OBSERVE

Have students make observations about the drops of water inside each loop and discuss their observations with their group or partner.

- What do you notice as you look through the loop?
- What words would you use to describe this effect?
- What is the property of water that helps the water to collect in the loop?

Part 2
Reading Through Water

GET READY!

Students will now try to read small and large letters on the newspaper or magazine using the drops of water inside the wire loop.

PREDICT

Ask students to make some predictions. Do you think you can read through the drops of water in the wire loop? Why or Why not?

OBSERVE

Have students make observations about the drop of water inside each different-sized loop and discuss their observations with their group or partner:

- Which loop is the better magnifier, the loop with more water or less water? Is it the larger loop, or the smaller loop?
- Why does the water act as a magnifier?
- Describe and draw the shape of your waterdrop lens.
- Try to place more or less water on the loop and read the letters again.

WRAP-UP

To wrap-up the investigation, bring your students together for a group discussion to help them understand why and how they achieved their results. It is important to share results so that everyone has a clear picture of what happened. To help you facilitate the discussion, review the explanation in "The Why and The How" using the Group Discussion questions as a guide.

Group Discussion

Explain to students that scientists learn from each other through discussion, and they build upon the work of others to make new discoveries. Just as scientists come to conclusions based on the findings of their experiments, they will now come together as a group to share their results and make conclusions about the investigations they've conducted. Have students record their final results and the explanation in their journals.

- How did your predictions differ from your results?
- What did you learn about the magnifying effects of water?
- What new things did you learn about water from this investigation?
- How do you think light and water work together to magnify objects?

Answer: Proper lighting will provide a better view of the objects you want to magnify. The better the quality of light used with a magnifying lens, the less power is needed.

The "Why" and The "How"

A water drop is a **plano-convex** lens, which means it has one surface that is flat, and one surface that is curved out. The **surface tension** of water causes the molecules to create a rounded surface on the water drop. The rounded shape of the drop bends the light and the image of the letters outwards. As it spreads out, the image of the letters gets larger. If the water drop moves or changes shape, the image will be **distorted**.

The image is also **magnified**, or enlarged. As magnification increases, any distortions are also exaggerated. The water drop works as a magnifying glass by refracting light. A magnifying glass is a single **convex** (curved outward) lens that is used to produce a larger image of an object. The water drop in the wire loop also curves outward. A magnifying glass, is the simplest form of a microscope – a tool that scientists use to see small organisms better. Light passes through a convex lens and converges, or comes together, from different directions to a point.

A **concave** lens curves inward. Light passing through a concave lens branches out in different directions from one point. Concave lenses can be used in telescopes, binoculars, microscopes, and eyeglasses.

When light traveling through air touches a glass surface at an angle, some of the light reflects. The rest of the light keeps going, but it bends or refracts as it goes through the glass of water. When light travels through water, it slows down. This change in speed causes the light to reflect and refract as it moves from one material (air) to another (glass and water).

Curriculum Match-Up

- Try this investigation again using glasses or binoculars in place of the wire loop.
- Draw the way the printed words look through the drop of water inside the loop.
- Repeat the investigation using different liquids (**variables**.) For example, what would happen if you used oil instead of water?

References
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Water Illusions: Refraction & Magnification

Learning Objectives

Students will:

1. Demonstrate how water distorts light to make objects look different.
2. Identify water's refractive and magnifying qualities.
3. Observe how water interacts with light.

Vocabulary Ventures

concave
control
convex
distort
lens
magnify
physics
plano
reflection
refraction
submerge
surface tension
variable

Water is an amazing molecule. It absorbs light and scatters light in three dimensions (back and forth, side to side, and up and down). Water is unique because it absorbs colors at different rates, or speeds. For instance, water absorbs red and orange before it absorbs other colors.

Have you ever seen a rainbow? After it rains, water can put on an amazing light show by **refracting** (bending) light from the sun and separating all of the colors of light – red, orange, yellow, green, blue, indigo, and violet – into the shape of a bow.

Scientists use **physics** (the science of matter, or stuff, and energy and how they interact with each other) to understand how light passes more slowly through water than through air. The "bending" that occurs is a side effect of the light slowing down in water.

Water can play lots of tricks with your eyes, especially when it takes on the shape of a sphere. Let's see how!

TIP
To help students remember the colors of the rainbow, the Rainbow Man's name is ROY G. BIV = Red, Orange, Yellow, Green, Blue, Indigo, Violet.

R	RED
O	ORANGE
Y	YELLOW
G	GREEN
B	BLUE
I	INDIGO
V	VIOLET

colors of the rainbow

Time Needed to Conduct Investigations

Investigation 1: *This investigation has two parts.*
Organize and set up materials: 10 minutes
Introduce the lesson: 5 minutes
Conduct the investigation: 20 minutes
Student journaling/group reflection: 10 minutes
Total estimated time: 45 minutes

Investigation 2: *This investigation has two parts.*
Organize and set up materials: 10 minutes
Introduce the lesson: 5 minutes
Conduct the investigation: 20 minutes
Student journaling/group reflection: 10 minutes
Total estimated time: 45 minutes

Investigation 1: Underwater Differences

Materials

For groups of two to four
Student journals and writing tools

- Small and large clear glass jars (120 mL, 600 mL to 1000 mL), 2 of each
- A gallon of water

INVESTIGATION 1
Part 1:
- Clear glass jar (holds 600 mL)
- Pencil

Part 2:
- Clear glass jar (holds 125 mL)
- Sticker about 1-inch in length and width

INVESTIGATION 2

Part 1
- 10 inch #22 gauge bare wire
- Nails of different sizes (5mm, 7mm, 9mm)
- Small jar of water (125 mL)
- Magazine or newspaper clipping

Part 1
Broken Pencil

GET READY!

