1st Grade Science Experiments

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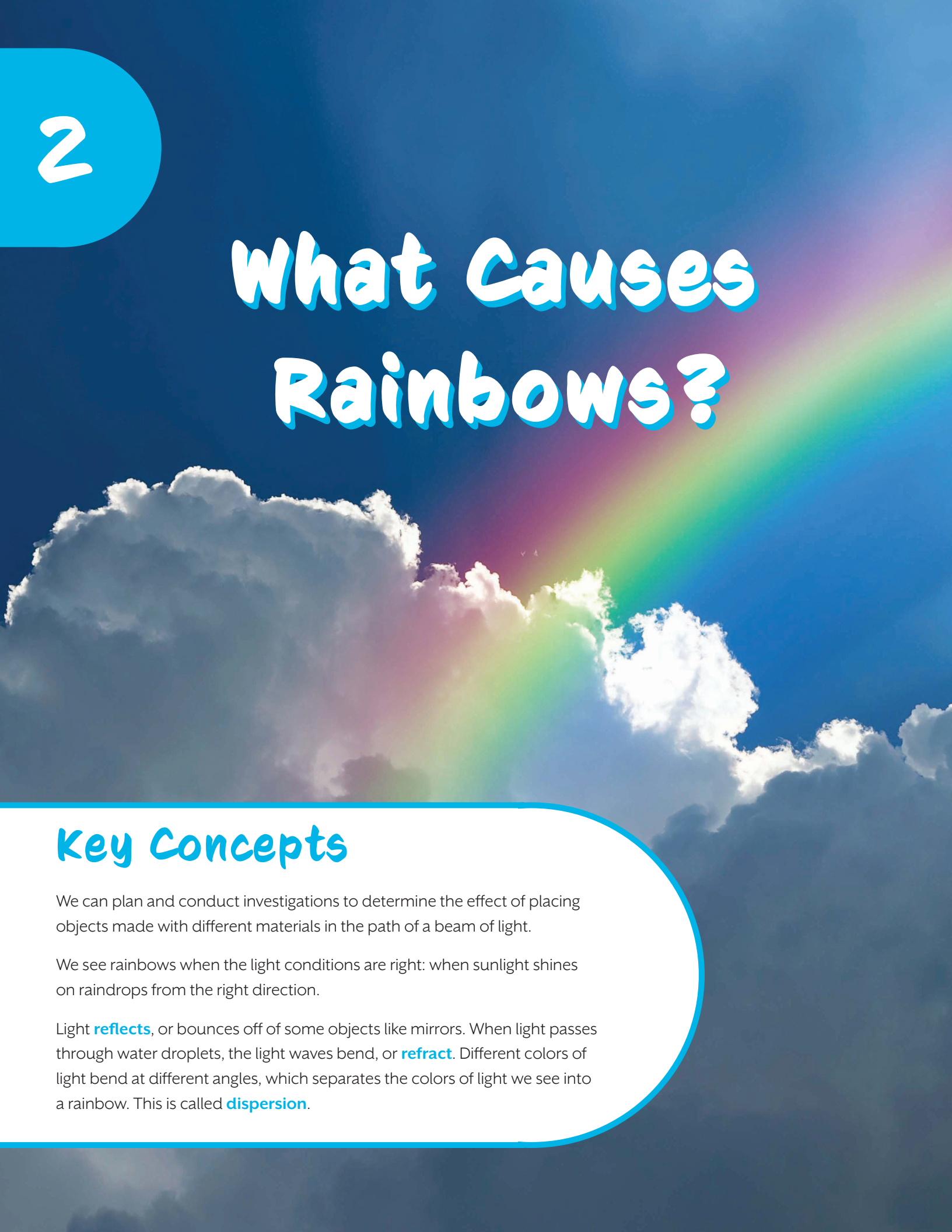
What Causes Rainbows?



Key Concepts

We can plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light.

We see rainbows when the light conditions are right: when sunlight shines on raindrops from the right direction.

Light **reflects**, or bounces off of some objects like mirrors. When light passes through water droplets, the light waves bend, or **refract**. Different colors of light bend at different angles, which separates the colors of light we see into a rainbow. This is called **dispersion**.

