Rainbow Refraction

Physical Science | Lesson Guide

5th Grade

Photo Description

This image shows a beautiful rainbow stretching across a wet highway on a partly cloudy day. The rainbow appears as a curved arc of colors in the sky, visible because sunlight is shining from behind the camera toward the moisture and water droplets in the air ahead. Trees line both sides of the wet road, and you can see vehicles on the highway below the rainbow.

Scientific Phenomena

Anchoring Phenomenon: Light refraction and reflection creating a rainbow

When sunlight enters water droplets in the air (from rain or mist), the light bends, bounces inside the droplet, and bends again as it exits. This bending and bouncing separates white sunlight into its different colors—red, orange, yellow, green, blue, indigo, and violet—which is why we see a rainbow. The observer must have the sun behind them and water droplets in front of them for a rainbow to be visible. This is an excellent real-world example of how light behaves as it passes through different materials.

Core Science Concepts

* Light travels in straight lines but can bend (refract) when passing through different materials. Water droplets have a different density than air, so light slows down and changes direction when entering the droplet.

* White light is made up of many colors with different wavelengths. Each color bends at a slightly different angle, which separates the colors and creates the rainbow we see.

* Rainbows require three elements: sunlight, water droplets, and the correct viewing angle. The observer must be positioned between the sun and the water droplets, with the sun behind them at approximately a 42-degree angle.

* Reflection occurs inside the water droplet. Light bounces off the back of the droplet, which is why rainbows appear in a curved arc rather than a straight line.

Pedagogical Tip:

When teaching refraction, use the "straw in water" demonstration first. Have students observe how a straw appears bent when placed in a clear glass of water. This concrete experience helps them visualize light bending before introducing the abstract concept of rainbows. Connect the two phenomena explicitly: "Light bends in both the straw and the raindrops—it's the same science!"

UDL Suggestions:

Provide multiple means of representation by offering both visual demonstrations (prisms, water droplets) and tactile experiences (feeling the angle needed to see a rainbow by turning in a circle). Allow students to express their learning through drawing, writing, or creating a physical model. Consider pairing visual learners with kinesthetic learners during activities so they can support one another's understanding.

Zoom In / Zoom Out

Zoom In: The Atomic Level
When we zoom in super close—closer than we can see even with a regular microscope—we discover that light travels as tiny packets of energy called photons. Each color of light has photons with different amounts of energy. When a photon enters a water droplet, it slows down because water molecules are packed more tightly than air molecules. This slowdown causes the photon to change direction (refraction). Red light photons have less energy and bend less, while violet light photons have more energy and bend more. This is why violet appears on the inside of the rainbow arc and red appears on the outside. The water molecules themselves are also vibrating and bouncing, creating the perfect conditions for light to bounce around inside the droplet.

Zoom Out: The Water Cycle and Weather Systems
Rainbows are visible signs of the water cycle in action. When water evaporates from oceans, lakes, and rivers, it rises into the atmosphere and forms clouds. When those clouds release rain, water droplets fall back to Earth—and that's when rainbows can appear! On a larger scale, rainbows tell us about weather patterns. A rainbow visible in the afternoon often means that rain has just passed through, and the sun is breaking through behind the observer. Meteorologists and weather scientists use observations of light phenomena (including rainbows) to understand atmospheric conditions and predict future weather. Understanding how light interacts with water droplets in our atmosphere helps us comprehend larger weather systems, climate patterns, and even how water moves around our entire planet.

Discussion Questions

1. Why do you think we can only see a rainbow when the sun is behind us and not in front of us? (Bloom's: Analyze | DOK: 2)

2. If you could catch the end of a rainbow and move it to a different location, what do you think would happen? Explain your thinking. (Bloom's: Evaluate | DOK: 3)

3. How is a rainbow similar to what happens when light passes through a prism in the classroom? (Bloom's: Compare | DOK: 2)

4. What would happen to the rainbow if there were no water droplets in the air, even though the sun and sky conditions were perfect? (Bloom's: Analyze | DOK: 2)

Potential Student Misconceptions

Misconception 1: "Rainbows are physical objects you can reach or touch."
Many Fifth Grade students believe rainbows are solid things in the sky that can be chased or caught. Scientific Clarification: A rainbow is not a physical object—it's an optical illusion created by light interacting with water droplets. The rainbow you see exists only from your specific viewing angle. If you move, the rainbow appears to move with you because you're now at a different angle to the water droplets. Another person standing next to you will see a slightly different rainbow because they're standing in a different spot. This is why you can never actually reach the end of a rainbow!

Misconception 2: "All rainbows have the same colors in the same order, and there are exactly seven colors."
Students often memorize "ROY G. BIV" and think every rainbow must have seven distinct colors. Scientific Clarification: While rainbows do follow a consistent pattern (red on the outside, violet on the inside), the exact number of colors you see depends on your eyesight, lighting conditions, and how carefully you're looking. Some people can distinguish more than seven colors, while others see fewer. The colors blend gradually into each other rather than having sharp lines between them. This is because light is a continuous spectrum, not seven separate buckets of color.

Misconception 3: "You need rain to see a rainbow."
Students assume rainbows only appear during or right after rainstorms. Scientific Clarification: While rain is a common source of water droplets for rainbows, you can create rainbows anytime water droplets are in the air—near a waterfall, fountain, sprinkler, or even a garden hose on a sunny day. The key requirement is having sunlight, water droplets, and the correct viewing angle (sun behind you). This is why rainbows can appear on sunny days when it's not raining at all!