1. Ask students if they've ever looked in a fish tank or pond from above to get a close view of the fish. Did they notice that the water made the fish appear in a different location than where they really were?
2. Tell students they will be doing an investigation to test how water bends (refracts) light and changes the images we see.
3. Break up the students into groups of 2 or 4 for this investigation.
4. Fill a large jar with water.

broken pencil effect in water

PREDICT

Ask your students to predict what will happen when they place the pencil in the water. Do they expect the pencil to look the same in and out of the water? If not, why?

OBSERVE

Have students place pencils into their beakers of water, and look at the pencils from the top and the sides of the beakers. Ask students to make the following observations:
- How does the pencil appear in the water?
- Look at the pencil below the surface and then at the surface of the water. What appears to happen to the pencil at the water level?
- Describe any changes to the pencil's appearance.
- Diagram what you observe about the pencil in the water.

Part 2
Stick it to the Bottom

PROCEDURE

1. Place a sticker on the table. (NOTE: don't remove the sticker from its coated backing!)
2. Then, place a small jar over the sticker.
3. Fill the jar completely with water.
4. Look through the water as you slide the jar back and forth over the sticker. What do you observe?

OBSERVE

Ask students to make the following observations:
- What happened when you placed the jar over the sticker?
- What ideas do you have about these illusions?
- Diagram what you see.
- How do you imagine we see examples of this illusion in everyday life?

Answer: rainbows, shadows at the bottom of a pool, contact lenses and glasses, when the setting sun looks flat at the horizon, twinkling stars, and halos (a ring of light around objects in the sky) are all examples of what happens when light is refracted or bent.

WRAP-UP

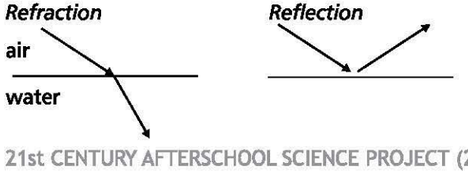
To wrap-up the investigation, bring your students together for a group discussion to help them understand why and how they achieved their results. It is important to share results so that everyone has a clear picture of what happened. To help you facilitate the discussion, review the explanation in "The Why and The How" using the Group Discussion questions as a guide.

Group Discussion
Scientists learn from each other through discussion, and they build upon the work of others to make new discoveries. Just as scientists come to conclusions based on the findings of their experiments, they will now come together as a group to share their results and make conclusions about the investigations they've conducted. Have students record their final results and the explanation in their journals.

- What did you notice about the objects in and under the water?
- How did your predictions differ from your results?
- What did they learn about water's refraction ability?
- What surprised you?
- What new questions do you have about water?
- What did you like about this activity?

The "Why" and The "How"
A property of water known as refraction creates the "broken pencil" effect. Light travels at different speeds through different materials. In fact, light travels slower through water than it does through air. This optical (eye) illusion causes light to refract, or bend, when it passes through materials of different densities -- in this case air, glass and water. In order to see the pencil under the water's surface, light must be reflected, or redirected, off the pencil and then travel through the water, the glass, and the air before it reaches your eyes. **Reflection** occurs when light bounces from a surface back toward the source, like a mirror reflects your image. Traveling through these materials slows the light just enough so that the image reaches your eyes just after the light reaches the top part of the pencil above the surface of the water. The combination of slower travel speed, and the density of the water and the glass distorts the image of the pencil. The water and the glass also magnify the submerged part of the pencil, making it appear larger than it really is -- just as a magnifying lens would do.

This diagram can help illustrate the effects of reflection and refraction:



Curriculum Match-Up

- Diagram the angles of refraction and reflection that occur in this experiment.
- Draw two fish of the same size (2 inches in length and ½ inch in width) on the line of a piece of lined paper. Place a glass or beaker filled with water over one of the fishes. Notice that the "underwater" fish looks higher up and a little further back than where you know it is on the paper. Predict what will happen. The second fish acts as a control to help you make the comparison.
- Shine a flashlight through a glass filled with salt water and a glass filled with fresh water. Add some drops of food coloring to the beakers and predict which transmitted light will be brighter. Which glass transmitted more light? Record your observations.

Investigation 2: Bigger Through Water

Part 1
Water Through a Loop

GET READY!

Inform students that they will be conducting an experiment that shows how water can magnify, or enlarge, objects.

PROCEDURE

1. Have students choose two (2) nails of different sizes.
2. Using one of two nails, wrap one end of the wire tightly around the nail. Tighten the wire by twisting it.
3. Carefully slide the wire loop off the nail.
4. Dip the wire in a cup of water so that water collects in the loop.
5. Repeat these steps with the second, different-sized nail.