Materials

- flashlight K (best with an incandescent or halogen light bulb)
- white paper
- What Causes Rainbows? Test Data Chart P
- drinking glass
- plate or shallow dish
- table
- measuring cup or small pitcher
- water
- camera (optional)
- colored pencils or crayons
- pencil
- small mirror K

Location: a room that can be darkened

Introduction

Have you ever seen a rainbow after a storm? Sometimes they can make an arc across the whole sky. If the conditions are right, you may even see two rainbows stacked on top of each other.

Think about the last gray, rainy day you experienced. Did you see any rainbows? Probably not. But why? Why do we see rainbows only sometimes, and not every time it rains? Today we'll conduct an experiment to make a rainbow to help us find out.

Point to Ponder

Why do we see rainbows only sometimes? What conditions allow us to see a rainbow in the sky?

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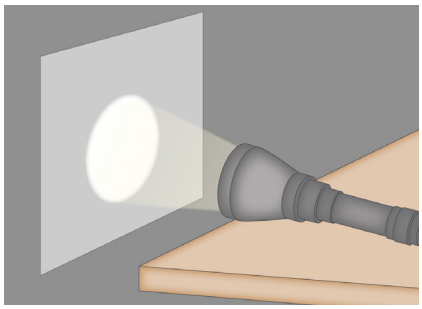
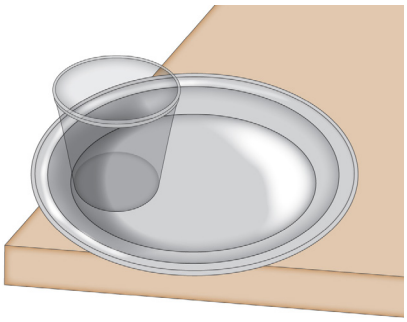
Investigate

Tip: This experiment works best in a room that can be darkened.

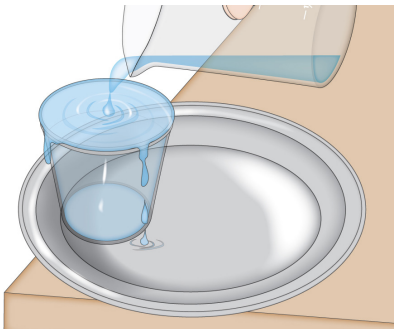
1. Shine a flashlight straight at a piece of white paper. Write down the colors of light you see on the **Test Data Chart**.



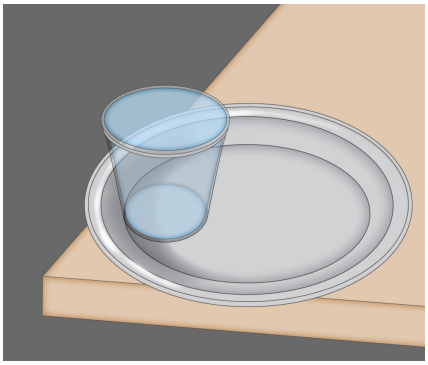
2. Place the glass on a plate or shallow dish to catch spilled water. Set it close to the edge of a table.



3. Use a measuring cup or other small pitcher to fill the glass to the very top with water so that the water level is above the brim.

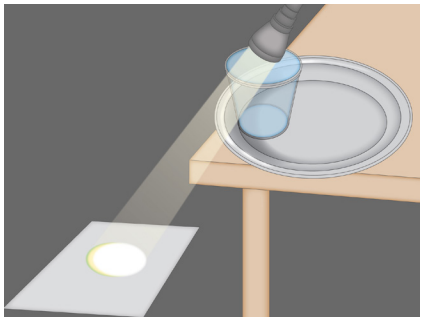


4. Turn off the lights.

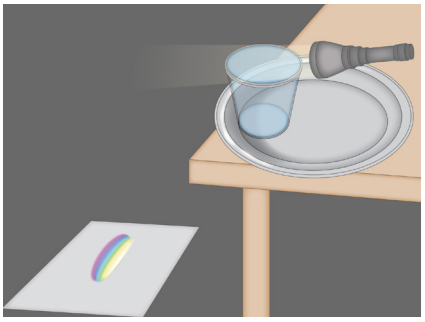


Make a Prediction: If we shine a flashlight at this cup of water, can we make a rainbow? Record your prediction on the **Test Data Chart**.

