**Light**

**Lesson #4:** **Bending Light**

**Time Frame:** 60 minutes

*Please write the vocabulary on the board before each lesson.*

**Vocabulary**

**Refraction -** the bending of a light wave caused by a change in the speed of light when moving through different mediums

**Learning Standards:**

*Science*

Waves and their Applications in Technologies for Information Transfer

1. An object can be seen when light reflected from its surface enters the eyes.

Crosscutting Concepts

1. Cause and effect relationships are routinely identified.

**Student will be able to:**

1. Explain the concept of refraction and use this natural property to manipulate the path of light reaching an object.
2. Explain why the sky is blue.

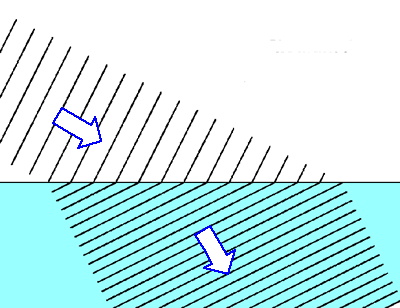
**Resources and Materials:**

|  |  |
| --- | --- |
| **Item** | **Amount** |
| Science Journals |  |
| iPads |  |
| Experimental Record Sheet | 25 (in bin) |
| Popsicle stick | 5 (in bin) |
| Rectangular glass container | 1 (in bin) |
| Glass rod | 1 (in bin) |
| Glass beaker | 3 (in bin) |
| Clear plastic cup | 1 (in bin) |
| Index cards | 50 (in bin) |
| Markers (not provided) | (in classroom) |

**Focus Activity:** Put a fat popsicle stick into the rectangular glass container and look through the side. Then take out the popsicle stick and fill about 3/4 of the beaker with water. Look through the side of the container, through the water. Put the popsicle stick in vertically at first, then at an angle. Looking down at the surface of the water through the side of the glass, the popsicle stick should appear to be bent, and then to return to its initial angle within the water itself. The popsicle stick should appear continuous if looked at from the side at eye level with the surface of the water. Ask students to write what they observed and try to hypothesize about what they think just happened in their science journals.

*Teacher Explanation: Light travels faster in air than in water. The light reflecting from the top of the popsicle stick only has to travel through glass and air to reach your eyes while the light reflecting from the submerged portion of the stick must travel through water as well as glass and air before reaching your eyes. When the popsicle stick is placed at an angle, the parts of the light rays that reflect off of the submerged stick hit the water at different times, and once the light enters the water, it travels at a slower speed. This change in speed causes the appearance of the stick to distort, and this distortion is called refraction.*

**Introduction:** Tell the students an analogy to explain the idea of refraction. Think of a shopping cart that has one broken front left wheel. What happens when you try to turn the cart to the left? The cart starts spinning because one of the wheels won't move. This is sort of what happens when light moves at an angle from a faster medium, like air, to a slower medium, like water: one side of the light beam reaches the water first and starts moving slower, while the other side gets to travels through the faster medium for a bit longer before it gets slowed down by traveling through the slower medium. Do a demonstration by drawing on the board. Draw a horizontal line maybe a foot or a foot and a half above the bottom of the board, and each teacher will draw one side of a light beam traveling through air (the area above the line) into water (the area below the line). Feel free to label these areas. Draw the lines parallel to each other in the air and then again in the water, but the person who starts at the lower side should turn at a shallower angle before the person who starts at the higher side. Explain that this bending of the light wave is what is called **refraction**. It happens when light moves at different speeds because of the properties of the mediums that it travels through. (See image below. On the left side, the light ray contacts water first and starts bending before the edge of the light ray on the right side.)



Ask them to think about what happens when light travels at the same speed in two different mediums (there would be no bending of light, a straight object would still look straight even when placed at an angle). Why did the popsicle stick only look bent when it was at an angle and not when it was vertical? (When the light rays travel vertically, there is not as a noticeable a different between the speeds of the two sides of the light rays, so the popsicle stick still appears to be straight.)