Extension Activities

1. Create Your Own Rainbow with a Prism or Water Spray:
Set up a clear prism or spray water from a hose in sunlight on a sunny day. Have students observe and draw the rainbow they create. Ask them to predict what would happen if they changed the angle of the prism or moved the spray. Test their predictions and discuss why changing the angle affects what they see.

2. Rainbow in a Bottle Experiment:
Fill a clear bottle with water and place it on a white piece of paper in sunlight. Have students observe the small rainbow created by light passing through the water. Students can rotate the bottle and record how the rainbow changes position and brightness. Connect this to the phenomenon in the photo: same science, smaller scale.

3. Design a Rainbow Observation Journal:
Challenge students to find and photograph or sketch rainbows over the next week or two (after rain, near sprinklers, etc.). Have them record the time of day, the sun's position, weather conditions, and their distance from the rainbow. Bring observations back to class and create a class chart showing the patterns they discovered about when and where rainbows appear.

Cross-Curricular Ideas

Mathematics Connection: Angles and Geometry
Have students investigate the rainbow angle—the 42-degree angle at which rainbows always appear relative to the sun. Students can use protractors to measure and draw rainbows at the correct angle. Create a math activity where students draw their position, the sun's position, and calculate where a rainbow would appear using angles. Students could also measure the arc of a rainbow in a photograph and calculate what fraction of a complete circle it represents (typically about 84 degrees of arc). This connects to measuring angles, understanding circles, and applying geometry to real-world phenomena.

English Language Arts Connection: Poetry and Descriptive Writing
Rainbows have inspired poets and writers for centuries. Have students read rainbow-themed poetry (such as poems by Emily Dickinson or simple picture books about rainbows) and discuss the language authors use to describe light, color, and wonder. Then have students write their own descriptive paragraphs or poems about rainbows, using vivid sensory language and metaphors. Students could also research and write about rainbow myths and legends from different cultures, comparing how different societies have explained rainbows throughout history before modern science understood them.

Art Connection: Color Theory and Light Mixing
Use the rainbow to teach color theory and the difference between additive color (light) and subtractive color (pigment). Create a hands-on activity where students use colored tissue paper, flashlights, and white paper to experiment with how colored light mixes differently than colored markers or paint. Students can create artwork inspired by rainbows using various media—watercolor paintings, collages with tissue paper, or digital art exploring color gradients. Challenge them to create their own "rainbow" using only three colors of light (red, green, blue) to see how light mixing differs from paint mixing.

Social Studies Connection: Geography and Weather Around the World
Rainbows appear in different parts of the world under different conditions. Have students research which regions experience rainbows most frequently based on climate and rainfall patterns. Students could create a world map showing where rainbows are common and investigate how geography (mountains, proximity to oceans, latitude) affects rainfall and rainbow frequency. Students could also research how different cultures and countries have valued, studied, or used rainbows in their histories—from ancient civilizations to modern weather science—connecting Earth science to human culture and geography.

STEM Career Connection

Meteorologist (Average Annual Salary: $96,000–$102,000 USD)
Meteorologists are scientists who study weather and the atmosphere. They use their understanding of how light interacts with water droplets and air to predict weather patterns, track storms, and understand climate. A meteorologist might observe rainbows and other atmospheric optical phenomena to learn more about atmospheric conditions—like humidity levels and water droplet size—that affect weather. They use tools like satellites, radar, and computers to help people prepare for rain, snow, and severe weather. If you love observing the sky and want to help people stay safe during storms, meteorology could be your career!

Optical Engineer or Physicist (Average Annual Salary: $120,000–$130,000 USD)
Optical engineers and physicists study how light behaves and create tools and technologies based on how light works. They design things like cameras, telescopes, microscopes, fiber optic cables (used for internet), and special lenses for glasses and contact lenses. By understanding refraction and how light bends through different materials (just like in a rainbow), optical engineers create technology that helps doctors see inside our bodies, lets us communicate across the world, and helps astronomers explore space. If you're curious about light and love building or designing things, this could be a perfect career for you!

Environmental Scientist (Average Annual Salary: $75,000–$90,000 USD)
Environmental scientists study Earth's systems, including the water cycle, atmosphere, and weather patterns. They use their knowledge of light, water, and atmospheric conditions to understand how our planet is changing and how to protect it. An environmental scientist might study how water moves through the atmosphere and falls as rain (which creates rainbows!) to understand drought, flooding, and water availability. They work to protect clean water and healthy air for all living things. If you care about protecting our planet and want to solve environmental problems, environmental science could be your calling!

NGSS Connections

Performance Expectation:
5-PS2-1: Support an argument that the gravitational force exerted by Earth on objects is directed down.

Disciplinary Core Ideas:
* 5-PS2.B - Types of Interactions (electromagnetic forces, including light interactions)
* K-PS3.B - Wave Properties (light travels and can be reflected, refracted, and absorbed)

Crosscutting Concepts:
* Patterns - Rainbow colors always appear in the same order
* Energy and Matter - Light energy is transformed as it passes through water droplets

Science Vocabulary

* Refraction: The bending of light when it passes from one material into another material that has a different density.

* Water droplet: A tiny ball of water, smaller than a raindrop, that floats in the air and can bend and reflect light.

* Reflection: The bouncing of light off a surface, like when light bounces inside a water droplet to create a rainbow.

* Wavelength: The distance between repeating patterns of light waves; different colors have different wavelengths.

* Prism: A transparent object with flat surfaces that can bend light and separate it into colors, similar to how water droplets create rainbows.

External Resources

Children's Books:

Rainbow* by Sam Usher (explores weather and light phenomena)

How Do You Raise a Dragon?* by Kate Westerlund (includes light and color concepts)

The Rainbow* by Marc Harshman (picture book about rainbows with accurate science)