5. From the side of the glass, shine the flashlight through the water at different angles, toward the open floor space. Look on the floor near the table. Lay the white paper on the spot where you see the light from the flashlight shining on the floor.



6. Slowly adjust the angle of the flashlight until you see the rainbow appear on the white paper.



Parents: When you see the rainbow, take a photo of the set-up to record the position of the flashlight, water, light, and paper. This will allow your students to draw the set up that produced a rainbow and you won't have to stand and hold the flashlight while they draw.

7. On the **Test Data Chart**, draw the position of the flashlight, water, glass, and sheet of paper. You may use the photo your parents took to help you. Use colored pencils or crayons to color the rainbow.

? When you shone the flashlight directly at the sheet of white paper, could you see a rainbow? (No.)

? When you put the glass with water between the flashlight and white paper, what happened? (A rainbow appeared.)

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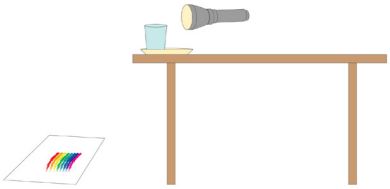
Why Do We See a Rainbow?

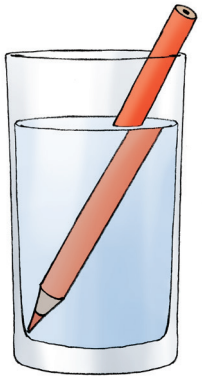
Look at your sketch of the flashlight, the water, and the rainbow on the paper. Use your finger to trace the path of the light from the flashlight through the water and down to the rainbow. What do you notice about the path the light takes? It changes direction. How does light do this?



Light waves change speed when they pass from one type of material to another. This change in speed causes light to bend. We call this bend **refraction**.

You can see light refract when you put a pencil into a glass of water.

8. Place a pencil into the glass of water.

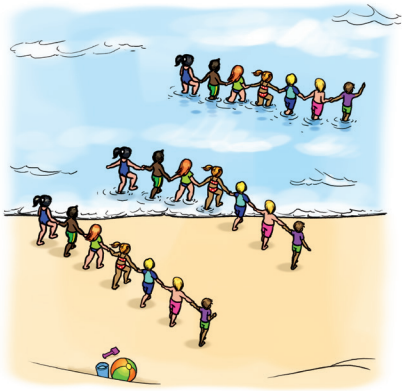


Do you see how it looks like the pencil has broken? It hasn't really. The pencil just looks bent or broken because light travels more slowly in water than it does in air.

Why does water bend light?

Have you ever run from a beach into a lake or ocean—or even into a kiddie pool in your yard? It's easy to run quickly across dry land, but when your feet reach the water, the water slows you down. That's because water is more dense than air, which just means the tiny bits that make up water are closer together, and it's harder to push through as you run.

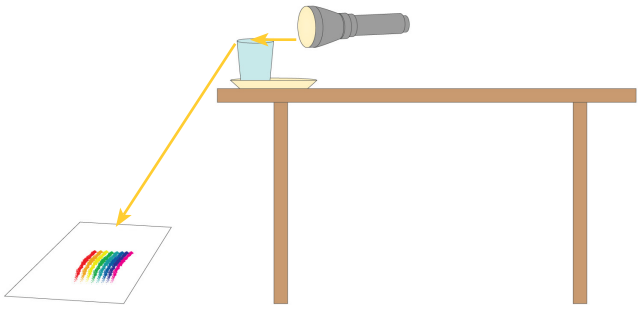
Now pretend you're at the beach with several friends, and you want to run into the water together. You all link arms and run toward the water in a line, but your line is at a bit of an angle to the water. When the first friend reaches the water, she slows down, but the other friends keep moving at the same speed because they're still running on sand. As each friend in the line reaches the water, they slow down and move at a different speed. This makes the line of friends bend.



When light waves travel through the air (which is a gas), they move at a certain speed, but when light hits the dense water, the light waves change speed, and bend—just like the line of friends on the beach.