**Activity:** Split students up into three groups to cycle through the stations together Have students make observations on their experimental record sheets throughout the experiments.

1. **Station 1: The Mystery of the Disappearing Glass Rod**

Students will be making observations on a glass rod when it is in air, submerged in water, and submerged in vegetable oil.

1. Set up 3 beakers at this station and label them from 1-3. Beaker #1 should be empty. Beaker #2 should be filled about ¾ with water. Beaker #3 should be filled about ¾ with vegetable oil.
2. Students will draw a picture of the glass rod as they see it in air.
3. Fill a beaker about ¾ of the way with water. Put the glass rod into the beaker. The glass rod should appear to bend where the glass rod hits the water. Have students draw a diagram of the glass rod in the water, labeling the point at with the rod bends.

*Teacher explanation: Water has a greater index of refraction than air, so light travels faster through air than water. The light rays that reflect off of the submerged portion of the glass rod travel at a slower speed. The refraction causes the glass rod to appear to distort and bend.*

1. Fill another beaker about ¾ of the way with vegetable oil. Put the glass rod into the beaker. The glass rod should appear to disappear under the vegetable oil. Have students draw a diagram of the glass rod in the vegetable oil, and think about why the rod disappears.

*Teacher explanation: The index of refraction (how quickly light travels through a medium) of glass and vegetable oil is very similar, which means that light travels at about the same speed through both glass and vegetable oil, so light travels in essentially a straight line through both the glass and the oil. Since light travels in a straight line through these substances, no light is reflected or refracted, so our eyes will not register any difference between the glass rod and the vegetable oil, essentially allowing the glass rod to disappear.*

1. **Station 2: Flipping Images**

Students will draw a picture on an index card and watch their drawing turn in the opposite direction behind a clear plastic cup filled with water.

1. Students will each draw a picture of their choice on an index card. Their drawings should not exhibit any left-right symmetry. If students need ideas, an arrow pointing left or right is a good drawing to use for the experiment!
2. Fill the transparent plastic cup with water.
3. Students will start by holding their index cards directly behind the plastic cup filled with water. How is this image different from the image they originally drew? Students should see their drawings magnified.
4. What happens to the drawing as you move the index card further away from the cup of water? Students should see their drawings reverse directions.

*Teacher Explanation: The cylinder of water is acting as a lens, an object that refracts light in predictable ways. When the drawing is close to the lens, it is magnified, but pointing in the original direction. As the drawing is moved away from the lens, it flips.*

1. **Station 3: Bobo & Light**

Have students explore the “Refraction” page in the iPad app Bobo & Light. If there is extra time, students can move onto other pages within the app.

1. After the students have visited three stations, discuss what they observed at stations 1 and 2 as a class. Ask students to volunteer their observations and predictions about what happened before discussing the teacher explanations.

**Closure:** Discuss this question as a class: Does refraction happen in nature? Have students try to answer the question of "Why is the sky blue?" on their own. Watch this video for an explanation: <http://youtu.be/oG-ibVdYmtI>

*Teacher explanation: Light from the sun is made up of different colors that become visible when the beams of light are bent. As light from the sun passes through the atmosphere, it is scattered by air molecules, dust particles, and molecules of water vapor in the atmosphere. Blue light has a shorter wavelength than red, green, or yellow light, so it bounces off of more particles in the atmosphere. This makes blue wavelengths of light spread out more across the atmosphere, making the sky appear blue. When sunlight strikes the earth at an angle, like it does during sunrise or sunset, it must pass through more of the atmosphere than what is directly overhead. Dust and other particles in the air allow only the red light to get through. This makes the sun appear red at sunrise and sunset.*

