LESSON 13: Disappearing Glass

ESTIMATED TIME **Setup:** 5 minutes | **Procedure:** 5–10 minutes

• DESCRIPTION

Submerge Pyrex® glass in vegetable oil and observe the effects of refraction.

• OBJECTIVE

This lesson teaches students about energy, light, and refraction. Students will make predictions and provide explanations based on what they see or do not see. This lesson can be simplified to discuss properties of matter and energy.

• CONTENT TOPICS

Scientific inquiry; measurement; states of matter; properties of matter; energy (electromagnetic waves); light (refraction)

• MATERIALS

- ❑ Large clear container
- ❑ Vegetable oil
- ❑ Pyrex® glass container, with or without markings
- ❑ Regular glass container without markings

Try using a one-quart clear container and a 50-mL Pyrex® beaker to perform this experiment.

Always remember to use the appropriate safety equipment when conducting your experiment. Refer to the ***Safety First*** section in the ***Resource Guide*** on pages 421–423 for more detailed information about safety in the classroom.

Jump ahead to page 168 to view the Experimental Procedure.

NATIONAL SCIENCE EDUCATION STANDARDS SUBJECT MATTER

This lesson applies both *Dimension 1: Scientific and Engineering Practices* and *Dimension 2: Crosscutting Concepts* from "A Framework for K–12 Science Education," established as a guide for the updated National Science Education Standards. In addition, this lesson covers the following Disciplinary Core Ideas from that framework:

- PS1.A: Structure and Properties of Matter
- PS3.A: Definitions of Energy
- PS4.A: Wave Properties
- PS4.B: Electromagnetic Radiation

OBSERVATION & RESEARCH

BACKGROUND

Energy is a measure of the ability to do work or generate heat. Energy is found in many forms and can change from one form to another. Some forms of energy include kinetic energy, chemical energy, thermal energy, and electromagnetic energy.

Electromagnetic waves carry energy through space by a type of energy transfer known as radiation. Light, microwaves, and X-rays are all types of electromagnetic waves. Light is a combination of electromagnetic waves that are visible to the human eye. White light is made up of different colors (different waves). If you pass white light through a prism, you can split the light into different colors. The general order of the resulting colors is red, orange, yellow, green, blue, and violet.

Light has a number of unique properties. Light reflects off surfaces, which allows us to see images in mirrors. Light also exhibits a property known as refraction. Scientists coined the word refraction to describe the bending of light as it passes from one medium to another. This property is used in optical devices, such as microscopes, prescription glasses, and magnifying glasses.

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Most students have experienced the refraction of light when looking at objects submerged in water. The object under the water usually looks larger than when you take it out of the water because of refraction.

The amount the light bends is based on the index of refraction of the substances being compared. The **index of refraction** refers to the angle that is formed between the light and the surface of the object. A substance's index of refraction is determined by dividing the speed of light in a vacuum by the speed of light through that substance.

Because the index of refraction of oil is almost the same as that of Pyrex® glass, light is not significantly refracted (bent) as it passes from the oil through the glass. Therefore, the Pyrex® glass seems to disappear because the light is not bent. Common glass has a different index of refraction than that of oil and therefore is visible when submerged in the oil.

FORMULAS & EQUATIONS

Electromagnetic waves are characterized by wavelength and frequency. **Wavelength** is the distance between one wave crest (top of the wave) and the next or between one wave trough (bottom of the wave) and the next. **Frequency** is the number of complete waves or pulses that passes a given point per second.

The product of the wavelength and frequency of a wave is a constant (c), the speed of light: $\mathbf{c = 3 \times 10^8\ m/sec.}$

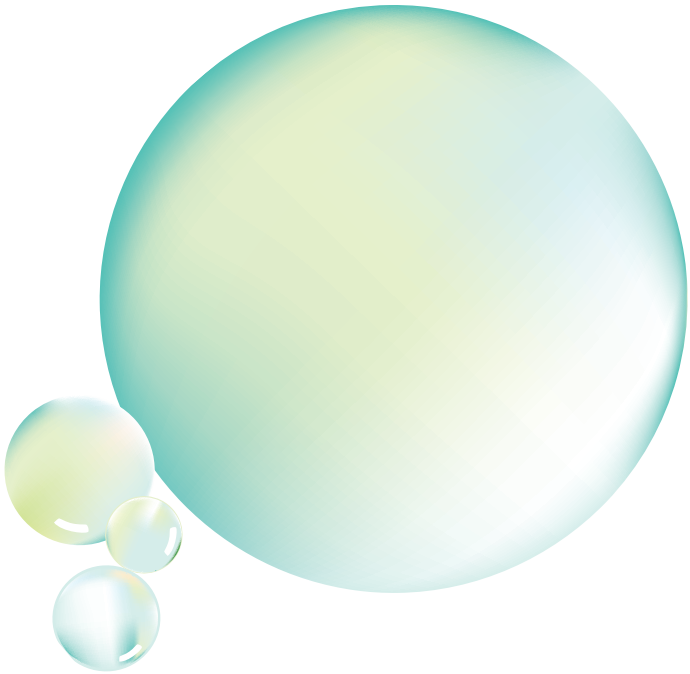
CONNECT TO THE *YOU BE THE CHEMIST* CHALLENGE