9. Look again at your diagram of the flashlight, glass of water and the paper on the **Test Data Chart**. Draw a line from the flashlight to the glass and then from the glass to the paper to show the path the light took to reach the paper.

Did the light bend? Yes. Here we can see how it **refracted**.



So now we know the light is bending to shine on the paper, but what else is happening to make the rainbow? Is the water doing something else? Water is just clear—doesn't the light simply shine through it?

Let's find out more ...

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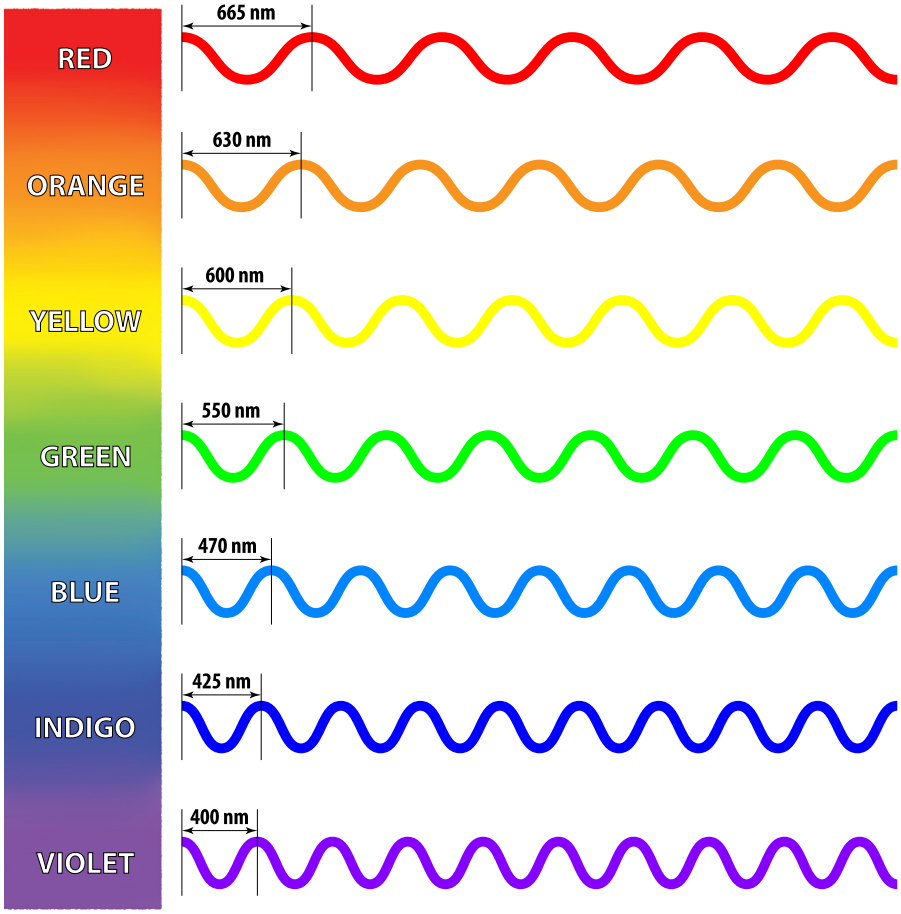
What's Happening?

Rainbows are made up of every color of visible light, and each color always appears in the same order. You can remember this order if with the acronym ROY G BIV:

Red		**B**lue
Orange	**G**reen	**I**ndigo
Yellow		**V**iolet



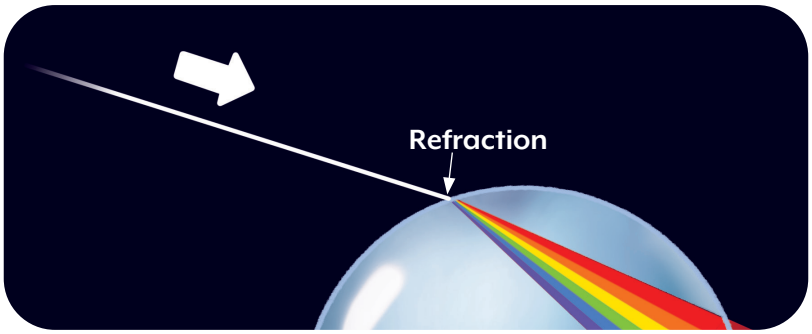
White light is made up of all of these colors. When they shine together, the colors mix and our eyes see it as white light, or a natural light color.