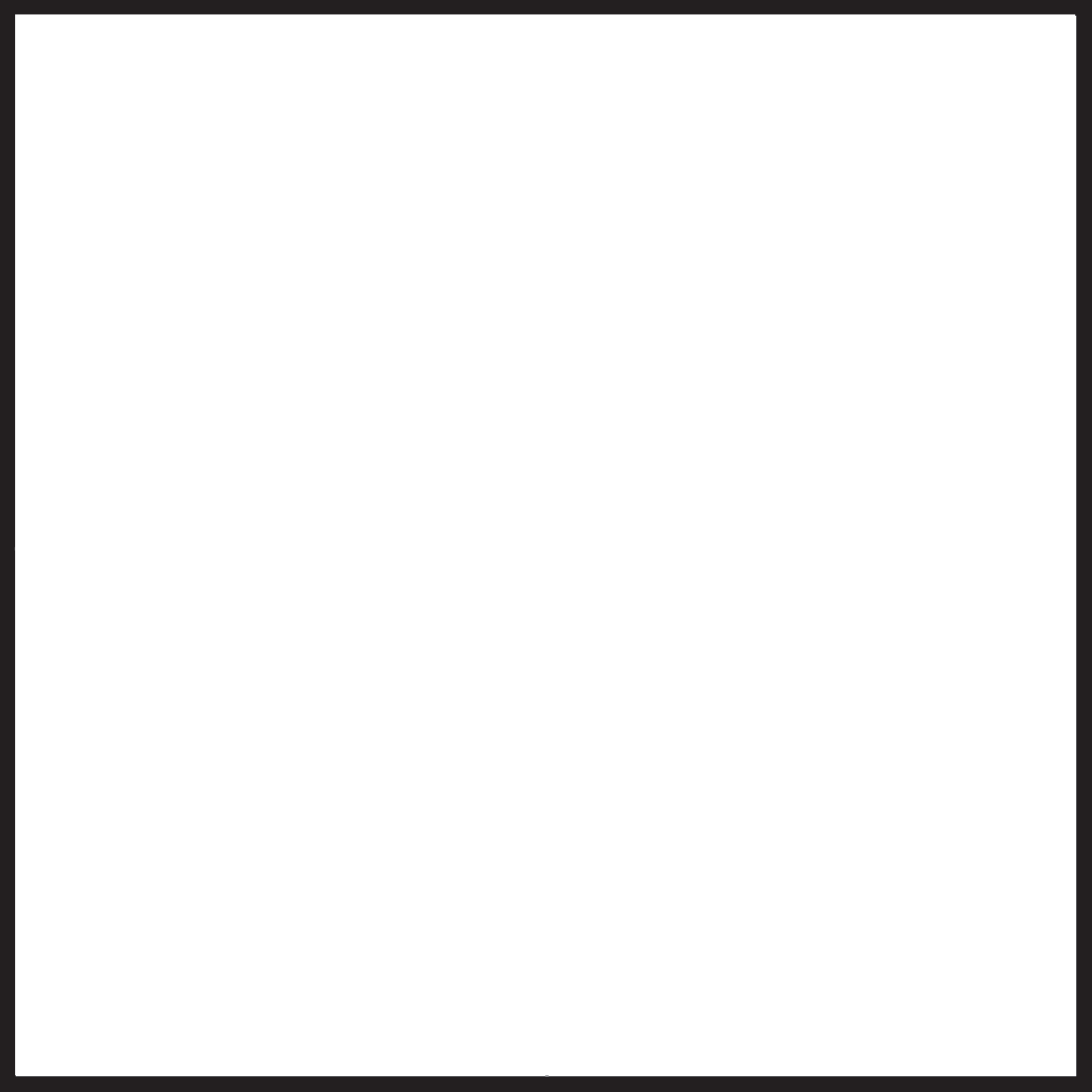
**Assessment:** Science notebooks, experiment sheet

Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

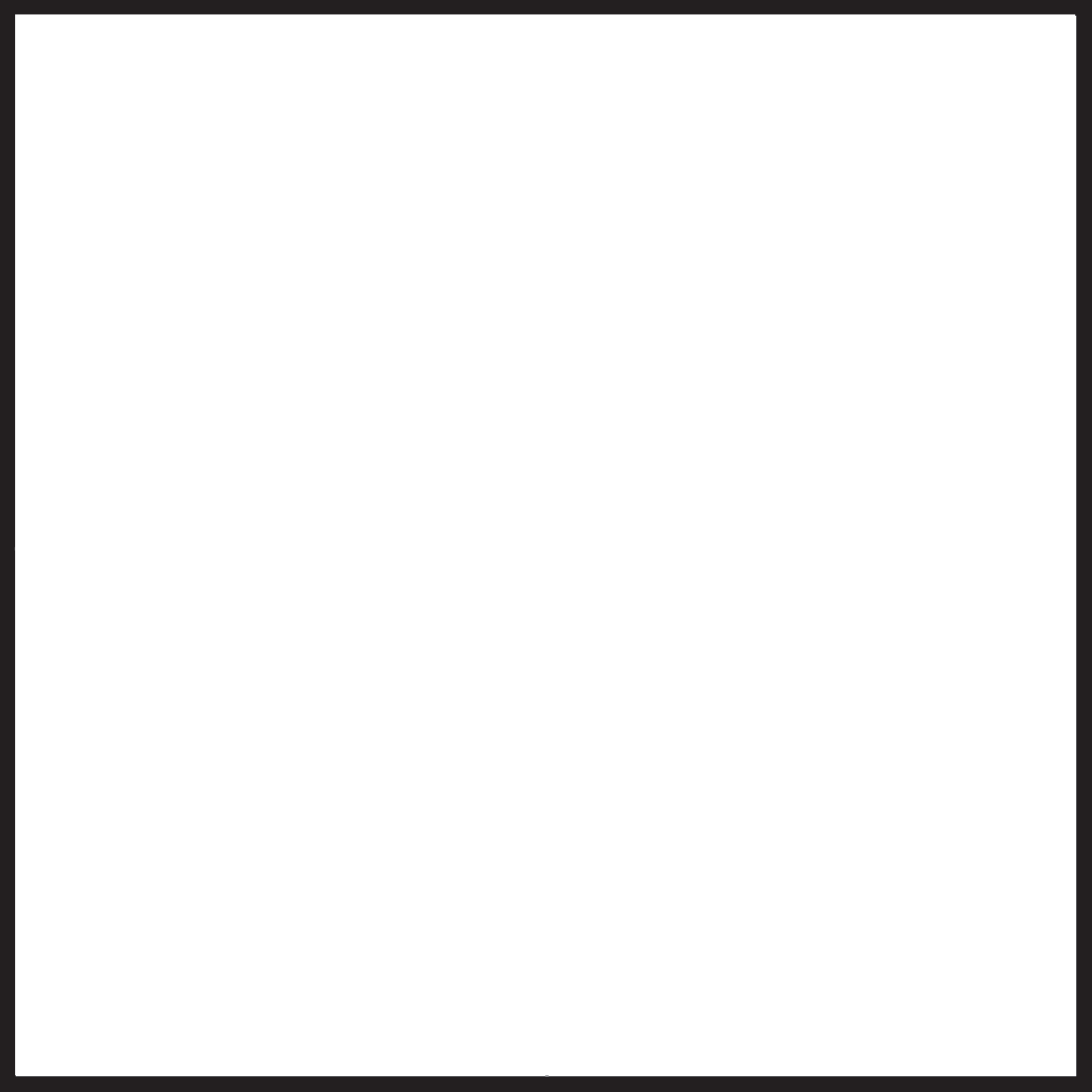
**Lesson 4 Experimental Record Sheet**

Experiment 1: The Mystery of the Glass Rod

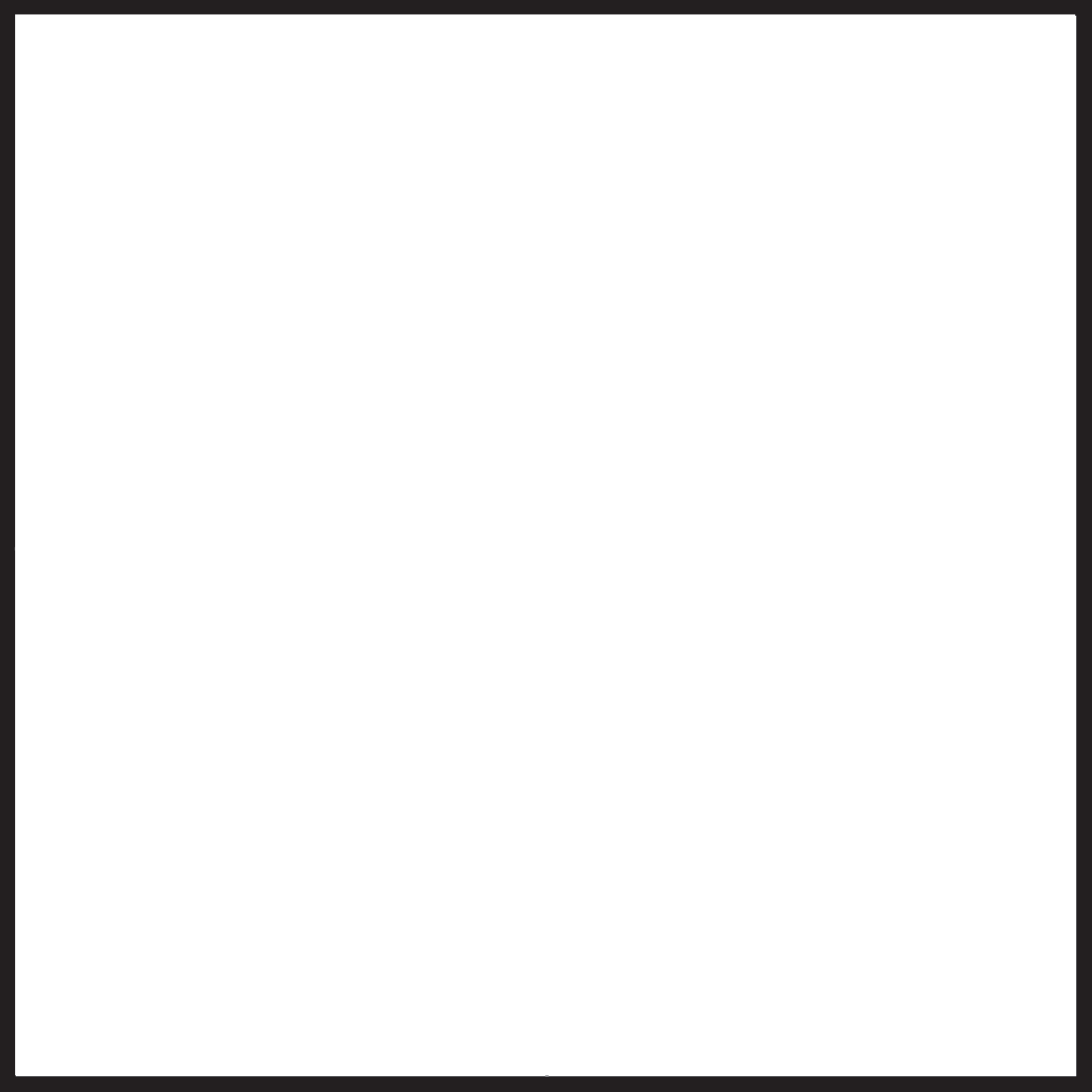
Put the glass rod into beaker #1. What does it look like in air? Draw a picture in the box below.



Put the glass rod into beaker #2. What does it look like in water? Draw a picture in the box.



Put the glass rod into beaker #3. What does it look like in vegetable oil? Draw a picture in the box.



Did you make the glass rod disappear? Why do you think that happened?

Experiment 2: Flipping Images

Draw a picture on an index card. The left side of the picture should look different from the right side.

After everyone at your group is finished with your drawings, send one person to fill the clear plastic cup with water.

Put the index card right behind the cup. How is the picture different when you look at it through the cup?

Try moving the index card farther away from the cup. How does the picture change?

Experiment 3: Bobo & Light

Find the “Refraction” page in the Bobo & Light app. Explore the readings on the page. What is one new thing you learned about refraction?