For additional background information, please review CEF's Challenge study materials online at http://www.chemed.org/ybtc/challenge/study.aspx.

- Additional information on properties of matter can be found in the Classification of Matter section of CEF's *Passport to Science Exploration: The Core of Chemistry*.
- Additional information on electromagnetic waves and light can be found in the Energy section of CEF's *Passport to Science Exploration: Chemistry Concepts in Action*.

HYPOTHESIS

▶When Pyrex® glass is submerged in a container of vegetable oil, the glass will seem to disappear because the light does not refract between the two materials.



Fun Fact

Scientists use refraction to determine the brand or composition of unknown glass.

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DIFFERENTIATION IN THE CLASSROOM

LOWER GRADE LEVELS/BEGINNERS

DESCRIPTION

Submerge Pyrex® glass in vegetable oil and observe as the glass seems to disappear.

OBJECTIVE

This lesson emphasizes properties of matter and properties of energy, specifically light.

OBSERVATION & RESEARCH

Matter is everything around us! It is characterized and classified by its properties. Mass and volume are two basic properties of all matter.

Mass is a measure of the amount of matter in a substance. The mass of an object can be measured with a balance. To determine the mass of an object, the object is compared to another object with a mass that is known. The unit of measurement that scientists use to measure mass is the kilogram (kg) or gram (g).

Volume is a measure of the amount of space an object occupies. Volume can be measured in a number of different ways. For liquids, volume can be measured using a graduated cylinder. To determine the volume of a rectangular solid, multiply its length, width, and height ($\mathbf{v = l \times w \times h}$). Volume is measured in liters or cubic units, such as cubic meters. A cubic meter is a cube that is one meter long on each side.

Matter exists primarily as a solid, liquid, or gas on the earth. Solids have a definite volume and a definite shape. Examples of solids are chairs, glasses, and trees. Liquids have a definite volume but no definite shape. Examples of liquids are water and oil. Gases have no definite shape and no definite volume. Examples of gases are the oxygen we breathe and the helium that fills balloons.

Along with differences in shape and volume, the different states of matter have other unique properties. Students can use the Pyrex® glass and oil to compare and contrast solids and liquids.

Likewise, different forms of energy can be identified by different properties as well. Energy is a measure of the ability to do work or generate heat. Energy is found in many forms and can change from one form to another. Some forms of energy include kinetic energy, chemical energy, thermal energy, and light.

Light has a number of unique properties. Light reflects off surfaces, which allows us to see images in mirrors. Light also exhibits a property known as refraction. Refraction is the bending of light as it passes from one medium to another. Most students have experienced the refraction of light when looking at objects submerged in water. The object under the water usually looks larger than when you take it out of the water because of refraction.

HIGHER GRADE LEVELS/ADVANCED STUDENTS

Complete the experiment as described on page 168, but discuss the properties of light further. Another interesting property of light combines both refraction and reflection. It is called total internal reflection. For example, when light coming from the air strikes water, part is reflected and part is refracted. When the angle at which the light strikes the water is large enough, it gets totally reflected and, in fact, cannot leave the water. Scientists have made use of this property of light in fiber optics. Fiber optic cables can carry digital information over very long distances.

CONNECT TO THE *YOU BE THE CHEMIST* CHALLENGE

For additional background information, please review CEF's Challenge study materials online at http://www.chemed.org/ybtc/challenge/study.aspx.

- Additional information on types of physical measurements can be found in the Measurement section of CEF's *Passport to Science Exploration: The Core of Chemistry*.
- Additional information on states of matter can be found in the Classification of Matter section of CEF's *Passport to Science Exploration: The Core of Chemistry*.