Light travels in waves. Each color of light has a different wavelength. Red light has the longest wavelength and violet has the shortest.

As the light goes into water, the waves that make up white light start to bend, or **refract**. Because each color is a wave that travels at a different speed, the water bends the waves in slightly different amounts—or at different angles. When one color bends more than another, the different colors spread out, or **disperse**. When the colors spread out, we see a rainbow.

Did you know?

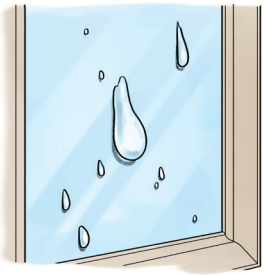
White light is a mixture of all of the colors of the rainbow, but mixing light is very different from mixing paint. Each pigment, or paint color, absorbs a certain color of light, instead of reflecting it. If you mixed all the colors of paint, you would end up with a dark gray or brown color instead of white, because all the colors are absorbed together.



In our glass of water, the light hits the water above the rim of the glass and refracts. The different light waves bend at slightly different amounts (because they're travelling at different speeds), and they disperse, or spread out. We see this spreading out—or **dispersion**—as a rainbow on the floor.

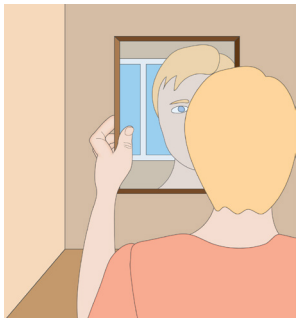
Rainbows in the Sky

We see rainbows after a storm because there are still raindrops in the air. One more thing happens, though, when light hits a raindrop to make a rainbow in the sky than is happening in our glass of water. If you've ever watched water trickle down a window, it makes a teardrop shape—one that is round on the bottom and a little pointed at the top. That's because a little bit of each drop has stuck to the glass and is being dragged behind the rest of the drop. When water falls through the air, it falls in a perfect sphere shape—or round ball. The raindrop's ball-shape changes where we are able to see rainbows.



To understand how raindrops differ from our glass of water, let's first talk about how light works in a mirror.

10. Hold the mirror out in front of you so you can see yourself in it.



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Try It:

The next time you're at the pool, you can see the ball shapes water makes by cupping your hand to catch a little water and throwing this bit of water straight up in the air. How does the water look as it falls?

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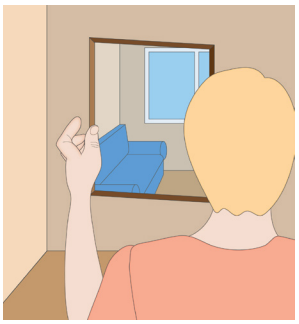
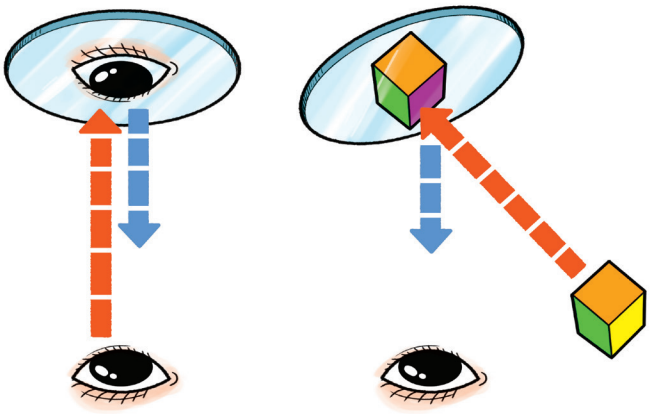
When you look directly into a mirror, you can see yourself. This is because light bounces directly from you, off of the mirror and back to your eyes. When light bounces, we say it **reflects**. The image of yourself in the mirror is your **reflection**.

