualizar nos puede ayudar con este libro. Esta vez, cuando visualicen, pueden usar el texto y los diagramas para hacer una película en la mente que les ayudará a pensar en cómo se mueve algo.*

5. **Model visualizing on pages 4–5.** Ask students to follow along as you read.
   - Read page 4 aloud. Continue reading on page 5, and pause after the second sentence.
     - *Say: I am making a movie in my mind of me running outside, and I’m trying to imagine what could be pulling on me.*
6. Students practice visualizing with a diagram and with text. Have students skip to page 11.

- Ask students to look at the diagram of Earth and the arrow and visualize what movement this diagram is trying to show.
  
  Say: *What did you visualize?* [This diagram shows Earth spinning.]

- Discuss classroom experiences that helped students visualize.
  
  Say: *How did you know what a spinning Earth looks like?* [I connected my experience with the Mount Nose Model and visualized Earth spinning in the direction of the arrow.]

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  Say: *Readers also use the text to help them make movies in their minds. Keep the movie of the spinning Earth in your mind. As I read, pay attention to how the movie in your mind changes, based on what I read.*

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  Say: *How did the movie in your mind change?* [Earth stopped spinning.] Point out that Earth doesn’t actually ever stop spinning, but imagining it being still helps you think more about gravity.

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2. Discuss students’ ideas.
   
   - *Based on what you read, what new ideas do you have about which way is up, and which way is down? Are up and down always the same? [Accept all responses.]*

   Dependiendo de cómo piensen en ello, arriba y abajo podría parecer como si estuvieran en diferentes direcciones para la gente en diferentes ubicaciones sobre la Tierra.

3. **Project pages 14–15 in Which Way Is Up?** Acknowledge that there can be different ways of thinking about up and down.

   - *Focus students on page 14 and discuss down.*

     Si visualizan a dos personas en lados opuestos de la Tierra apuntando hacia abajo, esas dos personas están apuntando hacia abajo en dirección a la Tierra, así que eso es igual. Pero no están apuntando en la misma dirección, así que eso es diferente.

   - *Focus students on page 15 and discuss up.*

     Si visualizan a dos personas en lados opuestos de la Tierra apuntando hacia arriba, esas dos personas están apuntando hacia arriba en la dirección opuesta a la Tierra, así que eso es igual. Pero una de ellas está apuntando hacia el sol y la otra está apuntando en la dirección opuesta al sol, así que eso es diferente.

4. **Post the vocabulary card for gravity on the classroom wall.** Connect the definition of gravity to up and down.
5. Explain that there is gravity on the Moon and on other planets too.

Si pensamos en la fuerza de la gravedad, abajo siempre es igual para todos en cualquier parte de la Tierra; abajo es hacia el suelo. Y, como arriba es lo opuesto de abajo, eso significa que arriba es siempre en la dirección opuesta al suelo, en cualquier lugar en la Tierra.

6. Remind students of the Investigation Question written on the board: "If Earth is spinning, which way is up?"

Entonces, la ley de la gravedad aplica no solo para la Tierra, sino también para otros planetas en el universo.

Teacher Support

Background

Science Note: Gravity of Objects Other Than Earth
In this unit, we define and discuss gravity with respect to Earth: Earth pulls us and other objects down toward Earth’s center. In reality, all objects with mass exert some gravitational force on other objects with mass. In the case of Earth, its mass is so much larger than our own that we only notice the force of gravity due to Earth. If we were on the surface of another planet or moon, such as Mars or Titan, a moon of Saturn, it would be that body, rather than Earth, that would be exerting its gravitational force on us. Gas giant planets and stars have even greater gravitational pull, due to their greater size, and they pull objects in toward their centers, even though they have no solid surface to stand on.

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