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EXPERIMENTATION

As the students perform the experiment, challenge them to identify the independent, dependent, and controlled variables, as well as whether there is a control setup for the experiment. (Hint: If you use a different type of glass, will you get the same results?) Review the information in the ***Scientific Inquiry*** section on pages 14–16 to discuss variables.

EXPERIMENTAL PROCEDURE

1. Fill a glass container with enough vegetable oil to submerge the Pyrex® glass.
2. Submerge the Pyrex® glass in the oil, and observe what happens.
3. Next, submerge a regular glass in the oil, and observe what happens.

Because of the large amount of materials used, it is best to do this experiment as a demonstration.

For this experiment to work properly, the Pyrex® glassware must be absolutely clean. After washing and rinsing the Pyrex® glass thoroughly with soap and water, you might need to give it a final rinse with acetone or nail-polish remover. Any spotting left on the glass will create telltale indicators of the "invisible glass."

The large clear container used to hold the oil should be clean as well; it does not need to be made of Pyrex® glass.

Try to create as few bubbles as possible when pouring the oil into the large glass container. If bubbles adhere to the Pyrex® glass, they will reveal the glass. Therefore, you should wait a few minutes for the bubbles to settle.

NOTES

DATA COLLECTION

Have students record data in their science notebooks or on the following activity sheet. What are the properties of the Pyrex® glass? What are the properties of the oil? Have students answer the questions on the activity sheet (or similar ones of your own) to guide the process.

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ANALYSIS & CONCLUSION

Use the questions from the activity sheet or your own questions to discuss the experimental data. Ask students to determine whether they should accept or reject their hypotheses. Review the information in the ***Scientific Inquiry*** section on pages 14–16 to discuss valid and invalid hypotheses.

ASSESSMENT/GOALS

Upon completion of this lesson, students should be able to …

- Apply a scientific inquiry process and perform an experiment.
- Understand that light is composed of visible electromagnetic waves that carry energy through space.
- Understand refraction of light and explain why the Pyrex® glass seems to disappear when placed in vegetable oil.
- Identify and understand the different properties of matter (see ***Differentiation in the Classroom***).
- Compare and contrast the different states of matter (see ***Differentiation in the Classroom***).

MODIFICATIONS/EXTENSIONS

Modifications and extensions provide alternative methods for performing the lesson or similar lessons. They also introduce ways to expand on the content topics presented and think beyond those topics. Use the following examples, or have a discussion to generate other ideas as a class.

- Tell the students before the experiment that you can dissolve glass in oil. If you have marked and unmarked Pyrex® glass, use the unmarked glass first and tell the students it has dissolved. Then try the marked glass. Since they will be able to see the markings, ask if they can explain what is really occurring. If you only have a marked Pyrex® glass, ask the students why the labels are not moving if the glass is dissolving.

REAL-WORLD APPLICATIONS

- You may observe refraction when you are at a swimming pool. The parts of our bodies that are out of the water may not line up with the parts in the water. This distortion is all due to the bending, or refraction, of light through the water.
- Refraction can be used to make distant objects visible. Some telescopes use the refraction of light through a convex glass lens to bend light and bring it into focus. Because the lens is thicker in the center than it is toward its edges, light at the edges is bent more than in the center. This process allows all of the light to come together at a focus point where the image is created.

COMMUNICATION

Discuss the results as a class and review the activity sheet. Review the information in the ***Scientific Inquiry*** section on pages 14–16 to discuss the importance of communication to scientific progress.

LESSON 13 ACTIVITY SHEET: Disappearing Glass

OBSERVE & RESEARCH

1. Write down the materials you observe. _____

_____

_____

2. Predict how these materials may be used. _____

_____

_____

3. Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

Term	Definition	Example (write or add image)
Energy		
Electromagnetic waves		
Light		
Refraction		
Index of refraction		

4. Consider what will happen if you place the Pyrex® glass in vegetable oil and why.

▶**Write your hypothesis.** _____

_____

_____

LESSON 13 ACTIVITY SHEET: Disappearing Glass

PERFORM YOUR EXPERIMENT

1. Fill the large glass container with enough vegetable oil to submerge the Pyrex® glass.
2. Carefully place the Pyrex® glass into the oil, and observe what happens.
3. Carefully place a regular glass in the oil, and observe what happens.