Now turn the mirror just slightly to the right or left. Can you still see yourself? What do you see?



Now you see part of the room near you, but you don't see yourself.

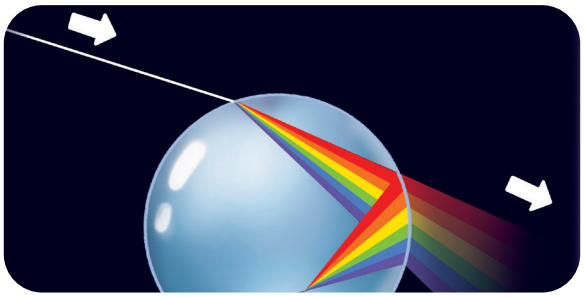
This is because light bounces into the mirror from another part of the room and back to your eyes. Since you're holding the mirror at an angle, you see another part of the room, off at an angle too.



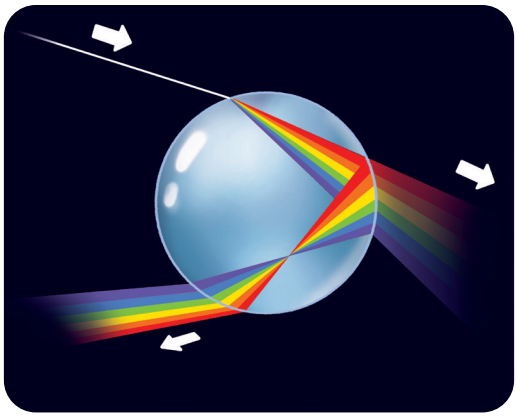
What you see when you look straight into a mirror

What you see when you look into a mirror at an angle.

Light enters a raindrop the same way it enters the water in our glass. While some light does shine through the other side of the water drop, much of the light bounces—or **reflects**—off of the back of the water drop, because the raindrop is shaped like a ball.



When the light passes out of the water drop and back into the air, it refracts again, because the water no longer slows it down. The light that reflects off the back comes out of the front of the water drop and is spread out (or **dispersed**) into different colors, so we see a rainbow.



When light refracts, our eyes can see each color individually, always in the same order.

This is what happens to light in a single raindrop. Since each raindrop is so small, it takes millions of raindrops refracting and reflecting light to create the giant rainbows we see in the sky.

So if water droplets are present after a storm *and* on gray rainy days, why do we only sometimes see rainbows?

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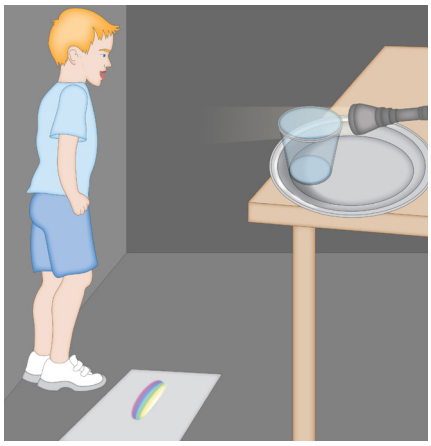
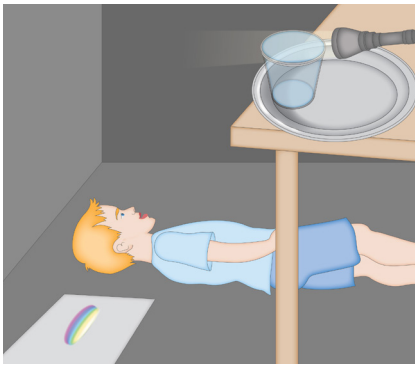
Explore

Set up the glass and the flashlight again and stand directly across from the flashlight. Look toward the flashlight. Do you see the rainbow? (no)



If you lay down on the floor with your head near the paper and look up toward the glass on the table, do you see the rainbow? (No—the water may look "lit up," but you will still just see white light.)



You don't see the rainbow from either of these two places because the light isn't bending the right way for you to see the colors dispersed by the refraction.