ANALYZE & CONCLUDE

1. What happens when you place Pyrex® glass in the oil? Why does that happen? _____

_____

_____

2. What do you think will happen if you submerge regular glass in vegetable oil? _____

_____

_____

3. Why do you think you can see some types of glass in the oil and not others? _____

_____

_____

_____

4. When you put a pencil straight down into a glass of water and look through the glass from the side, does the pencil appear to be straight? Why or why not? _____

_____

_____

5. Is your hypothesis valid? Why or why not? If not, what would be your next steps? _____

_____

_____

LESSON 13 ACTIVITY SHEET: Disappearing Glass

SHARE YOUR KNOWLEDGE

1. Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

Term	Definition	Example (write or add image)
Matter		
Mass		
Volume		
Solid		
Liquid		
Gas		

2. List some properties used to describe matter. _____

_____

_____

3. List some properties of light. _____

_____

_____

LESSON 13 ACTIVITY SHEET: Disappearing Glass

ANSWER KEY: *Below are suggested answers. Other answers may also be acceptable.*

OBSERVE & RESEARCH

1. Write down the materials you observe. Vegetable oil, Pyrex® glass …

2. Predict how these materials may be used. The vegetable oil may be used for cooking. The Pyrex® glass may be used to hold various substances. Together, they can be used to illustrate the effects of refraction.

3. Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

Term	Definition	Example (write or add image)
Energy	The ability to do work or produce heat.	
Electromagnetic waves	Waves (continuous vibrations through space) that carry energy through space by radiation.	
Light	A specific group of electromagnetic waves that travels freely through space and can be detected by the human eye; also known as visible light.	
Refraction	The bending of light as it passes from one medium to another.	
Index of refraction	The ratio of the speed of light in a vacuum to the speed of light in a substance.	

4. Consider what will happen if you place Pyrex® glass in vegetable oil and why.

▶**Write your hypothesis.** When the Pyrex® glass is submerged in a container of vegetable oil, the glass will seem to disappear because the vegetable oil and glass have similar refractive indexes.

LESSON 13 ACTIVITY SHEET: Disappearing Glass

ANSWER KEY: *Below are suggested answers. Other answers may also be acceptable.*

PERFORM YOUR EXPERIMENT

1. Fill the large glass container with enough vegetable oil to submerge the Pyrex® glass.
2. Carefully place the Pyrex® glass into the oil, and observe what happens.
3. Carefully place a regular glass in the oil, and observe what happens.

ANALYZE & CONCLUDE

1. What happens when you place Pyrex® glass in the oil? Why does that happen? The Pyrex® glass seems to disappear because the glass and vegetable oil have about the same index of refraction, so the light does not bend as it passes from one substance to the other.

2. What do you think will happen if you submerge regular glass in the vegetable oil? If you submerge regular glass in vegetable oil, the light is refracted between the oil and the glass surface, allowing you to see the glass through the oil.

3. Why do you think you can see some types of glass in the oil and not others? You can see some types of glass in vegetable oil when the angles of refraction are not equal. As a result, the light bends through the glass at a different angle than it does through the oil, and you can see the object because of this difference. The Pyrex® glass has the same angle of refraction as the vegetable oil, so the light bends at the same angle. As a result, the Pyrex® glass seems invisible.

4. When you put a pencil straight down into a glass of water and look through the glass from the side, does the pencil appear to be straight? Why or why not? The pencil does not appear straight because the angles of refraction of the water and the glass are not equal. This makes the pencil appear to bend in the water.

5. Is your hypothesis valid? Why or why not? If not, what would be your next steps? Answer 1: Valid because the data support my hypothesis.

Answer 2: Invalid because the data do not support my hypothesis. I would reject my hypothesis and could form a new one, such as …

LESSON 13 ACTIVITY SHEET: Disappearing Glass

ANSWER KEY: *Below are suggested answers. Other answers may also be acceptable.*

SHARE YOUR KNOWLEDGE—BEGINNERS

Have students complete this section if you used the beginners' differentiation information, or challenge them to find the answers to these questions at home and discuss how these terms relate to the experiment in class the next day.

1. Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

Term	Definition	Example (write or add image)
Matter	Any substance that has mass and takes up space; matter is generally found as a solid, liquid, or gas on the earth.	
Mass	A measure of the amount of matter in a substance.	
Volume	A physical property that measures the amount of space a substance occupies.	
Solid	A state of matter characterized by a definite volume and a definite shape.	
Liquid	A state of matter that has a definite volume but no definite shape; a liquid will take the shape of the container that holds it, filling the bottom first.	
Gas	A state of matter that has no definite volume or shape; a gas will take the shape of the container that holds it, filling the entire container.	

2. List some properties used to describe matter. Mass, volume, size, shape, texture, melting point ...

3. List some properties of light. Reflection, refraction, visible ...