We see rainbows in the sky when sunlight is behind us, but is able to shine on a droplet-filled, rainy storm cloud in front of us. We could see the rainbow on the floor when we stood above it because the light from the rainbow reflected off the white paper. We don't see rainbows on gray days because the sunlight is behind the clouds. The raindrops and the sun are over our heads, so we are on the wrong side of them to see a rainbow. The many raindrops in the thick clouds scatter the light too much. (Pilots in airplanes in the sunny sky above the clouds sometimes see rainbows we can't see from the ground, though!)

Draw Conclusions

Was your prediction correct: were you able to make a rainbow with a glass of water? How? (Yes, the water in the glass could refract the light and cause the colors to disperse.)

Why do we see rainbows after it rains? (The sunlight shines into raindrops which refract the sunlight and disperse the colors of light. The light reflects off the back of the raindrop and shines toward our eyes. We see the light split into different colors.)

Would you be able to see a rainbow in a sprinkler? (Yes, if you stand in the right place. The water from the sprinkler refracts the sunlight into all of the colors of visible light.)

Why can you not see a rainbow when it is cloudy? (The clouds block the sunlight, and the sun can't shine from behind us onto the droplets.)

What conditions allow us to see a rainbow? (Rainbows are formed when light shines through water, like when the sun shines through the rain. The water causes the light waves to slow down in different amounts. When light refracts we see all of the colors.)

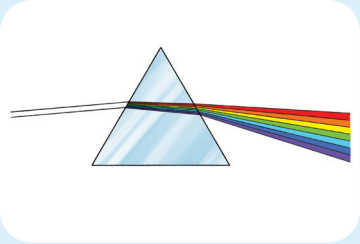
Takeaway

Light changes when we put different objects into a beam of light. Light shining from a flashlight is white light, which is a mixture of all the colors of light. When you shine light from a flashlight into water, the light bends or refracts. When the light bends, all of the colors of the rainbow are visible (red, orange, yellow, green, blue, indigo, and violet light). You created a rainbow. To see a rainbow in the sky, the sun almost always needs to shine from behind us onto a rain cloud's raindrops.

See the Bigger Picture

A famous scientist named Isaac Newton was the first person to discover "homemade" rainbows. He used a piece of glass shaped like a triangle, called a **prism**. When light passes through a prism, the light wave bends. Bending the light causes it to separate into different colors, and the colors form a rainbow.

After it rains, the light waves pass through droplets of rain. The rain droplets act like tiny prisms. They cause the light wave to bend. When the light passes through the droplets in just the right way, the colors of the rainbow appear in the sky in the shape of an arc.



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Go Further

If you're careful, you can look into the glass and see the individual colors of light refracting in the water. Lay on the floor and place your head under the rainbow while a parent holds the flashlight. What do you see? (Please do not try this too long—it may make your eyes tired!)

Make a rainbow using sunshine instead of a flashlight. Fill a glass almost full of water. Set the glass in the sunlight, maybe on a windowsill, for example. Find the rainbow on the floor. Tape white paper to the floor and use colored pencils or crayons to draw your rainbow on the paper.

You can also make rainbows with bubbles. Find an empty, clear, single-use water bottle. Add 2-3 drops of dish detergent and a small amount of water. Close the bottle tightly with the lid and shake the bottle until it is full of bubbles. Hold the bottle, with the bubbles, in a stream of sunlight and observe the rainbows. The bubbles make rainbows the same way that raindrops make rainbows, by separating the light into different colors.

You can use a clear prism to create a rainbow. Place a piece of white paper on the ground under the sunlight. Put the prism on or above the paper. Move the prism around until you see rainbow colors on the paper. They should be very bright.

Make a rainbow with a CD or DVD. First, look closely at the disc. You should notice little ridges or grooves. In a dark room, shine a flashlight on the disc and a rainbow will appear on it. You may also just hold it up to a stream of sunlight and you'll see a rainbow. A rainbow appears because the white light of the flashlight is reflecting off the ridges of the disc and creating a rainbow.

What Causes Rainbows?

Test Data Chart

Shine the flashlight on the white sheet of paper. Draw a picture of what you see.

Make a Prediction:

If you shine a flashlight on a glass of water, can you make a rainbow?

Yes No

Draw a picture that shows the position of the light, the water-filled **glass**, and the paper with the rainbow on it.